UNITED STATES
PATENT AND TRADEMARK OFFICE

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ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**08/23/2025 07:51:05 PM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	71987526	AUTHORIZED BY	-
CUSTOMER #	155075	FILING DATE	12/28/2022
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Xiaobo ZHANG

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
CARD / 9633	**E20258MJ51398701**	**Jialin Zhong**

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
1820	REQUEST FOR CONTINUED EXAMINATION (RCE)- 2ND AND SUBSEQUENT REQUEST (SEE 37 CFR 1.114)	2860.00	1	2860.00
			TOTAL AMOUNT:	**$2,860.00**

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

New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	18/089,999	Filing Date	2022-12-28	Docket Number (if applicable)	ZL0205-0002-PCT-US-CON2	Art Unit	2472
First Named Inventor	Xiaobo ZHANG			Examiner Name	DEEPA BELUR		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the orde in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

☐ Other _____

☒ Enclosed

☒ Amendment/Reply

☒ Information Disclosure Statement (IDS)

☐ Affidavit(s)/ Declaration(s)

☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____ (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

☒ The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 602313

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

☐ Applicant Signature

PTO/SB/30EFS (07-09)
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Signature of Registered U.S. Patent Practitioner			
Signature	/Jialin Zhong/	Date (YYYY-MM-DD)	2025-08-23
Name	Jialin Zhong	Registration Number	62937

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is t
file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection
estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Tim
will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions fo
reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce,
P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

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

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

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

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

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

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

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

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

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

PTO/SB/08 (01-25)
Approved for use through 11/30/2027. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

Application Number	18089999
Filing Date	2022-12-28
First Named Inventor	Xiaobo ZHANG
Art Unit	2472
Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-US-CON2

U.S. PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Inventor of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear
	1	10944527	B2	2021-03-09	Xiaobo Zhang	
	2	11546110	B2	2023-01-03	Xiaobo Zhang	

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

U.S. PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Inventor or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear
	1	20150162966	A1	2015-06-11	KIM et al.	

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

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

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PC.1.19.25

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

Application Number	18089999
Filing Date	2022-12-28
First Named Inventor	Xiaobo ZHANG
Art Unit	2472
Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-US-CON2

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Declaration of Dr. Narayan Mandayam	☐
	2	Declaration of June Munford	☐
	3	Complaint, Apex Beam Technologies LLC v. Apple Inc., 6:24-cv-00223, W.D. Tex., filed April 29, 2024	☐
	4	First Amended Complaint, Apex Beam Technologies LLC v. Apple Inc., 6:24-cv-00223, W.D. Tex., filed May 2, 2024	☐
	5	Proof of Service of Complaint, Apex Beam Technologies LLC v. Apple Inc., 6:24-cv-00223, W.D. Tex., May 14, 2024	☐
	6	PETITION FOR INTER PARTES REVIEW OF US PATENT NO. 10,944,527, dated May 5, 2025	☐
	7	PETITION FOR INTER PARTES REVIEW OF US PATENT NO. 11,546,110, dated May 5, 2025	☐

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

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

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

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

PC.1.19.25

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

Application Number	18089999
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First Named Inventor	Xiaobo ZHANG
Art Unit	2472
Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-US-CON2

TIMING STATEMENT

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

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

OR

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

☐ See attached timing statement under 37 CFR 1.97(e).

☒ A timing statement under 37 CFR 1.97(e) is not submitted herewith.

TIMING FEE

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

COPIES

☐ An identification of an earlier application pursuant to 37 CFR 1.98(d)(1) is attached.

SIZE FEE ASSERTION

Please see 37 CFR 1.17(v) and the IDS Auto-Load Instructions for completing this form to make the appropriate selection of an assertion under 37 CFR 1.98. For the information disclosure statement (IDS) submitted herewith, the applicant or patent owner certifies the following with respect to the cumulative number of applicant-provided or patent-owner provided items of information submitted to date including those in the accompanying IDS (select only one):

☒ No IDS size fee is required under 37 CFR 1.17(v) at this time.

☐ The IDS is accompanied by the IDS size fee under 37 CFR 1.17(v)(1).

☐ The IDS is accompanied by the IDS size fee under 37 CFR 1.17(v)(2).

☐ The IDS is accompanied by the IDS size fee under 37 CFR 1.17(v)(3).

SIGNATURE

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 11.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Jialin Zhong/	Date (YYYY-MM-DD)	2025-08-23
Name/Print	Jialin Zhong	Registration Number	62937

PC.1.19.25

INFORMATION DISCLOSURE STATEMENT BY APPLICANT		
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	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-US-CON2

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

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CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 10

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ZL0205-0002-PCT-US-CON2 RCE amendment 2025-8-23.pdf	12	Response After Final Action	137 KB
RCE _ZL0205-0002-PCT-US-CON2.pdf	3	Request for Continued Examination (RCE)	681 KB
ZL0205-0002-US-CON2_ids.pdf	5	Information Disclosure Statement (IDS) Form (SB08)	1315 KB
IPR2025-00903 Petition.pdf	105	Non Patent Literature	5821 KB
IPR2025-00897 Petition.pdf	111	Non Patent Literature	6921 KB
Amended Complaint_May 2 2024.pdf	211	Non Patent Literature	10600 KB
Munford Declaration.pdf	561	Non Patent Literature	14427 KB

Original Complaint_Apr 29 2024.pdf	11	Non Patent Literature	892 KB
Declaration of Dr. Narayan Mandayam.pdf	145	Non Patent Literature	6217 KB
Service of Complaint_May 14 2024.pdf	217	Non Patent Literature	16680 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
ZL0205-0002-PCT-US-CON2 RCE amendment 2025-8-23.pdf	05531BAD9E948C7909956FA267F1140E10A78A52B5ABE47CC0E83406C790044A2B71ADD808A9AAC6696CF212A6B0CBE5D7D57F4E42BEB6F535BDF7D0096B3B00
RCE _ZL0205-0002-PCT-US-CON2.pdf	6E143B75B6F32E700E327C0C1DA60BA48FED73F83B5C903A2A0756C39052C44CABD1D89E680395501A59214FD7ECD4AB6DF28B4DC6A8DB2361397E1443273B5E
ZL0205-0002-US-CON2_ids.pdf	CD8A21522014BEC5CAF7EDA9D16A909E0150DE819CD1F9A1A96841A99BB5A645F79776C3345801E3229F6DCA7D14D7B5EBF12A18E8BBEB01EB80A311EFA9B2F9
IPR2025-00903 Petition.pdf	0B50EF4613AD3F14725AC50F29B6F7AA697A56BFC132CAD6A2991C7A9865A098B9DC0E342A27E9ABAAB228DE71A9569BFDAD15EB70ED5382CC215A459C4BE120
IPR2025-00897 Petition.pdf	6ACAA3E24ECEBCA1F3CE4CA8BCED4C793BB86738675EB10C823ABA17D0D12FF43C2E3EA03AE264E4AD2DB0EB70DFA6575AAB0EFB2A245A3C3C54348CBD753BBD
Amended Complaint_May 2 2024.pdf	2A2D4B35C800423CC0511D5BFFB6D7C20F823BCCD27BBC223437F12B7DA47D500AFB8B37C553B5891405C4C9DBAD50922E726BC332D1E80AC0B73F86759D0D6D
Munford Declaration.pdf	573DB2EB4A597B14781266FD9349D983643F4556CD96F2A114ECB971C834A6B3571E7DD848075DD3E4E607D9AD575885F0F7130B895D8F6D0343AA0EDA66BFB7
Original Complaint_Apr 29 2024.pdf	A5BE21AD3DEC75A16D498EEAC63DE2D0853DB42C6487BD73058DFA67AD0F6E54F0ACC6F80CD590A4F69CA2EC788484A0532AAB8683F05B94A7F902E110B6E22E
Declaration of Dr. Narayan Mandayam.pdf	84F0877BDA41EB15BAAEBF2E9CE9D6F96E85763D630A299E1864BD6766AF25B46B22E959C3905BD2D2DA1A4AF03933DCEF14AB9BFE7A0F27A215ACDAA26F8282
Service of Complaint_May 14 2024.pdf	1826D2F37FA2173F31803A7423846D2328ED8926046D96B255B42621464CFB079F604F8E3B26C4E81EBD3B3C7C3F5FDDFB

89BAF15D02A434D30D52970111BB13

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

New Applications Under 35 U.S.C. 111

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Our Docket No: ZL0205-0002-PCT-US-CON2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	Examiner: DEEPA BELUR
	)	
Xiaobo ZHANG	)	Art Unit: 2472
	)	
Application No: 18/089,999	)	Confirmation No.: 9408
	)	
Filed: December 28, 2022	)	
	)	
For: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	)	

AMENDMENT ACCOMPANYING AN RCE

E-Filed via EFS-Web
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir/Madam:

In response to the non-final Office action mailed on May 23, 2025, applicant respectfully requests the Examiner to enter the following amendments and to consider the following in view of the concurrently-submitted Request for Continued Examination (RCE).

Claims 1-20 are reflected in the listing of claims which begin on page 2 of this document.

Remarks begin on page 10 of this document.

In the claims:

For the Examiner's convenience, all pending claims are presented below with changes shown in accordance with the mandatory amendment format.

What is claimed is:

1. (Currently amended) A method for multi-antenna transmission in a user equipment, comprising:

receiving a first radio signal from a base station; and

receiving a first signaling from the base station;

wherein the first radio signal is collectively transmitted by K antenna port groups of the base station; the K is a positive integer greater than 1; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; at least one of a first antenna virtualization vector and a second antenna virtualization vector is associated with the first antenna port group; the first antenna virtualization vector is an antenna virtualization vector available to the base station in the first time resource pool; ~~a second antenna virtualization vector is associated with the first antenna port group;~~ the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal).

2. (Previously presented) The method of claim 1, further comprising:

receiving a second signaling; and

operating a second radio signal in a first time resource sub-pool;

wherein the operating is one of receiving or transmitting the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; and the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI and (a) transmitting antenna port(s) of the second radio signal.

3. (Original) The method of claim 1, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, comprising:

receiving first information, wherein the first information is used to determine the first antenna port group.

4. (Original) The method of claim 1, further comprising:

transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

5. (Original) The method of claim 1, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

6. (Currently amended) A method for multi-antenna transmitting in a base station, comprising:

transmitting a first radio signal <u>to a target receiver</u>; and

transmitting a first signaling <u>to the target receiver</u>;

wherein the first radio signal is collectively transmitted by K antenna port groups of the base station; the K is a positive integer greater than 1; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; at least one of a first antenna virtualization vector and a second antenna virtualization vector is associated with the first antenna port group; the first antenna virtualization vector is an antenna virtualization vector available to the base station in the first time resource pool; ~~a second antenna virtualization vector is associated with the first antenna port group;~~ the second antenna virtualization vector is an antenna virtualization vector available to [[a]] the target receiver of the first signaling in the first time resource pool; and the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal)~~; the first signaling is a downlink signaling~~.

7. (Previously presented) The method of claim 6, further comprising:

transmitting a second signaling; and

performing a second radio signal in a first time resource sub-pool;

wherein the performing is one of transmitting or receiving the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI and (a) transmitting antenna port(s) of the second radio signal.

8. (Original) The method of claim 6, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, comprising:

transmitting first information, wherein the first information is used to determine the first antenna port group.

9. (Original) The method of claim 6, further comprising:

receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

10. (Original) The method of claim 6, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

11. (Currently amended) A user equipment (UE) for multi-antenna transmission, comprising:

a first transceiver, receiving a first radio signal <u>from a base station</u>; and

a second receiver, receiving a first signaling <u>from the base station</u>;

wherein the first radio signal is collectively transmitted by K antenna port groups <u>of the base station</u>; the K is a positive integer greater than 1; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; <u>at least one of a first antenna virtualization vector and a second antenna virtualization vector is associated with the first antenna port group; the first antenna virtualization vector is an antenna virtualization vector available to the base station in the first time resource pool;</u>

~~a second antenna virtualization vector is associated with the first antenna port group;~~ the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal).

12. (Previously presented) The UE of claim 11, comprising:

a third receiver, receiving a second signaling; and

a second transceiver, operating a second radio signal in a first time resource sub-pool;

wherein the operating is one of receiving or transmitting the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; and the second signaling is used to determine at least one of occupied frequency domain resources, a MCS, a HARQ process number, a RV, a NDI and (a) transmitting antenna port(s) of the second radio signal.

13. (Original) The UE of claim 11, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, the second receiver further receives first information, wherein the first information is used to determine the first antenna port group.

14. (Original) The UE of claim 11, wherein:

the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

15. (Original) The UE of claim 11, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

16. (Currently amended) A base station equipment for multi-antenna transmission, comprising:

a third transceiver, transmitting a first radio signal to a target receiver; and

a second transmitter, transmitting a first signaling to the target receiver;

wherein the first radio signal is collectively transmitted by K antenna port groups of the base station; the K is a positive integer greater than 1; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; at least one of a first antenna virtualization vector and a second antenna virtualization vector is associated with the first antenna port group; the first antenna virtualization vector is an antenna virtualization vector available to the base station in the first time resource pool; ~~a second antenna virtualization vector is associated with the first antenna port group;~~ the second antenna virtualization vector is an antenna virtualization vector available to [[a]] the target receiver of the first signaling in the first time resource pool; and the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal)~~; the first signaling is a downlink signaling~~.

17. (Previously presented) The base station equipment of claim 16, further comprising:

a third transmitter, transmitting a second signaling; and

a fourth transceiver, performing a second radio signal in a first time resource sub-pool;

wherein the performing is one of transmitting or receiving the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, a MCS, a HARQ process number, a RV, a NDI and (a) transmitting antenna port(s) of the second radio signal.

18. (Original) The base station equipment of claim 16, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, the second transmitter further transmits first information, wherein the first information is used to determine the first antenna port group.

19. (Original) The base station equipment of claim 16, wherein:

the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

20. (Original) The base station equipment of claim 16, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

REMARKS

Applicant respectfully requests reconsideration of this application. Claims 1, 6, 11, and 16 are amended. No claims have been canceled. No new claims have been added.

Applicant respectfully submits that the amendments to the Claims do not add new matters and respectfully requests the entry of the amendments to the Claims.

Summary of the Office Action

Claims 1-20 are rejected under 35 U.S.C. 103 as unpatentable over US 2013/0182594 to Kim ("Kim") in view of US 2015/0162966 to Kim (Kim*). While applicant does not agree with the rejection, to facilitate matters, independent claims 1, 6, 11, and 16 have been amended to overcome the rejection.

The representative claim 1 as presented recites:

> 1. A method for multi-antenna transmission in a user equipment, comprising:
> receiving a first radio signal from a base station; and
> receiving a first signaling from the base station;
> wherein ***the first radio signal is collectively transmitted by K antenna port groups of the base station***; the K is a positive integer greater than 1; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; ***the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use***; ***at least one of a first antenna virtualization vector and a second antenna virtualization vector is associated with the first antenna port group; the first antenna virtualization vector is an antenna virtualization vector available to the base station in the first time resource pool***; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal). (emphasis added)

Applicant respectfully submits that Kim in view of Kim* does not disclose or teach the above-emphasized features recited in claim 1. Therefore, claim 1 as well as its dependent claims is patentable over the combination of Kim and Kim*.

Claims 6, 11, and 16 as presented include features similar to claim 1. Therefore, claims 6, 11, and 16 as well as their respective dependent claims are also patentable over Kim and Kim* for the same reasons as claim 1.

The Examiner is requested to call the undersigned at (908) 591-2738 if there remains any issue with allowance of the case.

Please charge any shortage to our Deposit Account No. 60-2313.

Respectfully submitted,

ZHONG LAW, LLC

Date: August 23, 2025

/Jialin Zhong/
Jialin Zhong
Reg. No.: 62,937

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PTO/SB/06 (09-11)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 18/089,999	Filing Date 12/28/2022	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

	(Column 1)	(Column 2)			
FOR	NUMBER FILED	NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $480 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	08/23/2025	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0		x $200 =	0
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 4	= 0		x $600 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	SLIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/LISA R WRIGHT/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/089,999	12/28/2022	Xiaobo ZHANG	ZL0205-0002-PCT-US-CON2	9408

155075 7590 05/23/2025

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EXAMINER	
BELUR, DEEPA	

ART UNIT	PAPER NUMBER
2472	

NOTIFICATION DATE	DELIVERY MODE
05/23/2025	ELECTRONIC

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

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

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

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

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No. 18/089,999	Applicant(s) ZHANG, Xiaobo	
	Examiner DEEPA BELUR	Art Unit 2472	AIA (FITF) Status Yes

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 3/26/025.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☑ This action is **FINAL.** 2b) ☐ This action is non-final.

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

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-20 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-20 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

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

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

2. This action is in response to the amendments filed on 3/26/2025.

3. Independent claims 1, 6, 11, 16 are amended.

4. Claims 1-20 have been examined and rejected based on new grounds of rejection.

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

6. Claim(s) 1-20 are rejected under 35 U.S.C. 103 as being unpatentable over Kim (US 2013/0182594 A1) in view of Kim* (US 20150162966 A1) (Both references from Case IPR2023-00603).

Regarding Claim 1, Kim discloses a method for multi-antenna transmission in a user equipment **(see FIG. 5),** comprising:

receiving a first radio signal **(see para 55, a method of transmitting a CSI-RS/i.e., a first radio signal, for a massive MIMO system by using CSI-RS resources);** and

receiving a first signaling (**see paras 65-69, In order to transmit the CSI-RSs for massive MIMO as illustrated in FIGS. 5 and 6, an eNB should notify a UE of related control information/i.e., a first signaling, before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the received CSI-RSs by the UE. Such control information may include at least one of the following: Information on the time and frequency resource positions at which the CSI-RSs for massive MIMO are transmitted, wherein this information includes positions of time and frequency resources at which a CSI-RS for each antenna group is transmitted);**

wherein the first radio signal is collectively transmitted by K antenna port groups; the K is a positive integer greater than 1 **(see FIG. 5. para 60, each antenna group transmits a CSI-RS in each transmission interval by using one CSI-RS resource (as indicated by reference numeral 500 of FIG. 5) for 8 ports; also see FIG. 7, para 83, five beam groups 710 are illustrated, each antenna group includes 8 transmission antennas, and each antenna group transmits CSI-RSs by using one CSI-RS resource 700 for 8 ports in each transmission interval);**

the antenna port group includes a positive integer number of antenna port(s) **(see FIG. 5);**

a first antenna port group is one of the K antenna port groups **(see FIG. 5 depicting five antenna port group 510);**

the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use **(see FIG. 5, para 60, since each antenna**

group includes 8 transmission antennas, each antenna group transmits a CSI-RS in each transmission interval by using one CSI-RS resource/i.e., representing shared use (as indicated by reference numeral 500 of FIG. 5) for 8 ports; also see paras 65-69, In order to transmit the CSI-RSs for massive MIMO as illustrated in FIGS. 5 and 6, an eNB should notify a UE of related control information/i.e., a first signaling, before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the received CSI-RSs by the UE. Such control information may include at least one of the following: Information on the time and frequency resource positions at which the CSI-RSs for massive MIMO are transmitted, wherein this information includes positions of time and frequency resources at which a CSI-RS for each antenna group is transmitted);

the first radio signal includes **one or more of** ~~PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block)~~ **or** CSI-RS (Channel State Information Reference signal) **(see para 55, a method of transmitting a CSI-RS/i.e., a first radio signal, for a massive MIMO system by using CSI-RS resources)**.

Kim discloses all the above limitations, but does not disclose: a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool;

In the same field of endeavor, Kim* discloses this limitation: **see para 135, FIG. 12, CSI-RSs for M ports among N ports may be UE-specifically and aperiodically**

transmitted, which is a variation of cell-specific and periodic transmission of the CSI-RSs for N ports in resources corresponding to one CSI-RS configuration … mapping between CSI-RSs of N antenna ports and M UE-specific ports or antenna virtualization may be performed using a transform matrix B of N*M dimensions. It would have been obvious, to one having ordinary skill in the art, before the effective filing date of the claimed invention, to modify the system of Kim, so as to use antenna virtualization for mapping CSI-RS for M ports among N ports of the UE in massive MIMO as taught by Kim*, to reduce the overhead of transmitting CSI-RSs **(see Kim*, para 134).**

Regarding Claims 2, 7, 12 and 17, Kim discloses: receiving a second signaling; and operating a second radio signal in a first time resource sub-pool; wherein the operating is one of receiving or transmitting the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool **(see para , FIG. 8. illustrates a transmission of CSI-RSs for a plurality of beams by allocating not only individual time resources but also individual frequency resources; also see FIG. 5, para 60, since each antenna group includes 8 transmission antennas, each antenna group transmits a CSI-RS in each transmission interval by using one CSI-RS resource … each transmission antenna has an individual transmission resource/i.e., representing other resources or resource sub-pool, in transmitting a CSI-RS, and the UE can measure the channel state in each transmission antenna. The channel state in each transmission antenna needs to be measured for determination of an**

optimum precoding scheme; and at paras 65-69, In order to transmit the CSI-RSs for massive MIMO as illustrated in FIGS. 5 and 6, an eNB should notify a UE of related control information, before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the received CSI-RSs by the UE. Such control information may include at least one of the following: Information on the time and frequency resource positions at which the CSI-RSs for massive MIMO are transmitted, wherein this information includes positions of time and frequency resources at which a CSI-RS for each antenna group is transmitted).

Regarding Claims 3, 8, 13 and 18, Kim discloses the method of claim 1, wherein the first signaling indicates the first antenna port group from the K antenna port group(s) **(see FIG. 5. para 60, antenna groups 1 through 5 in FIG. 4 are allocated transmission time intervals and transmit CSI-RSs in the allocated transmission time intervals. In FIG. 4, since each antenna group includes 8 transmission antennas, each antenna group transmits a CSI-RS in each transmission interval by using one CSI-RS resource (as indicated by reference numeral 500 of FIG. 5) for 8 ports ... the CSI-RS 510 for massive MIMO, CSI-RSs 520 for non-massive MIMO with respect to all antenna groups are transmitted; also see paras 65-67, In order to transmit the CSI-RSs for massive MIMO as illustrated in FIGS. 5 and 6, an eNB should notify a UE of related control information before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the**

received CSI-RSs by the UE. Such control information may include at least one of the following: Information on the number of antenna groups which configure the CSI-RSs for massive MIMO); or, comprising: ~~receiving first information, wherein the first information is used to determine the first antenna port group~~

Regarding Claims 4, 9, 14 and 19, Kim discloses the method of claim 1, further comprising: transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer **(see paras 65-68, In order to transmit the CSI-RSs for massive MIMO as illustrated in FIGS. 5 and 6, an eNB should notify a UE of related control information before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the received CSI-RSs by the UE. Such control information may include at least one of the following: 1) Information on the number of transmission antennas which configure the CSI-RSs for massive MIMO; 2) Information on the number of antenna groups which configure the CSI-RSs for massive MIMO; 3) Information on the number of transmission antennas which configure each of the antenna groups configuring the CSI-RSs for massive MIMO); or**, ~~transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information~~

~~includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups~~; **or**, ~~transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group~~.

Regarding Claims 5, 10, 15 and 20, Kim discloses the method of claim 1, wherein ~~the first time resource pool is discontinuous in time domain~~; **or** the first signaling is a semi-static signaling **(see para 108, One method capable of reducing the quantity of control information for the second CSI-RS, which should be transmitted through a PDCCH or an E-PDCCH, is to semi-statically set the transmission resources for the second CSI-RS)**; **or** the first signaling is a high layer signaling **(see para 107, The control information is imperative for reception of a second CSI-RS allocated to a UE by the UE… the eNB may notify a corresponding UE of information needed for reception of a second CSI-RS allocated to UEs other than the corresponding UE. The reason why the eNB notifies a UE of information needed for reception of a second CSI-RS allocated to the other UEs is in order to enable the UE to measure the multi-user MIMO interference generated at the time of multi-user MIMO transmission by receiving the second CSI-RS allocated to the other UEs… some**

of the information may be set using a higher layer signaling while only indispensable information is transmitted using a PDCCH or an E-PDCCH); **or** ~~the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs~~; **or** ~~the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common~~; **or** ~~the first signaling is for the UE~~.

Regarding Claim 6, Kim discloses a method for multi-antenna transmitting in a base station, comprising:

transmitting a first radio signal **(see para 55, a method of transmitting a CSI-RS/i.e., a first radio signal transmitted by the base station, for a massive MIMO system by using CSI-RS resources);** and

transmitting a first signaling (**see paras 65-69, In order to transmit the CSI-RSs for massive MIMO/i.e., by the base station, as illustrated in FIGS. 5 and 6, an eNB should notify a UE of related control information/i.e., a first signaling, before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the received CSI-RSs by the UE. Such control information may include at least one of the following: Information on the time and frequency resource positions at which the CSI-RSs for massive MIMO are transmitted, wherein this information includes positions of time and frequency resources at which a CSI-RS for each antenna group is transmitted);**

wherein the first radio signal is collectively transmitted by K antenna port groups **(see FIG. 5. para 60, each antenna group transmits a CSI-RS in each transmission interval by using one CSI-RS resource (as indicated by reference numeral 500 of FIG. 5) for 8 ports; also see FIG. 7, para 83, five beam groups 710 are illustrated, each antenna group includes 8 transmission antennas, and each antenna group transmits CSI-RSs by using one CSI-RS resource 700 for 8 ports/i.e., representing collective transmission by the base station, in each transmission interval);**

the K is a positive integer greater than 1; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups **(see FIG. 5 depicting five antenna port group 510);**

the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use **(see FIG. 5, para 60, since each antenna group includes 8 transmission antennas, each antenna group transmits a CSI-RS in each transmission interval by using one CSI-RS resource/i.e., representing shared use (as indicated by reference numeral 500 of FIG. 5) for 8 ports; also see paras 65-69, In order to transmit the CSI-RSs for massive MIMO as illustrated in FIGS. 5 and 6, an eNB should notify a UE of related control information/i.e., a first signaling, before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the received CSI-RSs by the UE. Such control information may include at least one of the following: Information on the time and frequency resource positions at which the CSI-RSs for massive MIMO are**

transmitted, wherein this information includes positions of time and frequency resources at which a CSI-RS for each antenna group is transmitted);

the first radio signal includes **one or more** of ~~PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block)~~ **or** CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling **(see para 55, a method of transmitting a CSI-RS/i.e., a downlink signal, for a massive MIMO system by using CSI-RS resources)**.

Kim discloses all the above limitations, but does not disclose: a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool.

In the same field of endeavor, Kim* discloses this limitation: **see para 135, FIG. 12, CSI-RSs for M ports among N ports may be UE-specifically and aperiodically transmitted, which is a variation of cell-specific and periodic transmission of the CSI-RSs for N ports in resources corresponding to one CSI-RS configuration … mapping between CSI-RSs of N antenna ports and M UE-specific ports or antenna virtualization may be performed using a transform matrix B of N*M dimensions.**

It would have been obvious, to one having ordinary skill in the art, before the effective filing date of the claimed invention, to modify the system of Kim, so as to use antenna virtualization for mapping CSI-RS for M ports among N ports of the UE in massive MIMO as taught by Kim*, to reduce the overhead of transmitting CSI-RSs **(see Kim*, para 134).**

Regarding Claim 11, Kim discloses a user equipment (UE) for multi-antenna transmission, comprising:

a first transceiver, receiving a first radio signal **(see para 55, a method of transmitting a CSI-RS/i.e., a first radio signal, for a massive MIMO system by using CSI-RS resources);** and

a second receiver, receiving a first signaling (**see paras 65-69, In order to transmit the CSI-RSs for massive MIMO as illustrated in FIGS. 5 and 6, an eNB should notify a UE of related control information/i.e., a first signaling, before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the received CSI-RSs by the UE. Such control information may include at least one of the following: Information on the time and frequency resource positions at which the CSI-RSs for massive MIMO are transmitted, wherein this information includes positions of time and frequency resources at which a CSI-RS for each antenna group is transmitted);**

wherein the first radio signal is collectively transmitted by K antenna port groups; the K is a positive integer greater than 1 **(see FIG. 5. para 60, each antenna group transmits a CSI-RS in each transmission interval by using one CSI-RS resource (as indicated by reference numeral 500 of FIG. 5) for 8 ports; also see FIG. 7, para 83, five beam groups 710 are illustrated, each antenna group includes 8 transmission antennas, and each antenna group transmits CSI-RSs by using one CSI-RS resource 700 for 8 ports in each transmission interval);**

the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups **(see FIG. 5 depicting five antenna port group 510);**

the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use **(see FIG. 5, para 60, since each antenna group includes 8 transmission antennas, each antenna group transmits a CSI-RS in each transmission interval by using one CSI-RS resource/i.e., representing shared use (as indicated by reference numeral 500 of FIG. 5) for 8 ports; also see paras 65-69, In order to transmit the CSI-RSs for massive MIMO as illustrated in FIGS. 5 and 6, an eNB should notify a UE of related control information/i.e., a first signaling, before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the received CSI-RSs by the UE. Such control information may include at least one of the following: Information on the time and frequency resource positions at which the CSI-RSs for massive MIMO are transmitted, wherein this information includes positions of time and frequency resources at which a CSI-RS for each antenna group is transmitted**);

the first radio signal includes **one or more of** ~~PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block)~~ **or** CSI-RS (Channel State Information Reference signal) **(see para 55, a method of transmitting a CSI-RS/i.e., a first radio signal, for a massive MIMO system by using CSI-RS resources)**.

Kim discloses all the above limitations, but does not disclose: a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than 1;

Regarding Claim 16, Kim discloses a base station equipment for multi-antenna transmission, comprising:

a third transceiver, transmitting a first radio signal **(see para 55, a method of transmitting a CSI-RS/i.e., a first radio signal transmitted by the base station, for a massive MIMO system by using CSI-RS resources);** and

a second transmitter, transmitting a first signaling (**see paras 65-69, In order to transmit the CSI-RSs for massive MIMO/i.e., by the base station, as illustrated in FIGS. 5 and 6, an eNB should notify a UE of related control information/i.e., a first signaling, before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the received CSI-RSs by the UE. Such control information may include at least one of the following: Information on the time and frequency resource positions at which the CSI-RSs for massive MIMO are transmitted, wherein this information includes positions of time and frequency resources at which a CSI-RS for each antenna group is transmitted);**

wherein the first radio signal is collectively transmitted by K antenna port groups **(see FIG. 5. para 60, each antenna group transmits a CSI-RS in each transmission interval by using one CSI-RS resource (as indicated by reference numeral 500 of**

FIG. 5) for 8 ports; also see FIG. 7, para 83, five beam groups 710 are illustrated, each antenna group includes 8 transmission antennas, and each antenna group transmits CSI-RSs by using one CSI-RS resource 700 for 8 ports/i.e., representing collective transmission by the base station, in each transmission interval);

the K is a positive integer greater than 1;the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups **(see FIG. 5 depicting five antenna port group 510);**

the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use **(see FIG. 5, para 60, since each antenna group includes 8 transmission antennas, each antenna group transmits a CSI-RS in each transmission interval by using one CSI-RS resource/i.e., representing shared use (as indicated by reference numeral 500 of FIG. 5) for 8 ports; also see paras 65-69, In order to transmit the CSI-RSs for massive MIMO as illustrated in FIGS. 5 and 6, an eNB should notify a UE of related control information/i.e., a first signaling, before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the received CSI-RSs by the UE. Such control information may include at least one of the following: Information on the time and frequency resource positions at which the CSI-RSs for massive MIMO are transmitted, wherein this information includes positions of time and frequency resources at which a CSI-RS for each antenna group is transmitted**);

the first radio signal includes **one or more** ~~of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB~~

~~(System Information Block)~~ or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling **(see para 55, a method of transmitting a CSI-RS/i.e., a downlink signal, for a massive MIMO system by using CSI-RS resources)**.

Kim discloses all the above limitations, but does not disclose: a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool.

In the same field of endeavor, Kim* discloses this limitation: **see para 135, FIG. 12, CSI-RSs for M ports among N ports may be UE-specifically and aperiodically transmitted, which is a variation of cell-specific and periodic transmission of the CSI-RSs for N ports in resources corresponding to one CSI-RS configuration … mapping between CSI-RSs of N antenna ports and M UE-specific ports or antenna virtualization may be performed using a transform matrix B of N*M dimensions.**

It would have been obvious, to one having ordinary skill in the art, before the effective filing date of the claimed invention, to modify the system of Kim, so as to use antenna virtualization for mapping CSI-RS for M ports among N ports of the UE in massive MIMO as taught by Kim*, to reduce the overhead of transmitting CSI-RSs **(see Kim*, para 134).**

Response to Arguments

1. Applicant's arguments with respect to claim(s) 1, 6, 11 and 16 have been considered but are moot because the new ground of rejection does not rely on any

reference applied in the prior rejection of record for any teaching or matter specifically challenged in the argument.

Conclusion

2. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any nonprovisional extension fee (37 CFR 1.17(a)) pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

3. Any inquiry concerning this communication or earlier communications from the examiner should be directed to DEEPA BELUR whose telephone number is (571)270-3722. The examiner can normally be reached M-F 8 am - 4:30 pm.

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

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kevin Bates can be reached at 571-272-3980. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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

/DEEPA BELUR/
Primary Examiner, Art Unit 2472

Notice of References Cited	Application/Control No. 18/089,999	Applicant(s)/Patent Under Reexamination ZHANG, Xiaobo	
	Examiner DEEPA BELUR	Art Unit 2472	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Name	CPC Classification	US Classification
*	A	US-20130182594-A1	2013-07-18	KIM; Youn-Sun	H04L5/0037	370/252
*	B	US-20150162966-A1	2015-06-11	Kim; Kijun	H04L5/0057	370/252
	C					
	D					
	E					
	F					
	G					
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	I					
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	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title, Date, Publisher, Edition or Volume, Pertinent Pages
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in YYYY-MM-DD format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	Art Unit
	DEEPA BELUR	2472

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

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

CLAIM		DATE								
Final	Original	01/10/2024	05/22/2024	11/22/2024	05/21/2025					
	1	✓	✓	✓	✓					
	2	✓	✓	✓	✓					
	3	✓	✓	✓	✓					
	4	✓	✓	✓	✓					
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	19	✓	✓	✓	✓					
	20	✓	✓	✓	✓					

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	**Art Unit**
	DEEPA BELUR	2472

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04L5/005.cpc.	01/10/2024	DB
H04B7/0408.cpc.	01/10/2024	DB
H04B7/0413.cpc.	01/10/2024	DB
H04B7/06.cpc.	01/10/2024	DB
H04B7/0617.cpc.	01/10/2024	DB
H04L1/1819.cpc.	01/10/2024	DB
H04L1/0003.cpc.	01/10/2024	DB
H04L5/0082.cpc.	01/10/2024	DB
H04W88/02.cpc.	01/10/2024	DB

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

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

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

/DEEPA BELUR/ Primary Examiner, Art Unit 2472	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	Art Unit
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Search Notes		
Search Notes	**Date**	**Examiner**
H04L5/005.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/0408.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/0413.cpc.in combination with text search, see search history printout	01/10/2024	DB
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H04B7/0617.cpc.in combination with text search, see search history printout	01/10/2024	DB
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Inventor and Assignee search in PE2E, see search history printout	01/09/2024	DB
NPL search in Chrome, see web search history	01/10/2024	DB
search updated	05/22/2024	DB
search updated	11/22/2024	DB
search updated	05/21/2025	DB
IPR2023-00603; Reviewed Inter Partes Review of U.S. Patent No. US 10944527 on 5/19/2025	05/19/2025	DB
IPR2025-00897; Reviewed Inter Partes Review of U.S. Patent No. 10944527 on 5/20/2025	05/20/2025	DB
IPR2025-00903; Reviewed Inter Partes Review of U.S. Patent No. 10944527 on 5/20/2025	05/20/2025	DB

/DEEPA BELUR/ Primary Examiner, Art Unit 2472	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	Art Unit
	DEEPA BELUR	2472

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

/DEEPA BELUR/ Primary Examiner, Art Unit 2472	

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	5	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2024/01/09 01:51 PM
L2	1198	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/01/09 01:51 PM
L3	477901	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:34 PM
L5	34	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:39 PM
L6	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE,	OR	ON	ON	2024/01/09 02:42 PM

			SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L7	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:51 PM
L8	10	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:39 AM
L9	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:48 AM
L10	14	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2024/01/10 09:48 AM

		near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L11	13	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:49 AM
L12	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:07 AM
L13	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2024/01/10 10:09 AM

			TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L14	2371	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:14 AM
L15	115	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:15 AM
L18	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:19 AM
L19	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2024/01/10 10:21 AM

			HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L20	38	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:22 AM
L21	80	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:49 AM
L22	16	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:38 AM

L23	22	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:39 AM
L24	21	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:41 AM
L25	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:41 AM
L26	28	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2024/01/10 11:42 AM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L27	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L28	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L29	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L30	15	(resource WITH pool)	(US-PGPUB; USPAT;	OR	ON	ON	2024/01/10

		WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				11:44 AM
L31	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 12:45 PM
L32	15	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/01/10 12:48 PM
L34	11	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2024/05/22 08:44 AM

			TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L35	44	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2 OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:35 AM

		US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L36	40	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:35 AM

		A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L37	8	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2024/05/22 09:38 AM
L38	1316	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/05/22 09:38 AM
L39	486671	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L40	35	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L41	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2024/05/22 09:38 AM

		indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L42	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L43	10	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L44	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2024/05/22 09:38 AM

			IBM_TDB)				
L45	14	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L46	13	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L47	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L48	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2024/05/22 09:38 AM

			IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L49	2378	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L50	118	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L51	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L52	2	"41657461".fmid.	(US-PGPUB; USPAT;	OR	ON	ON	2024/05/22

			USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				09:38 AM
L53	39	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L54	85	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L55	16	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH,	OR	ON	ON	2024/05/22 09:38 AM

			TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L56	22	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L57	21	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L58	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L59	28	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2024/05/22 09:38 AM

			CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L60	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L61	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L62	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN,	OR	ON	ON	2024/05/22 09:38 AM

			WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L63	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L64	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L65	15	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/05/22 09:38 AM
L66	11	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2024/05/22 09:38 AM

			IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L67	44	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2 OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:38 AM

		OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L68	40	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:38 AM

		OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L69	13	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2024/11/14 12:35 PM
L70	1469	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/11/14 12:35 PM
L71	515044	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L72	40	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L73	11	(PSS SSS MIB SIB	(US-PGPUB; USPAT;	OR	ON	ON	2024/11/14

		CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				12:35 PM
L74	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L75	11	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L76	45	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL,	OR	ON	ON	2024/11/14 12:35 PM

			PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L77	17	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L78	14	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L79	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L80	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP,	OR	ON	ON	2024/11/14 12:35 PM

			AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L81	2449	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L82	133	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L83	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN,	OR	ON	ON	2024/11/14 12:35 PM

			WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L84	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/14 12:35 PM
L85	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L86	106	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L87	19	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2024/11/14 12:35 PM

		(H04B7/0408).cpc.	IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L88	25	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L89	24	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L90	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM

L91	31	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L92	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L93	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L94	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2024/11/14 12:35 PM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L95	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L96	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L97	18	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/14 12:35 PM
L98	11	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY,	OR	ON	ON	2024/11/14 12:35 PM

			CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L99	50	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2 OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/11/14 12:35 PM

		OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L100	49	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/11/14 12:35 PM

		CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L101	13	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2024/11/14 12:35 PM
L102	1469	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/11/14 12:35 PM
L103	515044	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L104	40	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN,	OR	ON	ON	2024/11/14 12:35 PM

			WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L105	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L106	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L107	11	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L108	45	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA,	OR	ON	ON	2024/11/14 12:35 PM

		receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L109	17	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L110	14	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L111	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO;	OR	ON	ON	2024/11/14 12:35 PM

			JPO; DERWENT; IBM_TDB)				
L112	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/14 12:35 PM
L113	2449	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L114	133	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L115	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV,	OR	ON	ON	2024/11/14 12:35 PM

			MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L116	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/14 12:35 PM
L117	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L118	106	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L119	19	(resource WITH pool) SAME (multi plural$3	(US-PGPUB; USPAT; USOCR; FIT (AP, AT,	OR	ON	ON	2024/11/14 12:35 PM

		many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L120	25	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L121	24	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L122	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE,	OR	ON	ON	2024/11/14 12:35 PM

			SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L123	31	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L124	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L125	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L126	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2024/11/14 12:35 PM

		(H04L5/0082).cpc.	CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L127	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L128	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L129	18	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2024/11/14 12:35 PM

			TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L130	11	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L131	50	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/11/14 12:35 PM

		OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L132	49	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/11/14 12:35 PM

		CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L133	25	"10462767"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 02:41 PM
L134	17	"10944527"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 03:04 PM
L135	8	"20170195100"	(US-PGPUB; USPAT;	OR	ON	ON	2024/11/14

			USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				03:37 PM
L136	18	"10951271"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 04:53 PM
L139	10	"20180262250"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 02:36 PM
L140	48	(Artificial Intelligence) More like doc: US-20180262250-A1 Text: (US-20080080516-A1 OR US-20090080365-A1 OR US-20120127869-A1 OR KR-20130113471-A OR EP-2795827-B1 OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO,	OR	ON	ON	2024/11/19 04:42 PM

		US-9660784-B2 OR US-11546787-B2 OR CN-103490865-B OR CN-104734753-B OR US-9225478-B2 OR US-9912430-B2 OR KR-101988285-B1 OR CN-103684676-B OR CN-103686987-A OR BR-112012033255-A2 OR WO-2014107030-A1 OR US-9936486-B2 OR US-9515711-B2 OR CN-104735691-B OR WO-2015133812-A1).did.	NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L141	48	L140 AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 04:42 PM
L142	16	L140 AND (antenna) near3 (port logical virtuli$6) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 04:44 PM
L143	18	L140 AND (antenna) near3 (port logical virtuli$6 group) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO,	OR	ON	ON	2024/11/19 04:45 PM

			MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L144	5	L140 AND (antenna) near3 (port logical virtuli$6 group) AND (SSB sync$12 near3 signal SSB$1PBCH) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 04:45 PM
L145	41	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (map$4 associat$3) near3 (antenna) near3 (vector)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 04:59 PM
L146	5	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (map$4 associat$3) near3 (antenna) near3 (vector) WITH resource$1	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 04:59 PM
L151	6	"61410780"	(US-PGPUB; USPAT;	OR	ON	ON	2024/11/19

			USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				05:18 PM
L152	12	"20170373743"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/20 09:43 AM
L153	46	(Artificial Intelligence) More like doc: US-20170373743-A1 Text: (EP-2169888-A1 OR US-20100232384-A1 OR KR-101715397-B1 OR KR-101710204-B1 OR KR-20110113542-A OR US-9136997-B2 OR US-8837621-B2 OR US-9270022-B2 OR CN-103391576-B OR US-8913682-B2 OR CN-103687010-B OR US-9918240-B2 OR WO-2014117352-A1 OR WO-2015079726-A1 OR EP-3709697-A1 OR US-20170373743-A1 OR US-10567057-B2 OR KR-101921710-B1 OR US-10944450-B2 OR EP-3169006-B1).did.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/20 04:27 PM
L154	18	L153 AND (resources)	(US-PGPUB; USPAT;	OR	ON	ON	2024/11/20

		WITH (HARQ MCS NDI RS antenna near3 ports)	USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				04:28 PM
L157	176	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing pool common) near3 (resource$1)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/20 05:21 PM
L158	79	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing pool common) near3 (resource$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/20 05:22 PM
L159	53	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing common) near3 (resource$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL,	OR	ON	ON	2024/11/20 05:24 PM

			PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L160	12	"20170373743"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 01:55 PM
L161	2	L160 AND (CSI$RS WITH (resource) near3 (pool group))	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 01:55 PM
L162	53	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing common global) near3 (resource$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 03:40 PM
L163	49	(multi$1antenna mimo) WITH (shared sharing	(US-PGPUB; USPAT; USOCR; FIT (AP, AT,	OR	ON	ON	2024/11/21 03:42 PM

		common global) near3 (resource$1) near3 (pool set$1 collection$1) AND @AD< "20161203"	AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L164	2	"55150266".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/21 03:43 PM
L165	6	"55642279".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/21 03:44 PM
L166	30	(multi$1antenna mimo) WITH (shared sharing global) near3 (resource$1) near3 (pool set$1 collection$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2024/11/21 03:48 PM

			IBM_TDB)				
L167	2	(multi$1antenna mimo) WITH (antenna) near3 (port virtual$7) WITH (shared sharing global) near3 (resource$1) near3 (pool set$1 collection$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 03:59 PM
L168	87	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing pool common) near3 (resource$1 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:05 PM
L169	175	(multi$1antenna mimo) WITH resource WITH pool WITH (shared sharing pool common) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:53 PM
L170	163	(multi$1antenna mimo) WITH (resource near3 pool) WITH (shared sharing pool common) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2024/11/21 04:54 PM

			IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L171	5	((multi$1antenna mimo) WITH (resource near3 pool) WITH (shared sharing pool common) near3 (cell)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:54 PM
L172	20	((multi$1antenna mimo) WITH (time near3 resource near3 pool) WITH (shared sharing pool common)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:56 PM
L173	20	((multi$1antenna mimo) WITH (shared sharing pool common) WITH (time near3 resource near3 pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:57 PM

L174	20	((multi$1antenna mimo) WITH (shared sharing pool common) near3 (time) near3 (resource) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:59 PM
L175	20	(multi$1antenna mimo) WITH ((shared sharing pool common) near3 (time) near3 (resource) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:59 PM
L176	163	(multi$1antenna mimo) WITH ((shared sharing pool common) near3 (resource$1) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 05:00 PM
L177	163	(multi$1antenna mimo) WITH ((resource$1) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2024/11/21 05:00 PM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L178	2812	(multi$1antenna mimo) WITH ((resource$1) near3 (shar$3 common)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 05:00 PM
L179	17	(multi$1antenna mimo) WITH ((resource$1) near3 (shar$3 common) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 05:01 PM
L180	654	(multi$1antenna mimo) WITH ((time) near3 (resource$1) near3 (shar$3 common)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 05:01 PM
L181	23	(multi$1antenna mimo)	(US-PGPUB; USPAT;	OR	ON	ON	2024/11/21

		WITH ((resource$1) near3 (pool) near3 (shar$3 common)) AND @AD< "20161203"	USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				05:03 PM
L182	2	"44888781".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/22 09:57 AM
L183	5	"18089999"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/04/28 08:22 AM
L184	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2025/04/28 08:23 AM

			TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L185	6	"16429077"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/04/28 08:23 AM
L186	26	"10462767"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/19 10:34 AM
L187	31	"20180309496"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/19 11:01 AM
L189	17	"10944527"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2025/05/19 11:12 AM

			CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L190	9	"20130182594"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/19 02:46 PM
L191	28	"20150162966"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/20 08:17 AM
L193	7	"20150199414"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA,	OR	ON	ON	2025/05/20 03:05 PM

			VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L195	23	"2015199414"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/20 03:05 PM
L196	13	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2025/05/21 02:32 PM
L197	1600	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2025/05/21 02:32 PM
L198	528773	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L199	40	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN,	OR	ON	ON	2025/05/21 02:32 PM

			WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L200	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L201	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L202	11	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L203	45	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA,	OR	ON	ON	2025/05/21 02:32 PM

		receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L204	17	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L205	14	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L206	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO;	OR	ON	ON	2025/05/21 02:32 PM

			JPO; DERWENT; IBM_TDB)				
L207	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L208	2449	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L209	137	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L210	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV,	OR	ON	ON	2025/05/21 02:32 PM

			MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L211	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L212	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L213	113	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L214	19	(resource WITH pool) SAME (multi plural$3	(US-PGPUB; USPAT; USOCR; FIT (AP, AT,	OR	ON	ON	2025/05/21 02:32 PM

		many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L215	25	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L216	24	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L217	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE,	OR	ON	ON	2025/05/21 02:32 PM

			SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L218	31	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L219	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L220	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L221	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2025/05/21 02:32 PM

		(H04L5/0082).cpc.	CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L222	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L223	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L224	18	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2025/05/21 02:32 PM

			TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L225	12	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L226	50	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2025/05/21 02:32 PM

		OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L227	49	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2025/05/21 02:32 PM

		CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L228	13	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2025/05/21 02:32 PM
L229	1600	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2025/05/21 02:32 PM
L230	528773	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L231	40	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV,	OR	ON	ON	2025/05/21 02:32 PM

		time) WITH (antenna near5 vector))	MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L232	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L233	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L234	11	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM

L235	45	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L236	17	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L237	14	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L238	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2025/05/21 02:32 PM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L239	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L240	2449	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L241	137	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L242	9	(antenna near5 virtual$7) WITH (resource near4 pool)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2025/05/21 02:32 PM

		AND @AD< "20161203"	CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L243	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L244	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L245	113	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO;	OR	ON	ON	2025/05/21 02:32 PM

			JPO; DERWENT; IBM_TDB)				
L246	19	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L247	25	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L248	24	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L249	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2025/05/21 02:32 PM

			HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L250	31	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L251	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L252	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2025/05/21 02:32 PM

			IBM_TDB)				
L253	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L254	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L255	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L256	18	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2025/05/21 02:32 PM

			IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L257	12	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L258	50	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2025/05/21 02:32 PM

		OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2 OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L259	49	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2025/05/21 02:32 PM

		OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L260	13	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2025/05/21 02:32 PM
L261	1600	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2025/05/21 02:32 PM
L262	528773	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L263	40	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2025/05/21 02:32 PM

		several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L264	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L265	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L266	11	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2025/05/21 02:32 PM

			TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L267	45	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L268	17	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L269	14	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L270	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2025/05/21 02:32 PM

		mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L271	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L272	2449	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L273	137	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2025/05/21 02:32 PM

			IBM_TDB)				
L274	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L275	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L276	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L277	113	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2025/05/21 02:32 PM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L278	19	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L279	25	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L280	24	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L281	18	(resource WITH pool)	(US-PGPUB; USPAT;	OR	ON	ON	2025/05/21

		WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				02:32 PM
L282	31	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L283	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L284	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL,	OR	ON	ON	2025/05/21 02:32 PM

			PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L285	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L286	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L287	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L288	18	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP,	OR	ON	ON	2025/05/21 02:32 PM

			AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L289	12	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L290	50	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2025/05/21 02:32 PM

		B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2 OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L291	49	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2025/05/21 02:32 PM

		A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L292	13	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2025/05/21 02:32 PM
L293	1600	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2025/05/21 02:32 PM
L294	528773	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2025/05/21 02:32 PM

			IBM_TDB)				
L295	40	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L296	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L297	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L298	11	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2025/05/21 02:32 PM

			IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L299	45	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L300	17	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L301	14	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM

L302	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L303	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L304	2449	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L305	137	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO,	OR	ON	ON	2025/05/21 02:32 PM

			RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L306	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L307	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L308	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L309	113	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA,	OR	ON	ON	2025/05/21 02:32 PM

		WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L310	19	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L311	25	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L312	24	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO;	OR	ON	ON	2025/05/21 02:32 PM

			JPO; DERWENT; IBM_TDB)				
L313	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L314	31	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L315	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L316	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2025/05/21 02:32 PM

			HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L317	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L318	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L319	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2025/05/21 02:32 PM

			IBM_TDB)				
L320	18	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L321	12	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L322	50	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2025/05/21 02:32 PM

		OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2 OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L323	49	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2025/05/21 02:32 PM

		OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L324	26	"10462767"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L325	17	"10944527"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2025/05/21 02:32 PM

			CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L326	8	"20170195100"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L327	19	"10951271"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L328	11	"20180262250"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA,	OR	ON	ON	2025/05/21 02:32 PM

			VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L329	47	(Artificial Intelligence) More like doc: US-20180262250-A1 Text: (US-20080080516-A1 OR US-20090080365-A1 OR US-20120127869-A1 OR KR-20130113471-A OR CN-104969637-B OR US-9660784-B2 OR US-11546787-B2 OR KR-102072024-B1 OR US-9225478-B2 OR US-9912430-B2 OR KR-101988285-B1 OR CN-103684676-B OR CN-103686987-A OR WO-2014067543-A1 OR WO-2014107030-A1 OR US-9936486-B2 OR WO-2015016512-A1 OR CN-110545133-B OR US-10020920-B2 OR US-10560858-B2).did.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L330	48	L140 AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L331	16	L140 AND (antenna) near3 (port logical virtuli$6) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2025/05/21 02:32 PM

			TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L332	18	L140 AND (antenna) near3 (port logical virtuli$6 group) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L333	5	L140 AND (antenna) near3 (port logical virtuli$6 group) AND (SSB sync$12 near3 signal SSB$1PBCH) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L334	43	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (map$4 associat$3) near3 (antenna) near3 (vector)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L335	5	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (map$4	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2025/05/21 02:32 PM

		associat$3) near3 (antenna) near3 (vector) WITH resource$1	CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L336	6	"61410780"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L337	12	"20170373743"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L338	47	(Artificial Intelligence) More like doc: US-20170373743-A1 Text: (EP-2169888-A1 OR US-20100232384-A1 OR KR-101715397-B1 OR KR-101710204-B1 OR KR-20110113542-A OR US-9136997-B2 OR US-8837621-B2 OR US-9270022-B2 OR CN-103391576-B OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA,	OR	ON	ON	2025/05/21 02:32 PM

		US-8913682-B2 OR CN-103687010-B OR US-9918240-B2 OR WO-2014117352-A1 OR WO-2015079726-A1 OR EP-3709697-A1 OR US-20170373743-A1 OR US-10567057-B2 OR KR-20180089901-A OR KR-101641187-B1 OR EP-3471318-A1).did.	VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L339	18	L153 AND (resources) WITH (HARQ MCS NDI RS antenna near3 ports)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L340	186	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing pool common) near3 (resource$1)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L341	79	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing pool common) near3 (resource$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN,	OR	ON	ON	2025/05/21 02:32 PM

			WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L342	53	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing common) near3 (resource$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L343	12	"20170373743"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L344	2	L160 AND (CSI$RS WITH (resource) near3 (pool group))	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L345	53	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing common global)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA,	OR	ON	ON	2025/05/21 02:32 PM

		near3 (resource$1) AND @AD< "20161203"	EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L346	49	(multi$1antenna mimo) WITH (shared sharing common global) near3 (resource$1) near3 (pool set$1 collection$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L347	2	"55150266".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L348	6	"55642279".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L349	30	(multi$1antenna mimo)	(US-PGPUB; USPAT;	OR	ON	ON	2025/05/21

		WITH (shared sharing global) near3 (resource$1) near3 (pool set$1 collection$1) AND @AD< "20161203"	USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				02:32 PM
L350	2	(multi$1antenna mimo) WITH (antenna) near3 (port virtual$7) WITH (shared sharing global) near3 (resource$1) near3 (pool set$1 collection$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L351	87	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing pool common) near3 (resource$1 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L352	175	(multi$1antenna mimo) WITH resource WITH pool WITH (shared sharing pool common) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL,	OR	ON	ON	2025/05/21 02:32 PM

			PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L353	163	(multi$1antenna mimo) WITH (resource near3 pool) WITH (shared sharing pool common) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L354	5	((multi$1antenna mimo) WITH (resource near3 pool) WITH (shared sharing pool common) near3 (cell)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L355	20	((multi$1antenna mimo) WITH (time near3 resource near3 pool) WITH (shared sharing pool common)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L356	20	((multi$1antenna mimo) WITH (shared sharing	(US-PGPUB; USPAT; USOCR; FIT (AP, AT,	OR	ON	ON	2025/05/21 02:32 PM

		pool common) WITH (time near3 resource near3 pool)) AND @AD< "20161203"	AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L357	20	((multi$1antenna mimo) WITH (shared sharing pool common) near3 (time) near3 (resource) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L358	20	(multi$1antenna mimo) WITH ((shared sharing pool common) near3 (time) near3 (resource) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L359	163	(multi$1antenna mimo) WITH ((shared sharing pool common) near3 (resource$1) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE,	OR	ON	ON	2025/05/21 02:32 PM

			SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L360	163	(multi$1antenna mimo) WITH ((resource$1) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L361	2820	(multi$1antenna mimo) WITH ((resource$1) near3 (shar$3 common)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L362	17	(multi$1antenna mimo) WITH ((resource$1) near3 (shar$3 common) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L364	23	(multi$1antenna mimo) WITH ((resource$1) near3 (pool) near3	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2025/05/21 02:32 PM

		(shar$3 common)) AND @AD< "20161203"	CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L365	2	"44888781".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2025/05/21 02:32 PM
L366	5	"18089999"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L367	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO;	OR	ON	ON	2025/05/21 02:32 PM

			JPO; DERWENT; IBM_TDB)				
L368	6	"16429077"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L369	26	"10462767"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L370	31	"20180309496"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L371	17	"10944527"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2025/05/21 02:32 PM

			HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L372	9	"20130182594"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L373	28	"20150162966"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM
L374	7	"20150199414"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2025/05/21 02:32 PM

			IBM_TDB)				
L375	23	"2015199414"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2025/05/21 02:32 PM

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

UNITED STATES
PATENT AND TRADEMARK OFFICE

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

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**03/26/2025 09:46:38 AM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	69739484	FILING DATE	12/28/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ZL0205-0002-PCT-US-CON2 NFOAR.pdf	11	Amendment/Request for Reconsideration-After Non-Final Rejection	146 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
ZL0205-0002-PCT-US-CON2 NFOAR.pdf	29DD65EB4D53DF1CAF167DDCC0D21B23FD6824BF272C24B7BD3F16CAFB039CA63DDE639118D8C8AB3EFBB6C22C877CD3D294D4393487373AD5140FBA539567FF

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

New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
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ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**03/26/2025 09:46:38 AM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	69739484	AUTHORIZED BY	-
CUSTOMER #	155075	FILING DATE	12/28/2022
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Xiaobo ZHANG

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
CARD / 9633	**E20253P047009807**	**Jialin Zhong**

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
1251	EXTENSION FOR RESPONSE WITHIN FIRST MONTH, EXCEPT PROVISIONAL APPLICATIONS	235.00	1	235.00
			TOTAL AMOUNT:	**$235.00**

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

New Applications Under 35 U.S.C. 111

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

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

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C.

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

New International Application Filed with the USPTO as a Receiving Office

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

Our Docket No: ZL0205-0002-PCT-US-CON2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	Examiner: DEEPA BELUR
	)	
Xiaobo ZHANG	)	Art Unit: 2472
	)	
Application No: 18/089,999	)	Confirmation No.: 9408
	)	
Filed: December 28, 2022	)	
	)	
For: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	)	

AMENDMENT

E-Filed via EFS-Web
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir/Madam:

In response to the non-final Office action mailed on November 27, 2024, applicant respectfully requests the Examiner to enter the following amendments and to consider the following.

Amendments to the Claims 1-20 are reflected in the listing of claims which begin on page 2 of this document.

Remarks begin on page 9 of this document.

In the claims:

For the Examiner's convenience, all pending claims are presented below with changes shown in accordance with the mandatory amendment format.

What is claimed is:

1. (Currently amended) A method for multi-antenna transmission in a user equipment, comprising:

receiving a first radio signal; and

receiving a first signaling;

wherein the first radio signal is collectively transmitted by K antenna port groups; the K is a positive integer greater than 1; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and ~~the K is a positive integer greater than 1;~~ the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal).

2. (Previously presented) The method of claim 1, further comprising:

receiving a second signaling; and

operating a second radio signal in a first time resource sub-pool;

wherein the operating is one of receiving or transmitting the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; and the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI and (a) transmitting antenna port(s) of the second radio signal.

3. (Original) The method of claim 1, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, comprising:

receiving first information, wherein the first information is used to determine the first antenna port group.

4. (Original) The method of claim 1, further comprising:

transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

5. (Original) The method of claim 1, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

6. (Currently amended) A method for multi-antenna transmitting in a base station, comprising:

transmitting a first radio signal; and

transmitting a first signaling;

wherein the first radio signal is collectively transmitted by K antenna port groups; the K is a positive integer greater than 1; the antenna port group includes a positive integer number of

antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; and ~~the K is a positive integer greater than 1;~~ the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

7. (Previously presented) The method of claim 6, further comprising:

transmitting a second signaling; and

performing a second radio signal in a first time resource sub-pool;

wherein the performing is one of transmitting or receiving the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI and (a) transmitting antenna port(s) of the second radio signal.

8. (Original) The method of claim 6, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, comprising:

transmitting first information, wherein the first information is used to determine the first antenna port group.

9. (Original) The method of claim 6, further comprising:

receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the

first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

10. (Original) The method of claim 6, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

11. (Currently amended) A user equipment (UE) for multi-antenna transmission, comprising:

a first transceiver, receiving a first radio signal; and

a second receiver, receiving a first signaling;

wherein the first radio signal is collectively transmitted by K antenna port groups; the K is a positive integer greater than 1; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and ~~the K is a positive integer greater than 1;~~ the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal).

12. (Previously presented) The UE of claim 11, comprising:

a third receiver, receiving a second signaling; and

a second transceiver, operating a second radio signal in a first time resource sub-pool;

wherein the operating is one of receiving or transmitting the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; and the second signaling is used to determine at least one of occupied frequency domain resources, a MCS, a HARQ process number, a RV, a NDI and (a) transmitting antenna port(s) of the second radio signal.

13. (Original) The UE of claim 11, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, the second receiver further receives first information, wherein the first information is used to determine the first antenna port group.

14. (Original) The UE of claim 11, wherein:

the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

15. (Original) The UE of claim 11, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

16. (Currently amended) A base station equipment for multi-antenna transmission, comprising:

a third transceiver, transmitting a first radio signal; and

a second transmitter, transmitting a first signaling;

wherein the first radio signal is collectively transmitted by K antenna port groups; the K is a positive integer greater than 1; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; and ~~the K is a positive integer greater than 1;~~ the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

17. (Previously presented) The base station equipment of claim 16, further comprising:

a third transmitter, transmitting a second signaling; and

a fourth transceiver, performing a second radio signal in a first time resource sub-pool;

wherein the performing is one of transmitting or receiving the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, a MCS, a HARQ process number, a RV, a NDI and (a) transmitting antenna port(s) of the second radio signal.

18. (Original) The base station equipment of claim 16, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, the second transmitter further transmits first information, wherein the first information is used to determine the first antenna port group.

19. (Original) The base station equipment of claim 16, wherein:

the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

20. (Original) The base station equipment of claim 16, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

REMARKS

Applicant respectfully requests reconsideration of this application. Claims 1, 6, 11, and 16 are amended. No claims have been canceled. No new claims have been added.

Applicant respectfully submits that the amendments to the Claims do not add new matters and respectfully requests the entry of the amendments to the Claims.

Summary of the Office Action

Claims 1-20 are rejected under 35 U.S.C. 103 as unpatentable over US 20170373743 to Park ("Park").

The representative claim 1 as presented recites:

> 1. A method for multi-antenna transmission in a user equipment, comprising:
> receiving a first radio signal; and
> receiving a first signaling;
> wherein ***the first radio signal is collectively transmitted by K antenna port groups; the K is a positive integer greater than 1***; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal). (emphasis added)

Applicant respectfully submits that Park does not disclose or teach features the above-emphasized features recited in claim 1. With respect to "***the first radio signal is collectively transmitted by K antenna port groups***," the Office action refers to Park (at Fig. 18, paras 355-356) as allegedly teaching these features recited in claim 1. See Office action at page 3. The relied-upon portions and relevant portions of Park state as follow:

[0196] In the case where the MIMO antenna is supported, *when the reference signal is transmitted* ***from a specific antenna port***, the reference signal is transmitted to the positions of specific resource elements according to a pattern of the reference signal and not transmitted to the positions of the specific resource elements for another antenna port. That is, *reference signals among different antennas are not duplicated with each other*.

[0355] According to this method, the UE accumulates channel information of vertical and horizontal logical (and physical) antenna ports according to a pattern of antenna ports grouped per subframe upon acquisition of channel information measured for RS transmission from the eNB.

[0356] FIG. 18 illustrates examples of vertical and horizontal antenna port groups to which methods proposed in the present description are applicable. (emphasis added)

As such, according to Park, *the reference signal is transmitted* ***from a specific antenna port***, and *reference signals among different antennas are not duplicated with each other*. In contrast, claim 1 requires that *the first radio signal is* ***collectively transmitted by K antenna port groups; the K is a positive integer greater than 1***. Because claim 1 requires that *the first radio signal is* ***collectively transmitted by K antenna port groups*** where K is greater than 1, claim 1 is distinguishable from Park where *the reference signal is transmitted* ***from a specific antenna port***. Therefore, Park does teach or suggest that *the first radio signal is* ***collectively transmitted by K antenna port groups; the K is a positive integer greater than 1*** recited in claim 1. Therefore, claim 1 as well as its dependent claims is patentable over Park.

Claims 6, 11, and 16 as presented include features similar to claim 1. Therefore, claims 6, 11, and 16 as well as their respective dependent claims are also patentable over Park for the same reasons as claim 1.

The Examiner is requested to call the undersigned at (908) 591-2738 if there remains any issue with allowance of the case.

Please charge any shortage to our Deposit Account No. 60-2313.

Respectfully submitted,

ZHONG LAW, LLC

Date: March 26, 2025

/Jialin Zhong/
Jialin Zhong
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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 18/089,999	Filing Date 12/28/2022	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

	(Column 1)	(Column 2)			
FOR	NUMBER FILED	NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $480 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	03/26/2025	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0		x $200 =	0
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 4	= 0		x $600 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	PSS
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/LINDA A WISE/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/089,999	12/28/2022	Xiaobo ZHANG	ZL0205-0002-PCT-US-CON2	9408

155075 7590 11/27/2024

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EXAMINER	
BELUR, DEEPA	

ART UNIT	PAPER NUMBER
2472	

NOTIFICATION DATE	DELIVERY MODE
11/27/2024	ELECTRONIC

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

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

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

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

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No. 18/089,999	Applicant(s) ZHANG, Xiaobo	
	Examiner DEEPA BELUR	Art Unit 2472	AIA (FITF) Status Yes

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 9/25/2024.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

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

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-20 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-20 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

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

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

2. This action is in response to the RCE filed on 9/25/2024.

3. The Double Patenting rejection has been overcome, as Terminal Disclaimer has been filed and approved on 10/30/2024.

4. Claims 1, 6, 11, 16 are amended.

5. Claims 1-20 have been examined and rejected based on IDS filed on 9/25/2024.

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

7. Claim(s) 1-20 are rejected under 35 U.S.C. 103 as being unpatentable over Park (US20170373743A1 **from IDS**).

Regarding Claim 1, Park discloses a method for multi-antenna transmission in a user equipment, comprising:

receiving a first radio signal **(see para 241, FIG. 15 is a diagram illustrating the CSI-RS configuration in a wireless communication system)**; and

receiving a first signaling **(see para 196, In the case where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements/i.e., the first signaling to indicate resources used by CSI-RS)**;

wherein the first radio signal is collectively transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups **(see FIG. 18, paras 355-356, the UE accumulates channel information of vertical and horizontal logical (and physical) antenna ports according to a pattern of antenna ports grouped per subframe upon acquisition of channel information measured for (reference signal) RS. FIG. 18 illustrates examples of vertical and horizontal antenna port groups)**;

the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use **(see para 196, where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements according to a pattern of the reference signal; also see FIG. 15 (a, b, c), para 247, <u>The CSI-RS for each of the antenna ports is transmitted with being CDM to the same radio resource for each of two antenna ports</u> (i.e., {15,16}, {17,18}, {19,20}, {21,22}). As an example of antenna ports 15 and 16, although the respective CSI-RS complex symbols are the same for antenna ports 15 and 16, the CSI-RS complex symbols are mapped to the same radio resource with being multiplied by different orthogonal codes)**;

a second antenna virtualization vector is associated with the first antenna port group **(see para 196, In the case where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements/i.e., representing time resource pool, according to a pattern of the reference signal and not transmitted to the positions of the specific resource elements for another antenna port. That is, reference signals among different antennas are not duplicated with each other);**

the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool **(see paras 479-481, when the eNB signals specific CSI-RS ports to the UE, the eNB applies the virtualization matrix V to multiple physical antenna elements in advance and signals virtualized CSI-RS ports (or precoded CSI-RS ports) to the UE. Such specific M′ (e.g., M′=4) CSI-RS ports can be grouped and defined as a "CSI-RS configuration 1" and other M′ CSI-RS ports on which virtualization has been performed in a different form can be grouped and defined as a "CSI-RS configuration 2". The eNB transmits the defined "CSI-RS configuration 1" and "CSI-RS configuration 2" to the UE and the UE measures related CSI-RSs on the basis of "CSI-RS configuration 1" and "CSI-RS configuration 2"/i.e., the second virtualization vector; also see para 246, when four CSI-RS antenna ports are configured for transmitting the CSI-RS for a specific cell, the CSI-RS is transmitted on the radio resource according to the configured CSI-RS configuration among ten CSI-RS configurations shown in FIG. 15(*b*). In addition,**

when eight CSI-RS antenna ports are configured for transmitting the CSI-RS for a specific cell, the CSI-RS is transmitted on the radio resource according to the configured CSI-RS configuration among five CSI-RS configurations shown in FIG. 15(*c*).); and

the K is a positive integer greater than 1 **(see para 480, "M" CSI-RS ports**);

the first radio signal includes **one or more of** ~~PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block)~~ **or** CSI-RS (Channel State Information Reference signal) **(see para 241, FIG. 15 is a diagram illustrating the CSI-RS configuration in a wireless communication system).**

Park does not specify a shared resource pool, i.e., Park does not disclose the underlined limitation: "the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use".

However, Park discloses at para 196, where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port and the reference signal is transmitted to the positions of specific resource elements. Further Park discloses at para 247 that the CSI-RS for each of the antenna ports is transmitted with being CDM to the same radio resource for each of two antenna ports by keeping them orthogonal. Therefore, it would have been obvious, to one having ordinary skill in the art, before the effective filing date of the claimed invention, to modify the system of Park, to specify a shared resource pool, since Park already discloses using specific resource elements for transmitting reference signal for MIMO antenna support and using the same radio resource for CSI-RS of different antenna ports.

Regarding Claims 2, 7, 12 and 17, Park discloses: receiving/transmitting a second signaling; and operating a second radio signal in a first time resource sub-pool; wherein the operating is one of receiving or transmitting the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool **(see paras 194-196);** and the second signaling is used to determine **at least one of** occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI and (a) transmitting antenna port(s) of the second radio signal **(see FIG. 8, paras 158-158, The respective HARQ processes are defined by a unique HARQ process identifier of 3 bit size, and individual soft buffer allocation for combination of retransmitted data is required for a reception end (that is, UE at the downlink HARQ process, and eNodeB at the uplink HARQ process). In addition, it is defined that information such as a new data indicator (NDI), a redundancy version (RV) and a modulation and coding scheme (MCS) fields in the downlink control information for the HARQ processes. The NDI field is toggled whenever a new packet transmission is started. The RV field indicates the RV that is selected for a transmission and a retransmission. The MCS field indicates a modulation and coding method level).**

Regarding Claims 3, 8, 13 and 18, Park discloses: the first signaling indicates the first antenna port group from the K antenna port group(s) **(see FIG. 18, paras 355-356, the UE accumulates channel information of vertical and horizontal logical (and physical) antenna ports according to a pattern of antenna ports grouped per**

subframe/i.e., representing the first antenna port group from K antenna port groups per subframe, upon acquisition of channel information measured for (reference signal) RS. FIG. 18 illustrates examples of vertical and horizontal antenna port groups); **or**, ~~comprising: receiving first information, wherein the first information is used to determine the first antenna port group~~.

Regarding Claims 4, 9, 14 and 19, Park discloses: transmitting/receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer **(see FIG. 18, paras 355-356, the UE accumulates channel information of vertical and horizontal logical (and physical) antenna ports according to a pattern of antenna ports grouped per subframe/i.e., representing the first antenna port group from K antenna port groups per subframe, upon acquisition of channel information measured for (reference signal) RS. FIG. 18 illustrates examples of vertical and horizontal antenna port groups)**;; **or**, ~~transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups~~; **or,** ~~transmitting second information, wherein the second information is used to determine~~

~~K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.~~

Regarding Claims 5, 10, 15 and 20, Park discloses: ~~the first time resource pool is discontinuous in time domain~~; **or** the first signaling is a semi-static signaling **(see para 421, For efficient feedback resource/overhead management of a UE, a PMI, a CQI and an RI may be information about the M antenna ports. Alternatively, a method by which the eNB indicates control information related to the PMI, CQI and RI through semi-static signaling (e.g., by RRC) or dynamic indicator (e.g., by DCI) such that they can be flexibly acquired/reported for a specific number of separated antenna ports, L′ (L′≦M), may be applicable.)**; ~~or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.~~

Regarding Claim 6, Park discloses a method for multi-antenna transmitting in a base station, comprising:

transmitting a first radio signal **(see para 241, FIG. 15 is a diagram illustrating the CSI-RS configuration in a wireless communication system)**; and

transmitting a first signaling **(see para 196, In the case where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements/i.e., the first signaling to indicate resources used by CSI-RS)**;

wherein the first radio signal is collectively transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups **(see FIG. 18, paras 355-356, the UE accumulates channel information of vertical and horizontal logical (and physical) antenna ports according to a pattern of antenna ports grouped per subframe upon acquisition of channel information measured for (reference signal) RS. FIG. 18 illustrates examples of vertical and horizontal antenna port groups)**;

the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use **(see para 196, where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements according to a pattern of the reference signal; also see FIG. 15 (a, b, c), para 247, The CSI-RS for each of the antenna ports is transmitted with being CDM to the same radio resource for each of two antenna ports (i.e., {15,16}, {17,18}, {19,20}, {21,22}). As an example of antenna ports 15 and 16, although the respective CSI-RS complex symbols are the same for antenna ports 15 and 16, the CSI-RS complex symbols are mapped to the same radio resource with being multiplied by different orthogonal codes)**;

a second antenna virtualization vector is associated with the first antenna port group **(see para 196, In the case where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements/i.e., representing time resource pool, according to a pattern of the reference signal and not transmitted to the positions of the specific resource elements for another antenna port. That is, reference signals among different antennas are not duplicated with each other);**

the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool **(see paras 479-481, when the eNB signals specific CSI-RS ports to the UE, the eNB applies the virtualization matrix V to multiple physical antenna elements in advance and signals virtualized CSI-RS ports (or precoded CSI-RS ports) to the UE. Such specific M′ (e.g., M′=4) CSI-RS ports can be grouped and defined as a "CSI-RS configuration 1" and other M′ CSI-RS ports on which virtualization has been performed in a different form can be grouped and defined as a "CSI-RS configuration 2". The eNB transmits the defined "CSI-RS configuration 1" and "CSI-RS configuration 2" to the UE and the UE measures related CSI-RSs on the basis of "CSI-RS configuration 1" and "CSI-RS configuration 2"/i.e., the second virtualization vector; also see para 246, when four CSI-RS antenna ports are configured for transmitting the CSI-RS for a specific cell, the CSI-RS is transmitted on the radio resource according to the configured CSI-RS configuration among ten CSI-RS configurations shown in FIG. 15(*b*). In addition,**

when eight CSI-RS antenna ports are configured for transmitting the CSI-RS for a specific cell, the CSI-RS is transmitted on the radio resource according to the configured CSI-RS configuration among five CSI-RS configurations shown in FIG. 15(*c*).); and

the K is a positive integer greater than 1 **(see para 480, "M" CSI-RS ports**);

the first radio signal includes **one or more of** ~~PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block)~~ **or** CSI-RS (Channel State Information Reference signal);

the first signaling is a downlink signaling **(see para 241, FIG. 15 is a diagram illustrating the CSI-RS configuration in a wireless communication system).**

Park does not specify a shared resource pool, i.e., Park does not disclose the underlined limitation: "the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use".

However, Park discloses at para 196, where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port and the reference signal is transmitted to the positions of specific resource elements. Further Park discloses at para 247 that the CSI-RS for each of the antenna ports is transmitted with being CDM to the same radio resource for each of two antenna ports by keeping them orthogonal. Therefore, it would have been obvious, to one having ordinary skill in the art, before the effective filing date of the claimed invention, to modify the system of Park, to specify a shared resource pool, since Park already discloses using specific resource elements for transmitting reference signal for MIMO antenna support and using the same radio resource for CSI-RS of different antenna ports.

Regarding Claim 11, Park discloses a user equipment (UE) **(see FIG. 27, UE)** for multi-antenna transmission, comprising:

a first transceiver, receiving a first radio signal **(see para 241, FIG. 15 is a diagram illustrating the CSI-RS configuration in a wireless communication system)**; and

a second receiver, receiving a first signaling **(see para 196, In the case where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements/i.e., the first signaling to indicate resources used by CSI-RS)**;

the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use **(see para 196, where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements according to a pattern of the reference signal; also see FIG. 15 (a, b, c), para 247, The CSI-RS for each of the antenna ports is transmitted with being CDM to the same radio resource for each of two antenna ports (i.e., {15,16}, {17,18}, {19,20}, {21,22}). As an example of antenna ports 15 and 16, although the respective CSI-RS complex symbols are the same for antenna ports 15 and 16, the CSI-RS complex symbols are mapped to the same radio resource with being multiplied by different orthogonal codes)**;

a second antenna virtualization vector is associated with the first antenna port group **(see para 196, In the case where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements/i.e., representing time resource pool, according to a pattern of the reference signal and not transmitted to the positions of the specific resource elements for another antenna port. That is, reference signals among different antennas are not duplicated with each other);**

the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool **(see paras 479-481, when the eNB signals specific CSI-RS ports to the UE, the eNB applies the virtualization matrix V to multiple physical antenna elements in advance and signals virtualized CSI-RS ports (or precoded CSI-RS ports) to the UE. Such specific M′ (e.g., M′=4) CSI-RS ports can be grouped and defined as a "CSI-RS configuration 1" and other M′ CSI-RS ports on which virtualization has been performed in a different form can be grouped and defined as a "CSI-RS configuration 2". The eNB transmits the defined "CSI-RS configuration 1" and "CSI-RS configuration 2" to the UE and the UE measures related CSI-RSs on the basis of "CSI-RS configuration 1" and "CSI-RS configuration 2"/i.e., the second virtualization vector; also see para 246, when four CSI-RS antenna ports are configured for transmitting the CSI-RS for a specific cell, the CSI-RS is transmitted on the radio resource according to the configured CSI-RS configuration among ten CSI-RS configurations shown in FIG. 15(*b*). In addition,**

when eight CSI-RS antenna ports are configured for transmitting the CSI-RS for a specific cell, the CSI-RS is transmitted on the radio resource according to the configured CSI-RS configuration among five CSI-RS configurations shown in FIG. 15(*c*).); and

the K is a positive integer greater than 1 **(see para 480, "M" CSI-RS ports**);

the first radio signal includes **one or more of** ~~PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block)~~ **or** CSI-RS (Channel State Information Reference signal) **(see para 241, FIG. 15 is a diagram illustrating the CSI-RS configuration in a wireless communication system).**

Park does not specify a shared resource pool, i.e., Park does not disclose the underlined limitation: "the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use".

However, Park discloses at para 196, where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port and the reference signal is transmitted to the positions of specific resource elements. Further Park discloses at para 247 that the CSI-RS for each of the antenna ports is transmitted with being CDM to the same radio resource for each of two antenna ports by keeping them orthogonal. Therefore, it would have been obvious, to one having ordinary skill in the art, before the effective filing date of the claimed invention, to modify the system of Park, to specify a shared resource pool, since Park already discloses using specific resource elements for transmitting reference signal for MIMO antenna support and using the same radio resource for CSI-RS of different antenna ports.

Regarding Claim 16, Park discloses a base station **(see FIG. 27, eNB)** equipment for multi-antenna transmission, comprising:

a third transceiver, transmitting a first radio signal **(see para 241, FIG. 15 is a diagram illustrating the CSI-RS configuration in a wireless communication system)**; and

a second transmitter, transmitting a first signaling **(see para 196, In the case where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements/i.e., the first signaling to indicate resources used by CSI-RS)**;

wherein the first radio signal is collectively transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups **(see FIG. 18, paras 355-356, the UE accumulates channel information of vertical and horizontal logical (and physical) antenna ports according to a pattern of antenna ports grouped per subframe upon acquisition of channel information measured for (reference signal) RS. FIG. 18 illustrates examples of vertical and horizontal antenna port groups)**;

the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use **(see para 196, where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements**

according to a pattern of the reference signal; also see FIG. 15 (a, b, c), para 247, The CSI-RS for each of the antenna ports is transmitted with being CDM to the same radio resource for each of two antenna ports (i.e., {15,16}, {17,18}, {19,20}, {21,22}). As an example of antenna ports 15 and 16, although the respective CSI-RS complex symbols are the same for antenna ports 15 and 16, the CSI-RS complex symbols are mapped to the same radio resource with being multiplied by different orthogonal codes);

a second antenna virtualization vector is associated with the first antenna port group **(see para 196, In the case where the MIMO antenna is supported, when the reference signal is transmitted from a specific antenna port, the reference signal is transmitted to the positions of specific resource elements/i.e., representing time resource pool, according to a pattern of the reference signal and not transmitted to the positions of the specific resource elements for another antenna port. That is, reference signals among different antennas are not duplicated with each other);**

the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool **(see paras 479-481, when the eNB signals specific CSI-RS ports to the UE, the eNB applies the virtualization matrix V to multiple physical antenna elements in advance and signals virtualized CSI-RS ports (or precoded CSI-RS ports) to the UE. Such specific M′ (e.g., M′=4) CSI-RS ports can be grouped and defined as a "CSI-RS configuration 1" and other M′ CSI-RS ports on which virtualization has been performed in a different form can be grouped and defined as a "CSI-RS**

configuration 2". The eNB transmits the defined "CSI-RS configuration 1" and "CSI-RS configuration 2" to the UE and the UE measures related CSI-RSs on the basis of "CSI-RS configuration 1" and "CSI-RS configuration 2"/i.e., the second virtualization vector; also see para 246, when four CSI-RS antenna ports are configured for transmitting the CSI-RS for a specific cell, the CSI-RS is transmitted on the radio resource according to the configured CSI-RS configuration among ten CSI-RS configurations shown in FIG. 15(*b*). In addition, when eight CSI-RS antenna ports are configured for transmitting the CSI-RS for a specific cell, the CSI-RS is transmitted on the radio resource according to the configured CSI-RS configuration among five CSI-RS configurations shown in FIG. 15(*c*).); and

the K is a positive integer greater than 1 **(see para 480, "M" CSI-RS ports**);

the first radio signal includes **one or more of** ~~PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block)~~ **or** CSI-RS (Channel State Information Reference signal);

the first signaling is a downlink signaling **(see para 241, FIG. 15 is a diagram illustrating the CSI-RS configuration in a wireless communication system).**

Park does not specify a shared resource pool, i.e., Park does not disclose the underlined limitation: "the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use".

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Conclusion

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to DEEPA BELUR whose telephone number is (571)270-3722. The examiner can normally be reached M-F 8 am - 4:30 pm.

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

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Meng Vang can be reached on 571-270-7023. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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/DEEPA BELUR/
Primary Examiner, Art Unit 2472

Notice of References Cited	Application/Control No. 18/089,999	Applicant(s)/Patent Under Reexamination ZHANG, Xiaobo	
	Examiner DEEPA BELUR	Art Unit 2472	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Name	CPC Classification	US Classification
*	A	US-20170202014-A1	2017-07-13	MOON; Sung-Hyun	H04B7/0626	1/1
*	B	US-20140328302-A1	2014-11-06	Park; Sungho	H04W72/23	370/329
*	C	US-20060035675-A1	2006-02-16	Karaoguz; Jeyhan	H04B7/0491	455/562.1
*	D	US-20070238420-A1	2007-10-11	Legouable; Rodolphe	H04L1/0625	455/101
	E					
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FOREIGN PATENT DOCUMENTS

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	N					
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	**Art Unit**
	DEEPA BELUR	2472

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04L5/005.cpc.	01/10/2024	DB
H04B7/0408.cpc.	01/10/2024	DB
H04B7/0413.cpc.	01/10/2024	DB
H04B7/06.cpc.	01/10/2024	DB
H04B7/0617.cpc.	01/10/2024	DB
H04L1/1819.cpc.	01/10/2024	DB
H04L1/0003.cpc.	01/10/2024	DB
H04L5/0082.cpc.	01/10/2024	DB
H04W88/02.cpc.	01/10/2024	DB

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

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

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

/DEEPA BELUR/ Primary Examiner, Art Unit 2472	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	Art Unit
	DEEPA BELUR	2472

Search Notes		
Search Notes	**Date**	**Examiner**
H04L5/005.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/0408.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/0413.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/06.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/0617.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04L1/1819.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04L1/0003.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04L5/0082.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04W88/02.cpc.in combination with text search, see search history printout	01/10/2024	DB
Inventor and Assignee search in PE2E, see search history printout	01/09/2024	DB
NPL search in Chrome, see web search history	01/10/2024	DB
search updated	05/22/2024	DB
search updated	11/22/2024	DB

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**

/DEEPA BELUR/ Primary Examiner, Art Unit 2472	

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	Art Unit
	DEEPA BELUR	2472

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

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

CLAIM		DATE								
Final	Original	01/10/2024	05/22/2024	11/22/2024						
	1	✓	✓	✓						
	2	✓	✓	✓						
	3	✓	✓	✓						
	4	✓	✓	✓						
	5	✓	✓	✓						
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	7	✓	✓	✓						
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	18	✓	✓	✓						
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	20	✓	✓	✓						

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	18089999
Filing Date	2022-12-28
First Named Inventor	Xiaobo ZHANG
Art Unit	2472
Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	18089999
	Filing Date	2022-12-28
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2472
	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	1	3GPP TS 36.304 version 14.0.0 release 14, 3rd Generation Partnership Project (3GPP), dated October 3, 2016	☒
	2	3GPP TS 36.304 version 9.1.0 Release 9, 3rd Generation Partnership Project (3GPP), dated February 9, 2010	☒
	3	3GPP TS 36.306 version 14.2.0 release 14, 3rd Generation Partnership Project (3GPP), dated April 11, 2017	☒
	4	3GPP TS 36.321 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 28, 2014	☒
	5	3GPP TS 36.321 version 12.6.0 release 12, 3rd Generation Partnership Project (3GPP), dated June 30, 2015	☒
	6	3GPP TS 36.321 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 4, 2016	☒
	7	3GPP TS 36.321 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	8	3GPP TS 36.321 version 14.3.0 release 14, Project (3GPP) ETSI publication of 3rd Generation, dated July 27, 2017	☒
	9	3GPP TS 36.331 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2014	☒
	10	3GPP TS 36.331 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	11	3GPP TS 36.331 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒

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	12	3GPP TS 36.331 version 13.3.0 release 13, 3rd Generation Partnership Project (3GPP), dated October 3, 2016	☒
	13	3GPP TS 36.331 version 13.5.0 release 13, 3rd Generation Partnership Project (3GPP), dated April 11, 2017	☒
	14	3GPP TS 38.212 version 15.2.0 release 15, 3rd Generation Partnership Project (3GPP), dated June 29, 2018	☒
	15	3GPP TS 38.214 version 15.2.0 release 15, 3rd Generation Partnership Project (3GPP), dated June 29, 2018	☒
	16	3GPP TS 38.306 version 15.5.0 release 15, 3rd Generation Partnership Project (3GPP), dated April 11, 2019	☒
	17	3GPP TS 36.304 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated February 2, 2016	☒
	18	3GPP TS 36.331 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 4, 2016	☒
	19	4G LTE/LTE Advanced for Mobile Broadband, Erik Dahlman, dated 2011	☒
	20	4G LTE/LTE Advanced for Mobile Broadband, Erik Dahlman, dated 2014	☒
	21	1st 5G Algorithm Innovation Competition - Filtered-OFDM, Terasic Inc., dated 2015	☒
	22	A Comparison of Symbol-wise and Self-contained Frame Structure for 5G Services, Mohamed Ibrahim, dated 2016	☒

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	23	Accurate Determination of Transport Block Size for 5G New Radio, Hao Wu, dated April 30, 2020	☒
	24	An Enhanced Multiantenna Solution through Beamforming to 3G Long-term Evolution, Ken Long, dated 2009	☒
	25	Antenna Grouping based Feedback Compression for FDD-based Massive MIMO Systems, Byungju Lee, dated July 21, 2015	☒
	26	Antenna Grouping Techniques for MIMO Beamforming Systems, Kyungchul Kim, dated 2008	☒
	27	Beam Selection Strategies for Orthogonal Random Beamforming in Sparse Networks, Jose Lopez Vicario, dated September 2008	☒
	28	Comparison Between Bit Error Rate And Signal To Noise Ratio in OFDM Using LSE Algorithm, Raghav Pandey, dated 2013	☒
	29	Delay-Prioritized Scheduling (DPS) for Real Time Traffic in 3GPP LTE System, 2010 Kumbesan Sandrasegaran, dated April 2010	☒
	30	Dynamic TDD in LTE Small Cells, Jussi Kerttula, dated 2016	☒
	31	Enabling Massive IoT in 5G and Beyond Systems: PHY Radio Frame Design Considerations, Ayesha Ijaz, dated June 24, 2016	☒
	32	Enhanced Beam Selection for Multiuser MM-Wave massissive MIMO Systems, Jiaxuan Chen, dated July 7, 2016	☒
	33	Filtered-OFDM: Foundational Waveform for Selfadaptive Air Interface, Terasic Inc., dated 2015	☒

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	34	Joint Transmitter- Receiver Beamforming Over Space-Time Fading Channels, T. Zhang, A. Manikas, dated 2007	☒
	35	LTE – The UMTS Long Term Evolution from Theory to Practice, Second Edition, Stefania Sesia, dated 2011	☒
	36	Millimeter Wave Communications for Future Mobile Networks, Ming Xiao, dated May 17, 2017	☒
	37	MIMO Beamforming for High-Bit-Rate Transmission over Frequency-Selective Fading Channels, Huy Hoang Pham, dated 2004	☒
	38	Multibeam Selection for Indoor MIMO Systems: Two Cases of Study, Luis Gurrieri, dated April 2007	☒
	39	Overview of Full- Dimension MIMO in LTE-Advanced Pro, Hyoungju Ji, dated August 10, 2016	☒
	40	Overview of Narrowband IoT in LTE Rel-13, Rapeepat Ratasuk, dated 2016	☒
	41	Novel OFDM transmission scheme to overcome caused by multipath delay longer than cyclic prefix, Chiwoo Lim, dated 2005	☒
	42	R1-130140, ZTE, dated January 28-February 1, 2013 (Meeting dates) January 19, 2013 (Publication)	☒
	43	R1-130269, LG Electronics, dated January 28-February 1, 2013 (Meeting dates) January 18, 2013 (Publication)	☒
	44	R1-144047, LG Electronics, dated October 6-10, 2014 (Meeting dates) September 27, 2014 (Publication)	☒

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	45	R1-150779, LG Electronics, ETRI, InterDigital, Qualcomm, Sony Coorperation, dated February 9-13, 2015 (Meeting dates) February 19, 2015 (Publication)	☒
	46	R1-151365, CATT, dated April 20-24, 2015 (Meeting dates) April 11, 2015 (Publication)	☒
	47	R1-151535, LG Electronics, dated April 20-24, 2015 (Meeting date) April 11, 2015 (Publication)	☒
	48	R1-153175, Ericsson, dated May 25-29, 2015 (Meeting date) May 16, 2015 (Publication)	☒
	49	R1-154127, Samsung, dated August 24-28, 2015 (Meeting date) August 14, 2015 (Publication)	☒
	50	R1-1608671, ZTE, ZTE Microelectronics, dated October 10-14, 2016 (Meeting dates) October 1, 2016 (Publication)	☒

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Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

CERTIFICATION STATEMENT

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

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

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☐ See attached certification statement.

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

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SIGNATURE

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

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2024-09-25
Name/Print	JIALIN ZHONG	Registration Number	62937

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

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	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	1	R1-1609080, Samsung, dated October 10-14, 2016 (Meeting dates) September 30, 2016 (Publication)	☒
	2	R1-1609414, Huawei, HiSilicon, dated October 10-14, 2016 (Meeting dates) October 1, 2016 (Publication)	☒
	3	R1-1609525, Intel Corporation, dated October 10-14, 2016 (Meeting date) October 1, 2016 (Publication)	☒
	4	R1-1609662, Nokia, Alcatel-Lucent Shanghai Bell, dated October 10-14, 2016 (Meeting date) September 30, 2016 (Publication)	☒
	5	R1-1609739, Nokia, Alcatel-Lucent Shanghai Bell, dated October 10-14, 2016 (Meeting dates) October 1, 2016 (Publication)	☒
	6	R1-1610145, Qualcomm, dated October 10-14, 2016 (Meeting date) October 1, 2016 (Publication)	☒
	7	R1-1610239, Nokia, Alcatel-Lucent Shanghai Bell, dated October 10-14, 2016 (Meeting date) September 30, 2016 (Publication)	☒
	8	R1-1611385, CATT, dated November 14-18, 2016 (Meeting date) November 5, 2016 (Publication)	☒
	9	R1-1611387, CATT, dated November 14-18, 2016 (Meeting dates) November 5, 2016 (Publication)	☒
	10	R1-1611415, ZTE, ZTE Microelectronics, dated November 14-18, 2016 (Meeting date) November 5, 2016 (Publication)	☒
	11	R1-1611417, ZTE, ZTE Microelectronics, dated November 14-18, 2016 (Meeting date) November 5, 2016 (Publication)	☒

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	12	R1-1611421, ZTE, ZTE Microelectronics, dated November 14-18, 2016 (Meeting date) November 5, 2016 (Publication)	☒
	13	R1-1612015, Qualcomm, dated November 14-18, 2016 (Meeting dates) November 6, 2016 (Publication)	☒
	14	R1-1612056, Qualcomm, dated November 14-18, 2016 (Meeting dates) November 6, 2016 (Publication)	☒
	15	R1-1612190, CMCC, dated November 14-18, 2016 (Meeting dates) November 6, 2016 (Publication)	☒
	16	R1-1612493, Samsung, dated November 14-18, 2016 (Meeting date) November 4, 2016 (Publication)	☒
	17	R1-1612717, NTT DOCOMO, dated November 14-18, 2016 (Meeting dates) November 5, 2016 (Publication)	☒
	18	R1-1612862, Nokia, Alcatel-Lucent Shanghai Bell, dated November 14-18, 2016 (Meeting date) November 4, 2016 (Publication)	☒
	19	R1-1613589, Samsung, Ericsson, NTT DOCOMO, Intel, Verizon, KT, dated 14-18, 2016 (Meeting dates) November 19, 2016 (Publication)	☒
	20	R1-1613716, ZTE, ZTE Microelectronics, dated November 14-18, 2016 (Meeting date) November 19, 2016 (Publication)	☒
	21	R1-164147, Intel Corporation, dated May 23-27, 2016 (Meeting dates) May 14, 2016 (Publication)	☒
	22	R1-166881, LG Electronics, dated August 22- 26, 2016 (Meeting dates) August 13, 2016 (Publication)	☒

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	23	R1-167028, KT Corp., dated August 22-26, 2016 (Meeting dates) August 12, 2016 (Publication)	☒
	24	R1-167287, Nokia, Alcatel-Lucent Shanghai Bell, dated August 22-26, 2016 (Meeting dates) August 12, 2016 (Publication)	☒
	25	R1-167520, Lenovo, dated August 22-26, 2016 (Meeting dates) August 12, 2016 (Publication)	☒
	26	R1-1700192, CATT, dated January 16-20, 2017 (Meeting dates) January 10, 2017 (Publication)	☒
	27	R1-1700539, Panasonic, January 16-20, 2017 (Meeting dates) January 10, 2017 (Publication)	☒
	28	R1-1700563, Guangdong OPPO Mobile Telecom, dated January 16-20, 2017 (Meeting dates) January 9, 2017 (Publication)	☒
	29	R1-1700703, InterDigital Communications, dated January 16-20, 2017 (Meeting dates) January 10, 2017 (Publication)	☒
	30	R1-1700771, Ericsson, dated January 16-20, 2017 (Meeting dates) January 10, 2017 (Publication)	☒
	31	R1-1701581, ZTE, ZTE Microelectronics, dated January 13-17, 2017 (Meeting dates) February 7, 2017 (Publication)	☒
	32	R1-1701979, NEC, dated February 13-17, 2017 (Meeting date) February 4, 2017 (Publication)	☒
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	34	R1-1704342, AT&T, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	35	R1-1704456, MediaTek Inc., dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	36	R1-1704465, MediaTek Inc., dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	37	R1-1704551, CATT, dated April 3-7, 2017 (Meeting date) March 25, 2017 (Publication)	☒
	38	R1-1704553, CATT, dated April 3-7, 2017 (Meeting date) March 25, 2017 (Publication)	☒
	39	R1-1704618, Guangdong OPPO Mobile Telecom, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	40	R1-1704867, LG Electronics, dated April 3-7, 2017 (Meeting date) March 25, 2017 (Publication)	☒
	41	R1-1705961, Nokia, Alcatel-Lucent Shanghai Bell, dated April 3-7, 2017 (Meeting dates) March 24, 2017 (Publication)	☒
	42	R1-1707475, CATT, dated May 15-19, 2017 (Meeting date) May 6, 2017 (Publication)	☒
	43	R1-1707782, Spreadtrum Communications, dated May 15-19, 2017 (Meeting dates) May 5, 2017 (Publication)	☒
	44	R1-1707830, MediaTek Inc., dated May 15-19, 2017 (Meeting dates) May 7, 2017 (Publication)	☒

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

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

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	18089999
Filing Date	2022-12-28
First Named Inventor	Xiaobo ZHANG
Art Unit	2472
Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

CERTIFICATION STATEMENT

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

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

OR

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

☐ See attached certification statement.

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

☐ A certification statement is not submitted herewith.

SIGNATURE

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

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2024-09-25
Name/Print	JIALIN ZHONG	Registration Number	62937

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

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

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

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

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

PTO/SB/08a (01-10)
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	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	1	R1-1710596, Lenovo, Motorola Mobility, dated June 27-30, 2017 (Meeting dates) June 16, 2017 (Publication)	☒
	2	R1-1710810, MediaTek Inc., dated June 27-30, 2017 (Meeting dates) June 17, 2017 (Publication)	☒
	3	R1-1710871, InterDigital Inc., dated June 20-27, 2017 (Meeting date) June 16, 2017 (Publication)	☒
	4	R1-1711161, Qualcomm Incorporated, dated June 27-30, 2017 (Meeting dates) June 17, 2017 (Publication)	☒
	5	R2-1700902, Ericsson, dated February 13-17, 2017 (Meeting date) February 4, 2017 (Publication)	☒
	6	R2-1701727, Intel Corporation, dated February 13-17, 2017 (Meeting date) February 4, 2017 (Publication)	☒
	7	R2-1702662, Ericsson, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	8	R2-1703344, LG Electronics, dated April 3-7, 2017 (Meeting date) March 24, 2017 (Publication)	☒
	9	R2-1703561, Qualcomm Incorporated, dated April 3-7, 2017 (Meeting dates) March 25, 2017 (Publication)	☒
	10	R2-1706926, Qualcomm Incorporated, dated June 27-29, 2017 (Meeting dates) June 17, 2017 (Publication)	☒
	11	R4-161779, Qualcomm Incorporated, dated April 11-15, 2016 (Meeting date) April 26, 2016 (Publication)	☒

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	12	SINR, RSRP, RSSI and RSRQ Measurements in Long Term Evolution Networks, Farhana Afroz, dated August 2015	☒
	13	Subcarrier Spacing - How to Make Use of This Degree of Freedom, Frank Schaich, dated July 7, 2016	☒
	14	Subcarrier Spacing - How to Make Use of This Degree of Freedom, Frank Schaich, dated July 7, 2016	☒
	15	Waveform and Numerology to Support 5G Services and Requirements, Ali A. Zaidi, dated November 1, 2016	☒
	16	Weight Control Scheme for MIMO System with Multiple Transmit and Receive Beamforming, Yoshitaka Hara, dated 2003	☒
	17	Declaration of Dr. Apostolos Kakaes for IPR2023-00603, Samsung Exhibit 1002, dated Feb 28, 2023	☒
	18	Prosecution History of the US Patent No. 10,944,527 patent, Samsung Exhibit 1003, 438 pages	☒
	19	Ken Long and Wei-ling Wu, “An enhanced multi-antenna solution through beamforming to 3G long-term evolution,” 2009 International Conference on Networks Security, Wireless Communications and Trusted Computing	☒
	20	T. Zhang and A. Manikas, “Joint Transmitter-Receiver Beamforming Over Space-Time Fading Channels,” IEEE International Conference on Communications, 2007	☒
	21	Huy Hoang Pham, Tetsuki Taniguchi, and Yoshio Karasawa, “MIMO Beamforming for High-Bit-Rate Transmission over Frequency- Selective Fading Channels,” Eighth IEEE International Symposium on Spread Spectrum Techniques and Applications, 2004	☒
	22	Yoshitaka Hara, Akinori Taira, and Takashi Sekiguchi, “Weight Control Scheme for MIMO System with Multiple Transmit and Receive Beamforming,” The 57th IEEE Semiannual Vehicular Technology Conference, 2003	☒

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	23	3GPP TS 36.212 v12.2.0: 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; (E-UTRA); Multiplexing and channel coding (Release 12), September 2014	☒
	24	Plaintiff's Disclosure of Asserted Claims and Infringement Contentions, Appendix D,Samsung Exhibit 1022, 37 pages	☒
	25	3GPP TS 36.211 v8.9.0: 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; (E-UTRA); Physical Channels and Modulation (Release 8), December 2009	☒
	26	Apex Beam Technologies LLC v. Samsung Electronics Co. Ltd. et al., No. 2:22-cv-00188-JRG, Dkt. No. 1, Complaint for Patent Infringement, June 1, 2022	☒
	27	Apex Beam Technologies LLC v. Samsung Electronics Co. Ltd. et al., No. 2:22-cv-00031-JRG, Dkt. No. 34-1, Docket Control Order, Feb. 2, 2023	☒
	28	Apex Beam Technologies LLC v. Samsung Electronics Co. Ltd. et al., No. 2:22-cv-00188-JRG, Plaintiff's Infringement Contentions Cover Pleading, Jan. 5, 2023	☒
	29	United States District Courts – National Judicial Caseload Profile, available at https://www.uscourts.gov/sites/default/files/fcms_na_distprofile0630.2022_0.pdf (retrieved Feb. 5, 2023)	☒
	30	U.S. Patent Application Publication No. 2013/028696 to Li et al., published October 31, 2013	☒
	31	3GPP Declaration of Friedhelm Rodermund IN SUPPORT OF A PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 10,944,527, Samsung Exhibit 1030, 47 pages, February 27, 2023	☒
	32	3GPP TSG RAN WG1, R1-1609256, dated Oct 14, 2016 (Publication)	☒
	33	3GPP TSG RAN WG1, R1-1611386, dated Nov 18, 2016 (Publication)	☒

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	34	APEX BEAM TECHNOLOGIES LLC v. ZTE CORPORATION, DEFENDANT'S INVALIDITY CONTENTIONS, Case No. 2:22-cv-00031-JRG-RSP, Apex Beam Exhibit No. 2001, IPR2023-00603, March 2, 2023	☒
	35	SAMSUNG ELECTRONICS CO., LTD., AND SAMSUNG ELECTRONICS AMERICA, INC., v. APEX BEAM TECHNOLOGIES LLC, PETITION FOR INTER PARTES REVIEW, Case IPR2023-00603, February 28, 2023	☒
	36	Decision on invalidation request for CN application number 201611098328.7, Case No. 562088, June 01, 2023,	☒

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

EXAMINER SIGNATURE

Examiner Signature	/DEEPA BELUR/ (11/19/2024)	Date Considered	11/19/2024

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PE2E SEARCH - Search History (Prior Art)

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L1	5	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2024/01/09 01:51 PM
L2	1198	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/01/09 01:51 PM
L3	477901	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:34 PM
L5	34	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:39 PM
L6	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE,	OR	ON	ON	2024/01/09 02:42 PM

			SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L7	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:51 PM
L8	10	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:39 AM
L9	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:48 AM
L10	14	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2024/01/10 09:48 AM

		near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L11	13	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:49 AM
L12	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:07 AM
L13	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2024/01/10 10:09 AM

			TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L14	2371	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:14 AM
L15	115	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:15 AM
L18	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:19 AM
L19	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2024/01/10 10:21 AM

			HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L20	38	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:22 AM
L21	80	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:49 AM
L22	16	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:38 AM

L23	22	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:39 AM
L24	21	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:41 AM
L25	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:41 AM
L26	28	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2024/01/10 11:42 AM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L27	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L28	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L29	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L30	15	(resource WITH pool)	(US-PGPUB; USPAT;	OR	ON	ON	2024/01/10

		WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				11:44 AM
L31	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 12:45 PM
L32	15	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/01/10 12:48 PM
L34	11	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2024/05/22 08:44 AM

			TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L35	44	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2 OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:35 AM

		US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L36	40	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:35 AM

		A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L37	8	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2024/05/22 09:38 AM
L38	1316	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/05/22 09:38 AM
L39	486671	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L40	35	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L41	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2024/05/22 09:38 AM

		indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L42	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L43	10	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L44	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2024/05/22 09:38 AM

			IBM_TDB)				
L45	14	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L46	13	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L47	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L48	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2024/05/22 09:38 AM

			IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L49	2378	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L50	118	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L51	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L52	2	"41657461".fmid.	(US-PGPUB; USPAT;	OR	ON	ON	2024/05/22

			USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				09:38 AM
L53	39	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L54	85	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L55	16	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH,	OR	ON	ON	2024/05/22 09:38 AM

			TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L56	22	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L57	21	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L58	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L59	28	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2024/05/22 09:38 AM

			CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L60	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L61	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L62	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN,	OR	ON	ON	2024/05/22 09:38 AM

			WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L63	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L64	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L65	15	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/05/22 09:38 AM
L66	11	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2024/05/22 09:38 AM

			IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L67	44	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2 OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:38 AM

		OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L68	40	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:38 AM

		OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L69	13	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2024/11/14 12:35 PM
L70	1469	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/11/14 12:35 PM
L71	515044	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L72	40	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L73	11	(PSS SSS MIB SIB	(US-PGPUB; USPAT;	OR	ON	ON	2024/11/14

		CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				12:35 PM
L74	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L75	11	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L76	45	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL,	OR	ON	ON	2024/11/14 12:35 PM

			PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L77	17	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L78	14	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L79	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L80	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP,	OR	ON	ON	2024/11/14 12:35 PM

			AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L81	2449	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L82	133	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L83	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN,	OR	ON	ON	2024/11/14 12:35 PM

			WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L84	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/14 12:35 PM
L85	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L86	106	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L87	19	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2024/11/14 12:35 PM

		(H04B7/0408).cpc.	IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L88	25	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L89	24	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L90	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM

L91	31	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L92	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L93	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L94	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2024/11/14 12:35 PM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L95	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L96	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L97	18	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/14 12:35 PM
L98	11	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY,	OR	ON	ON	2024/11/14 12:35 PM

			CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L99	50	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2 OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/11/14 12:35 PM

		OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L100	49	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/11/14 12:35 PM

		CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L101	13	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2024/11/14 12:35 PM
L102	1469	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/11/14 12:35 PM
L103	515044	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L104	40	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN,	OR	ON	ON	2024/11/14 12:35 PM

			WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L105	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L106	11	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L107	11	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L108	45	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA,	OR	ON	ON	2024/11/14 12:35 PM

		receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L109	17	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L110	14	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L111	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO;	OR	ON	ON	2024/11/14 12:35 PM

			JPO; DERWENT; IBM_TDB)				
L112	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/14 12:35 PM
L113	2449	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L114	133	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L115	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV,	OR	ON	ON	2024/11/14 12:35 PM

			MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L116	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/14 12:35 PM
L117	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L118	106	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L119	19	(resource WITH pool) SAME (multi plural$3	(US-PGPUB; USPAT; USOCR; FIT (AP, AT,	OR	ON	ON	2024/11/14 12:35 PM

		many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L120	25	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L121	24	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L122	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE,	OR	ON	ON	2024/11/14 12:35 PM

			SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L123	31	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L124	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L125	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L126	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2024/11/14 12:35 PM

		(H04L5/0082).cpc.	CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L127	18	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L128	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L129	18	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2024/11/14 12:35 PM

			TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L130	11	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 12:35 PM
L131	50	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/11/14 12:35 PM

		OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L132	49	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/11/14 12:35 PM

		CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L133	25	"10462767"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 02:41 PM
L134	17	"10944527"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 03:04 PM
L135	8	"20170195100"	(US-PGPUB; USPAT;	OR	ON	ON	2024/11/14

			USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				03:37 PM
L136	18	"10951271"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/14 04:53 PM
L139	10	"20180262250"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 02:36 PM
L140	48	(Artificial Intelligence) More like doc: US-20180262250-A1 Text: (US-20080080516-A1 OR US-20090080365-A1 OR US-20120127869-A1 OR KR-20130113471-A OR EP-2795827-B1 OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO,	OR	ON	ON	2024/11/19 04:42 PM

		US-9660784-B2 OR US-11546787-B2 OR CN-103490865-B OR CN-104734753-B OR US-9225478-B2 OR US-9912430-B2 OR KR-101988285-B1 OR CN-103684676-B OR CN-103686987-A OR BR-112012033255-A2 OR WO-2014107030-A1 OR US-9936486-B2 OR US-9515711-B2 OR CN-104735691-B OR WO-2015133812-A1).did.	NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L141	48	L140 AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 04:42 PM
L142	16	L140 AND (antenna) near3 (port logical virtuli$6) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 04:44 PM
L143	18	L140 AND (antenna) near3 (port logical virtuli$6 group) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO,	OR	ON	ON	2024/11/19 04:45 PM

			MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L144	5	L140 AND (antenna) near3 (port logical virtuli$6 group) AND (SSB sync$12 near3 signal SSB$1PBCH) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 04:45 PM
L145	41	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (map$4 associat$3) near3 (antenna) near3 (vector)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 04:59 PM
L146	5	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (map$4 associat$3) near3 (antenna) near3 (vector) WITH resource$1	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/19 04:59 PM
L151	6	"61410780"	(US-PGPUB; USPAT;	OR	ON	ON	2024/11/19

			USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				05:18 PM
L152	12	"20170373743"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/20 09:43 AM
L153	46	(Artificial Intelligence) More like doc: US-20170373743-A1 Text: (EP-2169888-A1 OR US-20100232384-A1 OR KR-101715397-B1 OR KR-101710204-B1 OR KR-20110113542-A OR US-9136997-B2 OR US-8837621-B2 OR US-9270022-B2 OR CN-103391576-B OR US-8913682-B2 OR CN-103687010-B OR US-9918240-B2 OR WO-2014117352-A1 OR WO-2015079726-A1 OR EP-3709697-A1 OR US-20170373743-A1 OR US-10567057-B2 OR KR-101921710-B1 OR US-10944450-B2 OR EP-3169006-B1).did.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/20 04:27 PM
L154	18	L153 AND (resources)	(US-PGPUB; USPAT;	OR	ON	ON	2024/11/20

		WITH (HARQ MCS NDI RS antenna near3 ports)	USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				04:28 PM
L157	176	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing pool common) near3 (resource$1)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/20 05:21 PM
L158	79	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing pool common) near3 (resource$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/20 05:22 PM
L159	53	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing common) near3 (resource$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL,	OR	ON	ON	2024/11/20 05:24 PM

			PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L160	12	"20170373743"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 01:55 PM
L161	2	L160 AND (CSI$RS WITH (resource) near3 (pool group))	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 01:55 PM
L162	53	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing common global) near3 (resource$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 03:40 PM
L163	49	(multi$1antenna mimo) WITH (shared sharing	(US-PGPUB; USPAT; USOCR; FIT (AP, AT,	OR	ON	ON	2024/11/21 03:42 PM

		common global) near3 (resource$1) near3 (pool set$1 collection$1) AND @AD< "20161203"	AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L164	2	"55150266".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/21 03:43 PM
L165	6	"55642279".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/21 03:44 PM
L166	30	(multi$1antenna mimo) WITH (shared sharing global) near3 (resource$1) near3 (pool set$1 collection$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2024/11/21 03:48 PM

			IBM_TDB)				
L167	2	(multi$1antenna mimo) WITH (antenna) near3 (port virtual$7) WITH (shared sharing global) near3 (resource$1) near3 (pool set$1 collection$1) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 03:59 PM
L168	87	(multi$1antenna mimo) WITH (antenna) near3 (port group logical virtuli$6) WITH (shared sharing pool common) near3 (resource$1 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:05 PM
L169	175	(multi$1antenna mimo) WITH resource WITH pool WITH (shared sharing pool common) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:53 PM
L170	163	(multi$1antenna mimo) WITH (resource near3 pool) WITH (shared sharing pool common) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2024/11/21 04:54 PM

			IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L171	5	((multi$1antenna mimo) WITH (resource near3 pool) WITH (shared sharing pool common) near3 (cell)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:54 PM
L172	20	((multi$1antenna mimo) WITH (time near3 resource near3 pool) WITH (shared sharing pool common)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:56 PM
L173	20	((multi$1antenna mimo) WITH (shared sharing pool common) WITH (time near3 resource near3 pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:57 PM

L174	20	((multi$1antenna mimo) WITH (shared sharing pool common) near3 (time) near3 (resource) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:59 PM
L175	20	(multi$1antenna mimo) WITH ((shared sharing pool common) near3 (time) near3 (resource) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 04:59 PM
L176	163	(multi$1antenna mimo) WITH ((shared sharing pool common) near3 (resource$1) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 05:00 PM
L177	163	(multi$1antenna mimo) WITH ((resource$1) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2024/11/21 05:00 PM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L178	2812	(multi$1antenna mimo) WITH ((resource$1) near3 (shar$3 common)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 05:00 PM
L179	17	(multi$1antenna mimo) WITH ((resource$1) near3 (shar$3 common) near3 (pool)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 05:01 PM
L180	654	(multi$1antenna mimo) WITH ((time) near3 (resource$1) near3 (shar$3 common)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/11/21 05:01 PM
L181	23	(multi$1antenna mimo)	(US-PGPUB; USPAT;	OR	ON	ON	2024/11/21

		WITH ((resource$1) near3 (pool) near3 (shar$3 common)) AND @AD< "20161203"	USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				05:03 PM
L182	2	"44888781".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/11/22 09:57 AM

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

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

PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	18089999
Filing Date	2022-12-28
First Named Inventor	Xiaobo ZHANG
Art Unit	2472
Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

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

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

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

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

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	42	10790953	B2	2020-09-29	Kijun KIM	
	43	10972974	B2	2021-04-06	Gang Xiong	
	44	11026217	B2	2021-06-01	Hyukjin Chae	
	45	11044744	B2	2021-06-22	Yuxin Wang	
	46	11088747	B2	2021-08-10	Muhammad Nazmul Islam	
	47	11088749	B2	2021-08-10	Wenting Chang	
	48	11139933	B2	2021-10-05	Ming Xu	
	49	11159213	B2	2021-10-26	Yushu Zhang	
	50	11223394	B2	2022-01-11	Moon-Il Lee	
	51	11265901	B2	2022-03-01	Martino M. Freda	
	52	11310764	B2	2022-04-19	Eunsun Kim	

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	53	11419173	B2	2022-08-16	Yugeswar DEENOO	
	54	10548129	B2	2020-01-28	FWU JONG-KAE	
	55	11233557	B2	2022-01-25	LEE MOON-IL	
	56	10432441	B2	2019-10-01	PAPASAKELLARIOU ARIS	
	57	11310764	B2	2022-04-19	KIM EUNSUN	
	58	10461994	B2	2019-10-29	LIU BIN	
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	60	10944527	B2	2019-09-19	Xiaobo Zhang	

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	2	20060164981	A1	2006-07-27	Patrik Olsson	
	3	20100039970	A1	2010-02-18	Aris Papasakellariou	
	4	20100202382	A1	2010-08-12	Sung Jun Park	
	5	20100202560	A1	2013-08-06	Xiliang Luo	
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	9	20110286420	A1	2011-11-24	Hee Jeong CHO	
	10	20120122495	A1	2012-05-17	Jianfeng Weng	
	11	20120257515	A1	2012-10-11	Klaus Hugl	
	12	20120314711	A1	2012-12-13	Jason A. Trachewsky	

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	13	20130083753	A1	2013-04-04	Moon-Il Lee	
	14	20130148515	A1	2013-06-13	Cássio Barboza Ribeiro	
	15	20130182594	A1	2013-07-18	Youn-Sun Kim	
	16	20130195067	A1	2013-08-01	Ahmad Khoshnevis	
	17	20130286960	A1	2013-10-31	Ying Li	
	18	20130301562	A1	2013-11-14	Pei-Kai Liao	
	19	20130308608	A1	2013-11-21	Jun Hu	
	20	20140036806	A1	2014-02-06	Wanshi Chen	
	21	20140140435	A1	2014-05-22	Jiayin Zhang	
	22	20140192917	A1	2014-07-10	Young-Han Nam	
	23	20140211656	A1	2014-07-31	Yang Hu	

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	24	20150003343	A1	2015-01-01	Yang Li	
	25	20150009968	A1	2015-01-08	Hyun-Kyu Yu	
	26	20150036612	A1	2015-02-05	Kijun KIM	
	27	20150055555	A1	2015-02-26	Hyungtae Kim	
	28	20150063287	A1	2015-03-05	David Mazzarese	
	29	20150141026	A1	2015-05-21	Roger Piqueras Jover	
	30	20150195025	A1	2015-07-09	Jiwon Kang	
	31	20150230102	A1	2015-08-13	Jiwon Kang	
	32	20150282070	A1	2015-10-01	Mohamed Salem	
	33	20150341093	A1	2015-11-26	Hyoungju Jl	
	34	20150358060	A1	2015-12-10	Jonghyun Park	

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	35	20150358848	A1	2015-12-10	Bonghoe Kim	
	36	20160080052	A1	2016-03-17	Yang Li	
	37	20160105265	A1	2016-04-14	Jianguo Wang	
	38	20160112099	A1	2016-04-21	Kilbom LEE	
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	40	20160182137	A1	2016-06-23	Eko Onggosanusi	
	41	20160183228	A1	2016-06-23	Young Seog SONG	
	42	20160211902	A1	2016-07-21	Jonghyun Park	
	43	20160277092	A1	2016-09-22	Zhouyue Pi	
	44	20160323028	A1	2016-11-03	Qian Cheng	
	45	20170070277	A1	2017-03-09	Hongbo Si	

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	46	20170085303	A1	2017-03-23	Yijian Chen	
	47	20170086195	A1	2017-03-23	Kunil YUM	
	48	20170094547	A1	2017-03-30	Kunil YUM	
	49	20170150480	A1	2017-05-25	Donghan KIM	
	50	20170207843	A1	2017-07-20	Byounghoon JUNG	
	51	20170215170	A1	2017-07-27	Toufiqul Islam	
	52	20170230994	A1	2017-08-10	Hyangsun You	
	53	20170237478	A1	2017-08-17	Youngwoo KwaK	
	54	20170288743	A1	2017-10-05	Young-Han Nam	
	55	20170331670	A1	2017-11-16	Stefan Parkvall	
	56	20170339667	A1	2017-11-23	Xingya SHEN	

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	57	20170373743	A1	2017-12-28	Jonghyun Park	
	58	20180007574	A1	2018-01-04	Jonghyun Park	
	59	20180007673	A1	2018-01-04	Jong-Kae Fwu	
	60	20180034525	A1	2018-02-01	Jonghyun Park	
	61	20180054290	A1	2018-02-22	Haewook Park	
	62	20180054348	A1	2018-02-22	Tao Luo	
	63	20180054790	A1	2018-02-22	Muhammad Nazmul Islam	
	64	20180054800	A1	2018-02-22	Jeongho Yeo	
	65	20180083680	A1	2018-03-22	Li Guo	
	66	20180092139	A1	2018-03-29	Thomas David Novlan	
	67	20180098234	A1	2018-04-05	Kijun KIM	

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	68	20180110074	A1	2018-04-19	Sony Akkarakaran	
	69	20180192443	A1	2018-07-05	Thomas Novlan	
	70	20180227156	A1	2018-08-09	Aris Papasakellariou	
	71	20180241454	A1	2018-08-23	Keon-Kook LEE	
	72	20180254867	A1	2018-09-06	Kijun KIM	
	73	20180294859	A1	2018-10-11	Huaning Niu	
	74	20180310283	A1	2018-10-25	Yugeswar DEENOO	
	75	20180310322	A1	2018-10-25	Xi Zhang	
	76	20180323842	A1	2018-11-08	Milap Majmundar	
	77	20180324780	A1	2018-11-08	Thomas Novlan	
	78	20180324843	A1	2018-11-08	Namjeong LEE	

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	79	20180324865	A1	2018-11-08	Bing HUI	
	80	20180332605	A1	2018-11-15	Ghyslain Pelletier	
	81	20180367203	A1	2018-12-20	Andreas Nilsson	
	82	20180367374	A1	2018-12-20	Bin Liu	
	83	20180368009	A1	2018-12-20	Pengfei Xia	
	84	20180375556	A1	2018-12-27	Xiaoyi Wang	
	85	20190028162	A1	2019-01-24	Hyunho Lee	
	86	20190052337	A1	2019-02-14	Young Hoon Kwon	
	87	20190053294	A1	2019-02-14	Pengfei Xia	
	88	20190075582	A1	2019-03-07	Cheulsoon KIM	
	89	20190081688	A1	2019-03-14	Yugeswar DEENOO	

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	90	20190081832	A1	2019-03-14	Paul Marinier	
	91	20190116611	A1	2019-04-18	Hyunho Lee	
	92	20190182821	A1	2019-06-13	Hyangsun You	
	93	20190182856	A1	2019-06-13	Hideyuki Moroga	
	94	20190229777	A1	2019-07-25	Peng Guan	
	95	20190281639	A1	2019-09-12	Ning Yang	
	96	20190319686	A1	2019-10-17	Wei CHEN	
	97	20190349915	A1	2019-11-14	Minki AHN	
	98	20190387501	A1	2019-12-19	Jonghyun Park	
	99	20200014453	A1	2020-01-09	Kazuaki Takeda	
	100	20200022119	A1	2020-01-16	Ting Wang	

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	101	20200028609	A1	2020-01-23	Minki AHN	
	102	20200059958	A1	2020-02-20	Runhua Chen	
	103	20200076492	A1	2020-03-05	Lianhai Wu	
	104	20200099437	A1	2020-03-26	Hiroki Harada	
	105	20200099499	A1	2020-03-26	Jeongho Yeo	
	106	20200186218	A1	2020-06-11	Lianhai Wu	
	107	20200374960	A1	2020-11-26	Yugeswar DEENOO	
	108	20200389220	A1	2020-12-10	Jiwon Kang	
	109	20210204346	A1	2021-07-01	Chunxuan Ye	
	110	20210235479	A1	2021-07-29	Hai Tang	
	111	20220061025	A1	2022-02-24	Tao Deng	

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	112	20170339667	A1	2017-11-23	Xingya SHEN	
	113	20220061025	A1	2022-02-24	Tao Deng	
	114	20170207843	A1	2017-07-20	Byounghoon JUNG	
	115	20190281639	A1	2019-09-12	Ning Yang	
	116	20150009968	A1	2015-01-08	Hyun-Kyu Yu	
	117	20160323028	A1	2016-11-03	Qian Cheng	
	118	20100039970	A1	2010-02-18	Aris Papasakellariou	
	119	20120314711	A1	2012-12-13	Jason A. Trachewsky	
	120	20190182821	A1	2019-06-13	Hyangsun You	
	121	20180227156	A1	2018-08-09	Aris Papasakellariou	
	122	20110096856	A1	2011-04-28	John S. Sadowsky	

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	123	20180054290	A1	2018-02-22	Haewook Park	
	124	20130286960	A1	2013-10-31	Ying Li	
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	134	20160183228	A1	2016-06-23	Young Seog SONG	
	135	20200099499	A1	2020-03-26	Jeongho Yeo	
	136	20190053294	A1	2019-02-14	Pengfei Xia	
	137	20150141026	A1	2015-05-21	Roger Piqueras Jover	
	138	20180367374	A1	2018-12-20	Bin Liu	
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	140	20130182594	A1	2013-07-18	Youn-Sun Kim	
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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	2712228	EP		2014-03-26	Chen et al.		☒
	2	2996378	EP		2016-03-16	Wang et al.		☒
	3	110062398	CN		2020-07-24	Guan et al.		☒
	4	108809488	CN		2018-11-13	Chen et al.		☒
	5	108633047	CN		2018-10-09	Wang et al.		☒
	6	20130130593	KR		2013-12-02	Kim et al.		☒
	7	2014074894	WO		2014-05-15	Lou et al.		☒

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	18089999
	Filing Date	2022-12-28
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2472
	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	8	2014158255	WO		2014-10-02	Li et al.		☒
	9	2014201638	WO		2014-12-24	Wang et al.		☒
	10	2015113664	WO		2015-08-06	Webb et al.		☒
	11	2015131494	WO		2015-09-11	Chen et al.		☒
	12	2015199414	WO		2015-12-30	Zhang et al.		☒
	13	2016126099	WO		2016-08-11	Park et al.		☒
	14	2016015307	WO		2016-02-04	Liu et al.		☒
	15	2016025899	WO		2016-02-18	Stern-Berkowitz et al.		☒
	16	2016122232	WO		2016-04-08	Park et al.		☒
	17	2016130175	WO		2016-08-18	Fwu et al.		☒
	18	2016136143	WO		2016-09-01	Basu Mallick et al.		☒

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	19	2017/023352	WO		2017-02-09	Xiong et al.		☒
	20	2017/024516	WO		2017-02-16	Lu et al.		☒
	21	2017/026983	WO		2017-02-16	Khoryaev et al.		☒
	22	2017/052199	WO		2017-03-30	You et al.		☒
	23	2017/079530	WO		2017-05-11	Pelletier		☒
	24	2017/079574	WO		2017-05-11	Lee et al.		☒
	25	2017/083489	WO		2017-05-18	Lee et al.		☒
	26	2017/083514	WO		2017-05-18	Deenoo et al.		☒
	27	2017/084235	WO		2017-05-26	Zhang et al.		☒
	28	2017/171398	WO		2017-10-05	Yi et al.		☒
	29	2017/174469	WO		2017-10-12	Wong et al.		☒

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	30	2018/081913	WO		2018-05-11	Liu et al.		☒
	31	2018/126401	WO		2018-07-12	Liu et al.		☒
	32	2018/175809	WO		2018-09-27	Dinan et al.		☒
	33	2018/201861	WO		2018-11-08	Chen et al.		☒
	34	2018/202178	WO		2018-11-08	Guan et al.		☒
	35	2018/227464	WO		2018-12-20	Wu et al.		☒
	36	108155923	CN		2018-06-12	Xiaobo Zhang		☒
	37	108111198	CN		2018-06-01	Xiaobo Zhang		☒
	38	104620551	CN		2015-05-13	LI et al.		☒
	39	2015166840	WO		2015-11-05	KISHIYAMA YOSHIHISA		☒
	40	2015113205	WO		2015-08-06	ZHANG et al.		☒

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	1	3G Evolution: HSPA and LTE for Mobile Broadband, 2007, Erik Dahlman, Stefan Parkvall, Johan Skold, Per Beming dated	☒
	2	3GPP TR 25.892 version 6.0.0 release 6, June 28, 2004, 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	3	3GPP TR 36.873 version 12.2.0 release 12, July 3, 2015 , 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	4	3GPP TR 36.897 version 13.0.0 release 13, July 3, 2015 , 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	5	3GPP TR 37.840 version 12.1.0 release 12, January 6, 2014, 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	6	3GPP TR 38.802 version 1.2.0 release 14, March 1, 2017, 3rd Generation Partnership Project (3GPP) 3rd Generation	☒
	7	3GPP TR 38.802 version 14.0.0 release 14, March 25, 2017, 3rd Generation Partnership Project (3GPP) Author(s)	☒
	8	3GPP TS 36.133 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 9, 2015	☒
	9	3GPP TS 36.133 version 13.2.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 8, 2016	☒

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	10	3GPP TS 36.211 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 2, 2014	☒
	11	3GPP TS 36.211 version 12.5.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 16, 2015	☒
	12	3GPP TS 36.211 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 26, 2016	☒
	13	3GPP TS 36.211 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	14	3GPP TS 36.211 version 13.2.0 release 13, 3rd Generation Partnership Project (3GPP), dated August 24, 2016	☒
	15	3GPP TS 36.211 version 14.2.0 release 14, 3rd Generation Partnership Project (3GPP), dated April 18, 2017	☒
	16	3GPP TS 36.211 version 8.9.0 release 8, 3rd Generation Partnership Project (3GPP), dated December 9, 2009	☒
	17	3GPP TS 36.211 version 11.3.0 release 11, 3rd Generation Partnership Project (3GPP), dated June 26, 2013	☒
	18	3GPP TS 36.211 version 12.5.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 16, 2015	☒
	19	3GPP TS 36.211 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 5, 2016	☒
	20	3GPP TS 36.212 version 12.2.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 23, 2014	☒

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	21	3GPP TS 36.212 version 12.2.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 2, 2014	☒
	22	3GPP TS 36.212 version 12.4.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 18, 2015	☒
	23	3GPP TS 36.212 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 27, 2016	☒
	24	3GPP TS 36.212 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated March 27, 2016	☒
	25	3GPP TS 36.212 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated April 22, 2016	☒
	26	3GPP TS 36.212 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 5, 2016	☒
	27	3GPP TS 36.212 version 13.3.0 release 13, 3rd Generation Partnership Project (3GPP), dated September 29, 2016	☒
	28	3GPP TS 36.212 version 14.2.0 release 14, 3rd Generation Partnership Project (3GPP), dated April 11, 2017	☒
	29	3GPP TS 36.213 version 12.11.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2016	☒
	30	3GPP TS 36.213 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 2, 2014	☒
	31	3GPP TS 36.213 version 12.8.0 release 12, Project (3GPP) ETSI publication of 3rd Generation, dated May 3, 2016	☒

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	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	32	3GPP TS 36.213 version 12.8.0 release 12 Annex A, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	33	3GPP TS 36.213 version 12.8.0 release 12, Cover, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	34	3GPP TS 36.213 version 12.8.0 release 12, Section 14, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	35	3GPP TS 36.213 version 12.8.0 release 12, Sections 0-9, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	36	3GPP TS 36.213 version 12.8.0 release 12, Sections 10-13, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒
	37	3GPP TS 36.213 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 5, 2016	☒
	38	3GPP TS 36.213 version 13.2.0 release 13, 3rd Generation Partnership Project (3GPP), dated August 5, 2016	☒
	39	3GPP TS 36.214 version 12.0.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 2, 2014	☒
	40	3GPP TS 36.214 version 12.2.0 release 12, 3rd Generation Partnership Project (3GPP), dated April 24, 2015	☒
	41	3GPP TS 36.214 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated December 15, 2015	☒
	42	3GPP TS 36.300 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2014	☒

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	43	3GPP TS 36.300 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 4, 2016	☒
	44	3GPP TS 36.300 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	45	3GPP TS 36.300 version 14.3.0 release 14, Project (3GPP) ETSI publication of 3rd Generation, dated July 27, 2017	☒
	46	3GPP TS 36.302 version 12.1.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2014	☒
	47	3GPP TS 36.302 version 12.6.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	48	3GPP TS 36.304 version 12.2.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2014	☒
	49	3GPP TS 36.304 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated August 25, 2016	☒
	50	3GPP TS 36.304 version 12.8.0 release 12, Project (3GPP) 3rd Generation Partnership, dated July 1, 2016	☒

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CERTIFICATION STATEMENT

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Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2024-09-25
Name/Print	JIALIN ZHONG	Registration Number	62937

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	1	Search report received for CN Application No. 2020103207517, dated September 9, 2024.	☒

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

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

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

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

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

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

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

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

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

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

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

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

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	18089999
Filing Date	2022-12-28
First Named Inventor	Xiaobo ZHANG
Art Unit	2472
Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	18089999
	Filing Date	2022-12-28
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2472
	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	1	Administrative Judgment of the Beijing Intellectual Property Court of the People's Republic of China, (2023) Jing 73 Hang Chu No. 18545, dated September 25, 2024.	☒

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EXAMINER SIGNATURE

Examiner Signature	/DEEPA BELUR/ (11/14/2024)	Date Considered	11/14/2024

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

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

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(Not for submission under 37 CFR 1.99)

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First Named Inventor	Xiaobo ZHANG
Art Unit	2472
Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

CERTIFICATION STATEMENT

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

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

OR

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

☐ See attached certification statement.

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

☐ A certification statement is not submitted herewith.

SIGNATURE

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

Signature	/Jialin Zhong/	Date (YYYY-MM-DD)	2024-10-30
Name/Print	Jialin Zhong	Registration Number	62937

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

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

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/089,999	12/28/2022	Xiaobo ZHANG	ZL0205-0002-PCT-US-CON2	9408

155075 7590 11/01/2024

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

EXAMINER	
BELUR, DEEPA	

ART UNIT	PAPER NUMBER
2472	

NOTIFICATION DATE	DELIVERY MODE
11/01/2024	ELECTRONIC

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

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

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

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

PTOL-90A (Rev. 04/07)

Examiner-Initiated Interview Summary	Application No. 18/089,999	Applicant(s) ZHANG, Xiaobo		
	Examiner DEEPA BELUR	Art Unit 2472	AIA (First Inventor to File) Status Yes	Page 1 of 1

All Participants (applicant, applicants representative, PTO personnel)	**Title**	**Type**
DEEPA BELUR	Primary Examiner	Telephonic
Mr. Jialin Zhong	Attorney	

Date of Interview: 29 October 2024

Issues Discussed:

Non-statutory Double Patenting

The Applicant was informed that a Terminal Disclaimer needs to be filed to overcome the non-statutory double patenting rejection. This will put the application in a condition for Allowance.

/DEEPA BELUR/ Primary Examiner, Art Unit 2472	

Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04
Please further see:
MPEP 713.04
Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b)
37 CFR § 1.2 Business to be transacted in writing

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**10/30/2024 11:15:36 AM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	67774431	FILING DATE	12/28/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 2

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
petition-request.pdf	3	Terminal Disclaimer-Filed (Electronic)	44 KB
grantLetter.pdf	1	Terminal Disclaimer-Electronic-Approved	18 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
petition-request.pdf	8A41696788EB4DF535B8F3D7879874DDB3A2464F0CF2E7B67C0A8CDF635F5D2335311B83CC9EA1694ABB6E5867BBB1CA06FB3E1FB87E56D592BF44CAB23C2137
grantLetter.pdf	FB0134B2390CE9139C6A2EEFD4BC3630421A7E4E10666E784

6D257AA8B4513A3085B9DE60D44EFE43D4828A9DD635DFB4
3431E0F877DCF536FDE6E6816C4F3C5

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

New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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

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TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A PRIOR PATENT

APPLICATION #	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET #
18089999	**12/28/2022**	**Xiaobo ZHANG**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

✓	Filing of terminal disclaimer does not obviate requirement for response under 37 CFR 1.111 to outstanding Office Action
✓	This electronic Terminal Disclaimer is not being used for a Joint Research Agreement.

Owner	Percent interest
APEX BEAM TECHNOLOGIES LLC	100%
Total	**100%**

The owner(s) of percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of any patent granted on pending reference Application Number(s)

Application #	Filing Date

as the term of any patent granted on said reference application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending reference application. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and any patent granted on the reference application are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.
In making the above disclaimer, the owner does not disclaim the terminal part of any patent granted on the instant application that would extend to the expiration date of the full statutory term of any patent granted on said reference application, "as the term of any patent granted on said reference application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending reference application," in the event that any such patent granted on the pending reference application: expires for failure to pay a maintenance fee, is held unenforceable, is found invalid by a court of competent jurisdiction, is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321, has all claims canceled by a reexamination certificate, is reissued, or is in any manner terminated prior to the expiration of its full statutory term as shortened by any terminal disclaimer filed prior to its grant.

The owner(s) of percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of prior patent number(s)

Patent #
10944527
11546110

as the term of said prior patent is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.
In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the prior patent, "as the term of said prior patent is presently shortened by any terminal disclaimer," in the event that said prior patent later:
- expires for failure to pay a maintenance fee;
- is held unenforceable;
- is found invalid by a court of competent jurisdiction;
- is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
- has all claims canceled by a reexamination certificate;
- is reissued; or
- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.



Terminal disclaimer fee under 37 CFR 1.20(d) included with Electronic Terminal Disclaimer request.

Applicant claims the following entity status:
Regular Undiscounted

I hereby declare that all statements made herein of my own knowledge are true and that all statemnts made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I certify, in accordance with 37 CFR 1.4(d)(4) that I am: An attorney or agent registered to practice before the Patent and Trademark Office who is of record in this application

Signature	Name	Registration #
/Jialin Zhong/	Jialin Zhong	62937

---

* Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner). Form PTO/SB/96 may be used for making this certification. See MPEP 324.

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APPROVAL LETTER

APPLICATION #	FILING DATE	APPLICANT/PATENT UNDER REEXAMINATION
18/089,999	12/28/2022	Xiaobo ZHANG

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Electronic terminal disclaimer filed on 10/30/2024

☑ Approved

This patent is subject to a Terminal Disclaimer

Approved / Disapproved by: Electronic Terminal Disclaimer automatically approved

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ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**10/30/2024 11:15:36 AM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

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PATENT CENTER #	67774431	AUTHORIZED BY	-
CUSTOMER #	155075	FILING DATE	12/28/2022
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Xiaobo ZHANG

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
CARD / 9633	**E20240TB16127366**	**Jialin Zhong**

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
1814	STATUTORY DISCLAIMER, INCLUDING TERMINAL DISCLAIMER	170.00	1	170.00
			TOTAL AMOUNT:	**$170.00**

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

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

New International Application Filed with the USPTO as a Receiving Office

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PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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Application Number	18089999
Filing Date	2022-12-28
First Named Inventor	Xiaobo ZHANG
Art Unit	2472
Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

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

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	Filing Date	2022-12-28
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2472
	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	1	Administrative Judgment of the Beijing Intellectual Property Court of the People's Republic of China, (2023) Jing 73 Hang Chu No. 18545, dated September 25, 2024.	☒

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

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

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

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	18089999
	Filing Date	2022-12-28
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2472
	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

CERTIFICATION STATEMENT

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

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

OR

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

☐ See attached certification statement.

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

☐ A certification statement is not submitted herewith.

SIGNATURE

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

Signature	/Jialin Zhong/	Date (YYYY-MM-DD)	2024-10-30
Name/Print	Jialin Zhong	Registration Number	62937

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

Privacy Act Statement

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

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

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

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

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

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

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

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

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

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

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

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**10/30/2024 10:52:29 AM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	67774020	FILING DATE	12/28/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 2

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ZL0205-0002-PCT-US-CON2-IDS 2024-10-30.pdf	4	Information Disclosure Statement (IDS) Form (SB08)	1010 KB
Beijing IP Court Judgment.pdf	36	Non Patent Literature	2996 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
ZL0205-0002-PCT-US-CON2-IDS 2024-10-30.pdf	AA61AAAE047C46D4145702C9D896861E82157DED98946CE39C167EBE696E4213012FDB6F79CA83AC012336D4C53693F5833C370EBED03FA0BBCCEF473F041B96
Beijing IP Court Judgment.pdf	7732205440FD66D8D5D35BE35E2F57CABF0D729AB1E415848

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98398D2BEDBF6CF90901296C84879DFE

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New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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First Named Inventor	Xiaobo ZHANG
Art Unit	2472
Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

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	1	103220024	CN	A	2013-07-24	ZHAO et al.		☒

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	18089999
	Filing Date	2022-12-28
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2472
	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	1	Search report received for CN Application No. 2020103207517, dated September 9, 2024.	☒

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☐ See attached certification statement.

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

☐ A certification statement is not submitted herewith.

SIGNATURE

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

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2024-09-27
Name/Print	JIALIN ZHONG	Registration Number	62937

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

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**09/27/2024 09:34:14 PM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	67362998	FILING DATE	12/28/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 3

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ZL0205-0002-PCT-US-CON2_IDS_2024_9_27.pdf	4	Information Disclosure Statement (IDS) Form (SB08)	598 KB
CN103220024A.pdf	33	Foreign Reference	3355 KB
Search Report.pdf	4	Foreign Reference	194 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
ZL0205-0002-PCT-US-CON2_IDS_2024_9_27.pdf	408925E0A516031E9E93643BCFFCA801831023B064E0DA6005 62384437C3396DBE0490B9A2401ED72057B22C26D2A0A2B78 6775091545EA8300B8FA745081FA6
CN103220024A.pdf	ACA5182FBBB57A1FE2C684FEE912B036DC824C9B5BDAFFE

	C2F27412A9599AC5AEC4C665506F3FBFA53E6CC6E25DD0C9614954FCCAE9A33120BF95F919A1A9FD7
Search Report.pdf	8CC4DB1F4DCB9E0E9E1D626B9C609D7216ED6E07C6B834A96F8FD1599C55E90CA9DE2CFCE0B649C832DA647E57AC4A816814CC0EEFE5E6FFA5EAC2519D39E2C4

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New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**09/25/2024 07:25:45 PM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	67325542	FILING DATE	12/28/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 66

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
R1 167028 KT Group.pdf	3	Non Patent Literature	968 KB
R1 1608671 ZTE.pdf	7	Non Patent Literature	1013 KB
R1 167287 Nokia.pdf	4	Non Patent Literature	1861 KB
R1 1609080 Samsung.pdf	5	Non Patent Literature	2375 KB
R1 167520 Lenovo.pdf	5	Non Patent Literature	2786 KB
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R1 1707832 Media Tek.pdf	7	Non Patent Literature	4336 KB
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R1 1708334 InterDigital.pdf	4	Non Patent Literature	2232 KB
R1 1708336 InterDigital.pdf	4	Non Patent Literature	1842 KB
R1 1710078 CATT.pdf	3	Non Patent Literature	1385 KB
R1 1710596 Lenovo.pdf	5	Non Patent Literature	2172 KB
R1 1708135 Huawei.pdf	9	Non Patent Literature	7061 KB
R1-1612717 NTT.pdf	3	Non Patent Literature	1064 KB
R1 1710871 InterDigital.pdf	3	Non Patent Literature	2206 KB
R1 1711161 Qualcomm.pdf	5	Non Patent Literature	1967 KB
R1 1710810 MediaTek.pdf	6	Non Patent Literature	5043 KB
R2 1702662 Ericsson.pdf	2	Non Patent Literature	216 KB
R2 1706926 Qualcomm.pdf	3	Non Patent Literature	1172 KB
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Waveform and Numerology to Support 5G Services.pdf	9	Non Patent Literature	10873 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
R1 167028 KT Group.pdf	A1DAE725CE232C5DDB7478F1B775E5A4CDE9F88A9C732215598CBCD378EE510FF315C98DA09A380FDD9B98B5FC4ECEBDF98E7A90EBB3B48AA3056224363FFC3C
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Waveform and Numerology to Support 5G Services.pdf	4E4795ED2058B0B41794F8EC95BDDA8A012C49036F8758BE0 3DD09CF7E633C3B8C399000BF3A27182B5B233813AFCE09B3 0D329819A0A9286946073D284AA27E

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APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**09/25/2024 06:45:15 PM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	67324945	FILING DATE	12/28/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 90

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4G LTE-LTE Advanced for Mobile Broadband Dahlman 2011 pp201-291.pdf	91	Non Patent Literature	18238 KB
4G LTE-LTE Advanced for Mobile Broadband Dahlman 2011 pp1-100.pdf	100	Non Patent Literature	19698 KB
4G LTE-LTE Advanced for Mobile Broadband Dahlman 2011 pp101-200.pdf	100	Non Patent Literature	22350 KB
Accurate Determination of Transport Block Size Wu.pdf	3	Non Patent Literature	3740 KB
Antenna Grouping Techniques for MINO Kim.pdf	5	Non Patent Literature	3520 KB
An Enhanced Multi-Antenna Solution Through Beamforming Long.pdf	4	Non Patent Literature	4362 KB
Beam Selection Strategies for Orthogonal Random Beamforming.pdf	12	Non Patent Literature	4335 KB

A Comparison of Symbol-Wise and Self-contained Frame Structure.pdf	6	Non Patent Literature	6471 KB
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Delayed-Prioritized Scheduling DPS Sandrasegaran.pdf	7	Non Patent Literature	5224 KB
Filtered-OFDM.pdf	3	Non Patent Literature	2679 KB
Antenna Grouping based Feedback.pdf	13	Non Patent Literature	14078 KB
Enhanced Beam Selection for Multi-User MM-Wave Massive Mimo Systems.pdf	7	Non Patent Literature	6692 KB
Dynamic TDD in LTE Small Cells.pdf	10	Non Patent Literature	8760 KB
Joint Transmitter-Receiver Beamforming Zhang.pdf	6	Non Patent Literature	4007 KB
Enabling Massive IoT in 5G and Beyond System.pdf	18	Non Patent Literature	23475 KB
LTE UMTS Long Term Evolution Sesia pp701-794.pdf	94	Non Patent Literature	15346 KB
LTE UMTS Long Term Evolution Sesia pp581-700.pdf	120	Non Patent Literature	17852 KB
LTE UMTS Long Term Evolution Sesia pp451-580.pdf	130	Non Patent Literature	21379 KB
LTE UMTS Long Term Evolution Sesia pp301-450.pdf	150	Non Patent Literature	22699 KB
LTE UMTS Long Term Evolution Sesia pp151-300.pdf	150	Non Patent Literature	22179 KB
LTE UMTS Long Term Evolution Sesia pp1-150.pdf	150	Non Patent Literature	21278 KB
OFDM Transmission.pdf	5	Non Patent Literature	1000 KB

MIMO Beamforming for High-Bit-Rate Transmission Pham.pdf	5	Non Patent Literature	3010 KB
Novel OFDM.pdf	5	Non Patent Literature	3248 KB
Overview of Narrowband IoT in LTE Rel-13.pdf	7	Non Patent Literature	4923 KB
Multibeam Selection for Indoor MIMO Systems.pdf	11	Non Patent Literature	11028 KB
Overview of Full-Dimension MIMO Ji.pdf	22	Non Patent Literature	13643 KB
Millimeter Wave Communications.pdf	25	Non Patent Literature	14114 KB
R1 150779 LG Electronics.pdf	2	Non Patent Literature	47 KB
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R1 151535 LG Electronics.pdf	4	Non Patent Literature	1460 KB
R1 144047 LG Electronics.pdf	5	Non Patent Literature	1824 KB
R1 130269 LG Electronics.pdf	3	Non Patent Literature	2138 KB
R1 151365 CATT.pdf	5	Non Patent Literature	3300 KB
R1 153175 Ericsson.pdf	3	Non Patent Literature	291 KB
R1 164147 Intel.pdf	4	Non Patent Literature	637 KB
R1 154127 Samsung.pdf	8	Non Patent Literature	4673 KB

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DOCUMENT	MESSAGE DIGEST(SHA-512)
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Antenna Grouping Techniques for MINO Kim.pdf	5BC52E28B325E3BD2BE9E2F8D8FB052F9AD778B48EB1A712D729CDF467D56FA3A36284620BFFEF17D7D40C79955B868CF

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APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**09/25/2024 06:28:35 PM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	67324627	FILING DATE	12/28/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 99

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3GPP TS 36.133 v13.2.0 2016-1 pp201-300.pdf	D091954D54D6BE115839B7885A3E28AE0684641F6E37CABF32B4D6DC7017C611E126BB98422AC499C5AF56E8C8921B87B993EC0B5A602AB25EE6BDDEB16B9950

3GPP TS 36.133 v13.2.0 2016-1 pp101-200.pdf	E00FAC96B4F43744FCAAC05E3DCAFB2ECF48BF7A3130A11BF320A43309F0A4DC33B7EBC2AA532B34C8B375326914DC9D41BF190769663B0003761AC3D01D044F
3GPP TS 36.133 v13.2.0 2016-1 pp401-500.pdf	310EA49B66C4DA1499F15693938F4FBE99314C3DA8CF4F8BC4DCF031D23D14C5220B083277AF3E356779DFD807B50E438D5C4C86BA64C2DDFC3F688C1D4269A9
3GPP TS 36.133 v13.2.0 2016-1 pp501-600.pdf	32F3253EBD16A88C87757289A335529B97B65461FB407B0FAFB0F194E224B25697A152B8275D9C79930D3487FB0FED4F8410E7C822100E1E320B83F0BC0D2D6E
3GPP TS 36.133 v13.2.0 2016-1 pp601-700.pdf	00D4950A8458F20CA9AF608EB9DE35627FC4678DA266DCA585F7BD74210D4A00F797FF289CB16031BCFE6C04FAC7B218D491646E37E0D597A741FA1E076F1BDE
3GPP TS 36.133 v12.8.0 2015-9 pp1201-1300.pdf	3D660B71ABD985614DEF941361BBD9BD07D00BCEB64714BAFBF1FEC873F983C02D722D8DD8EC2823E43744E1C97484E0204C51DD563A32C820C7B11513D2169A
3GPP TS 36.133 v13.2.0 2016-1 pp301-400.pdf	E32BCE76E57A8859E8B5BFB76DC143E887C04007908A86A2BFD69019475AD941D3A17ED00B89F7EB9FCB40B9178308AA35E9683ED9AAEBF473C4A3B4AF63348E
3GPP TS 36.133 v13.2.0 2016-1 pp701-800.pdf	71183CE0914DCC84219AE1059C712CA6C3EC3AB7688114D42E128B0AA6EADA6CD404043780338EDB80772F2E49F89ADAD67561D446287B2257BA04BD385E9D00
3GPP TS 36.133 v13.2.0 2016-1 pp801-900.pdf	FD1A72AEFC060AD49E7292B8ABD5F283248BFF26FFA62E1922657434D45C9C0486CA87DCECAD2C20CF1AA4686DDAB665DFBE79F45DAD255333C8505061A086B4
3GPP TS 36.133 v13.2.0 2016-1 pp901-1000.pdf	FDABC36C85989D3B8C75BD99B8038E067FEE06B3EB2C83007BBAFF39743D6D6BFA985EAEF90B057AEB231C95F7B14CBF8926FD0612C63FB93CE7F5E02BFCE70F
3GPP TS 36.133 v13.2.0 2016-1 pp1001-1100.pdf	543A06963C9AA26BC3203729BCC023A4045587D6D646C62CF9378C9B833211BA747C9F0C765FA1DF35FD6E2FDC1A73A7900B76D5AB821702165F401F6F6A6FC5
3GPP TS 36.133 v13.2.0 2016-1 pp1201-1300.pdf	FB90070CBF11DEA1A139BE4892A1B753D26D35E46BC44F8E58D1446D012BEDEEE97B7B6ED344544EA2B356F355F4F93ED9479A1754FBA181D376CBEDE0B6B4B5
3GPP TS 36.133 v13.2.0 2016-1 pp1101-1200.pdf	2BDBEFAACD3C3313D326C1406807BAF34262839CEA203529F0E8117E687D7C861876C48987FEBAA735F81294C27091F7105285EF03671487BD685F084E296E5C
3GPP TS 36.133 v13.2.0 2016-1 pp1301-1400.pdf	465FA8F406362B706522CC154CDF7E9FAD22F05B1CFA6087881F4C367048CECD59E8AEFFD8FB0F1C2314AD94DE3599C16F8058D5D41DDC80D831B251BC6C4BE6
3GPP TS 36.211 14.2.0 2017-4 pp1-100.pdf	EE29F60F2A10ED8A8F02E918E8C3914F405DC628CD97EC9C155F9993D978822C331D92BAAFEEB2CEDA47B74E13EF12FE

	67AA4EE03769EEB331981A2D0F61B8EA
3GPP TS 36.211 14.2.0 2017-4 pp100-196.pdf	B77F7CBD8A55EE3A393288C4458539F17BFE7906ACEE4D6E 26F5E50C289E6C03B4D3C7807AC5FD692F95D9289888828CD BD3774C3AF67BEBE4AA007B70F0C1CC
3GPP TS 36.133 v13.2.0 2016-1 pp1401-1517.pdf	DC41ECAADD52D2745153C40F13488DD59E2C68A8F1416562 F8B1C9D923C22F09CEEEB5AB8EAE9F4677F977A45424F0964 F6A548CDEFF5A65FEBB6F7C4575CF07
3GPP TS 36.211 v13.0.0 2015-12 pp1-70.pdf	3D7010026EC1A69848BECE6E34A1E9EC255E6E832664C3E53 39CE70A633DB3A5D92D4F9D9A2CF2CC100727748C57F54D0 421A1E59FE272F87A3AE9F938FE08CA
3GPP TS 36.211 v8.9.0 2009-12.pdf	B30EA9F2FF5DA16AAC2E14E1AE76B7FD2557699CAEF48DA2 18028F5E1915EA8A9695464337F823936A8895B72749B889003 F385A39858E78C751AEEF504B067B
3GPP TS 36.211 v12.8.0 2015-12.pdf	0CF9540CCF18595C2A869F85973FA9BEE2C4A2631C533A0E D01B9D84EAD82E2B76BC772AB73B7B98F066E39D8E188C83 3560479349E0C2FEC639CDAC2D4318DD
3GPP TS 36.211 v11.3.0 2013-6.pdf	C6CAB00E5571E4CE819D376855BEE008A8416CAC8F3873863 B23DEF044674B19CDE03C0B5A1FBE29169084425375882DD0 26D3CED22A3422F69A4B5C288BA0AF
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3GPP TS 36.211 v12.5.0 2015-3.pdf	AC3482AE296564962E3AFBE1ADDB95CFEDE80BC28B1C1610 0595CB7A177D90AE85D19708F0B316445DE2920E92AD564DE 122CC0DBA6153DEFFD33FF1FABC2E52
3GPP TS 36.211 v13.2.0 2016-8 pp1-85.pdf	3419FDD2E57E5E51B338AED6488D33A86C35C31DF46D695B ACA8CFC56FD43832823D3AE5C91DC6DE03BAFE455BE5E9D 95082D8C810B1355B376454EB4AC9ABE4
3GPP TS 36.211 v13.0.0 2015-12 pp71-141.pdf	B2EE8B51655A205A71C6E7C3F948957CC2531EAD48882907A 4B3DCA62A01068AEA420D41205B5C7963FC325132526C2573 5C30850F70C50C259E0140763DF774
3GPP TS 36.211 v13.2.0 2016-8 pp86-170.pdf	A18FC3B27583FA3FDBBAE4DEEBB957FDE1C4B6CED2325EB 2607B4C66CA1E3BE5E189758161626B5EF4E9F97945F0AF9D 6A4228D9EC0651EDFDECEF0C0BE64BCA
3GPP TS 36.212 v12.2.0 2014-9.pdf	972FF1A61C63E4772D13A9475ABCE1B83BD57AE383219407E 08B3D23C8169BCFC456ED8D7A9B5502CF966DBB7DF9EC995 F4397CA2D2E0CE6A1E8F9D2D5AFE06E
3GPP TS 36.212 v12.8.0 sec14 2015-12.pdf	F8A28F913B9FE64D5A02D4C138E7A3F3BC5A4311944651468 2070B901D1CCC941E9685F5B11541DB4E5FD9069B3F62D0A5 95E592BFD52554640B85D159F1318F

3GPP TS 36.212 v12.2.0 2014-10.pdf	F833CB6EFFCD064DB93BD34A62732CE0AB33BA9CC8F988D5A61E8F975DAB7CF1A2E530A0F4D195573A214CA1CD758F11C531E21BAE1F7A2E0B3F5D45D5F34BCE
3GPP TS 36.212 v12.4.0 2015-3.pdf	92BE92645450DD6CF0F9BB272469A0D55FB9340FCFBAFA4BE4F511A33F9C951C878435600D473BCCED6FA6ECB2094529B2E073390C5FC35B4BEE19C5AB8416A5
3GPP TS 36.212 v12.8.0 2016-3.pdf	4FF33740ECFC008680C77C995962F22DE132288197BDFED826918C4B000557BC10E7C3EC43069E5A0EE1402477E19E6904BAB25FB7B6938AB61C79FF7F3C1DD3
3GPP TS 36.212 v12.8.0 2016-4.pdf	021B8BDEA25D6710385013F2BD28BA4BB0A83E564070BA78D40BE1736722F11BB745A7603E8BEE5E0C445FD3ED5F1ECE5F0BE88872B8201DD68FF459A0B30129
3GPP TS 36.212 v12.8.0.pdf	D5B27D6831FF32B4B0065EBA04E6557EEB98B540CBBB20AF63C4319BFC010FAEDC5075E07FA32B0FD85BFA0D96E5D286FAA9782A9E67DCEB680F67AA9884F105
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3GPP TS 36.212 v13.3.0 2016-9 pp61-127.pdf	D499CD4660752679AF837A216DBC924C7DD42B877CCCD26C4FFB65337BD8FA3AF4B212B09BE3D17156F1F0E974C8B155008A37F4AD53372795B67D6FD38452EC
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3GPP TS 36.212 v14.2.0 2017-4 pp1-100.pdf	FA85631FB433981EA6E72DE65E1791FD004357C94B879A6ADB94B4A93DA9ADCE09FEB65DD2EC8F9406CC33885D3760022E82CBB859E12694DE2AC387189C0D85
3GPP TS 36.213 v12.8.0 2015-12.pdf	344DAF5ABBE2D9A44E6810517F0390ED4753BC5AC5ECB27D7B287F37C3D7C5AAF553CE378C997C6A4723971E2B35A22ED2464188C2DB326DECFC4EF2CFD845BD
3GPP TS 36.212 v14.2.0 2017-4 pp101-206.pdf	393D3256096AA500AE223BB74020C25995AF23DAEC22A4BB7BA7A486BC0D49D50CC4B46BF558E8CA477883CF122A19F53DB4CEA75582C4460CCA65AAA6C3D80D
3GPP TS 36.213 v 12.11.0 2016-11 pp1-118.pdf	5C7910A94B3F50917349C087EF3551A0040AC928AFC108E16D35677FCA73A1EAA596A1BD7F67345A112388930DFFAF0A157939431A20619429532C9AD75F8C9D
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3GPP TS 36.213 v12.8.0 Annex A 2015-12.pdf	4390A1307ECBEBBCAAB262AED38300AFC35B5C4019C379B348DA4A6570E9B7FA2275C000E4F52EBE2226F92F2650A7A57

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3GPP TS 36.213 v13.0.0 2015-12 pp111-220.pdf	49FCE3F997A2909A611A59565972AF17F00234B276E8FEC18B 468925DBC473AC7C13BAF2F3B62EB6C444FD2836F156C8804 FAC5370E83DD592EE3C8C89EE7AC0
3GPP TS 36.213 v13.0.0 2015-12 pp220-326.pdf	B04EF4897B04DDFB529B7FF2988F89F945016EC3B3BBA5FAF 00B014FA06AD00698302993EF908B2B204C6CE3689AE0F8585 81117BFF96F211F5ACCA2E8662564
3GPP TS 36.213 v13.2.0 2016-8 pp1-100.pdf	BE9D523CD471B3A654FC99944E7301405A3F8ED573FFA001E EBAAF63C86B5B7D73158D1DF6BFBA376B8DD375351B91EC9 D91BD1166735086915D2F06859784A7
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3GPP TS 36.213 v13.2.0 2016-8 pp201-300.pdf	7AAC624926990D0E25BB803BA71952121FC9BD9082696EC3C745F65ECEE8570B5F929E03D72120B91B6B6ECF3D5CC391F88FA2363B4FBC79156F1045024727DF
3GPP TS 36.214 v12.2.0 2015-4.pdf	0239712C088242FFACE7033321D1B17171B5617B96EB4AD389870CBE0A1F295F3455D949DCC158EB0577D57C4504862D8CDF0008F6A54B9FBFE3E4E84DF79B10
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3GPP TS 36.300 v12.3.0 2014-9 pp201-230.pdf	EE71A99138E2A3FD99F9C6BD4CA1DE91BE9E1E4076F1963F46615AB9C2089A7D6C6478EB405E13856459F9B96DF22C8C2CE606AF69A6D51AA690FE5B31633BED
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3GPP TS 36.300 v12.8.0 2016-1 pp1-60.pdf	3A583BEF8A1B9C0B1B6EAB17D4B274D44144AD3A1C88951C3344C03698E7A104F053AF2CD07970EB394C54C0B2938547D267DB801871ED0CB19309A46AD71C57
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3GPP TS 36.300 v12.8.0 2016-1 pp121-180.pdf	C15186B924D24D9255C3A8B9861353659E9F87067B14B6B65C879A27B5B8027A1D270685958CC1B8605C13FE7EAB8C4FB112BB211FC761990037F951E9436B07
3GPP TS 36.300 v12.8.0 2016-1 pp181-225.pdf	11BCF552225101218036F87D10ECA7290189C3A8C5043591E034CA9928E619B060546F62839BAB450B17DE1632CB74D4D7656759789829E2C49C6ACCD4E0C117
3GPP TS 36.300 v14.3.0 2017-7 pp1-70.pdf	454310D0421C9FD8FE05793AFB5128D742CAC2FFAEED155345A3B1182B26EFBB8B9CE473B9D67BF3C8660925002A50E93C86F0B4A51B83EB9416FF04775433ED
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New International Application Filed with the USPTO as a Receiving Office

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(54) **TRANSMISSION SCHEMES AND MODES AND FALLBACK SCHEMES FOR THE ACCESS LINK OF SYSTEMS OPERATING IN HIGHER FREQUENCY BANDS**

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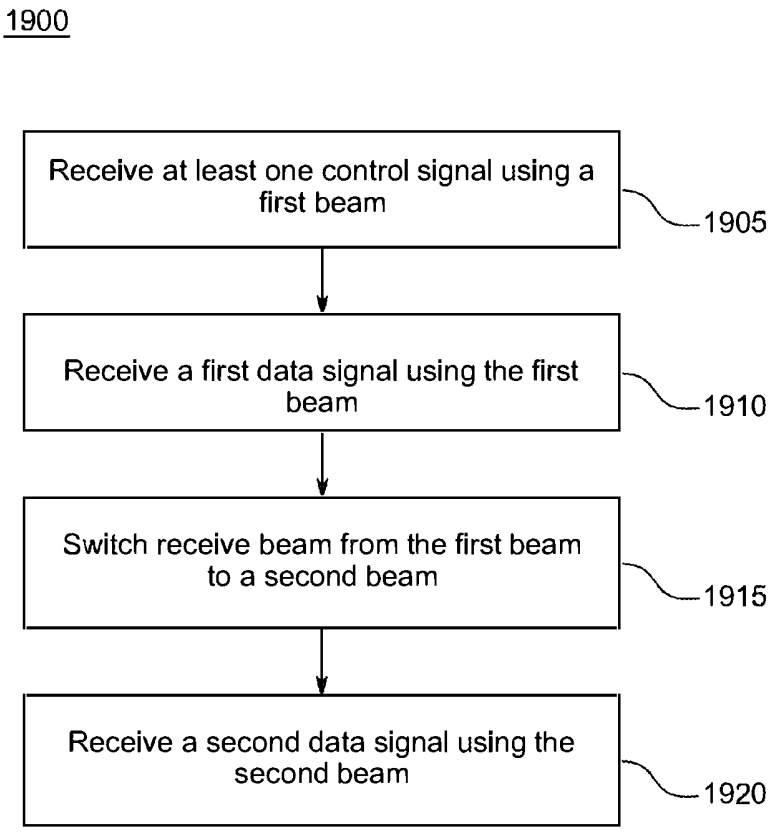
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(57) **ABSTRACT**

A wireless transmit/receive unit (WTRU) configured to perform wireless communications in higher frequency bands (e.g., above 6 GHz) using a fallback scheme is provided. The WTRU includes a receiver configured to receive, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID, such that one of the at least one control signal indicates the second beam ID; and a processor configured to switch a receive beam of the receiver from the first beam to the second beam based on the second beam ID to receive the second data signal.



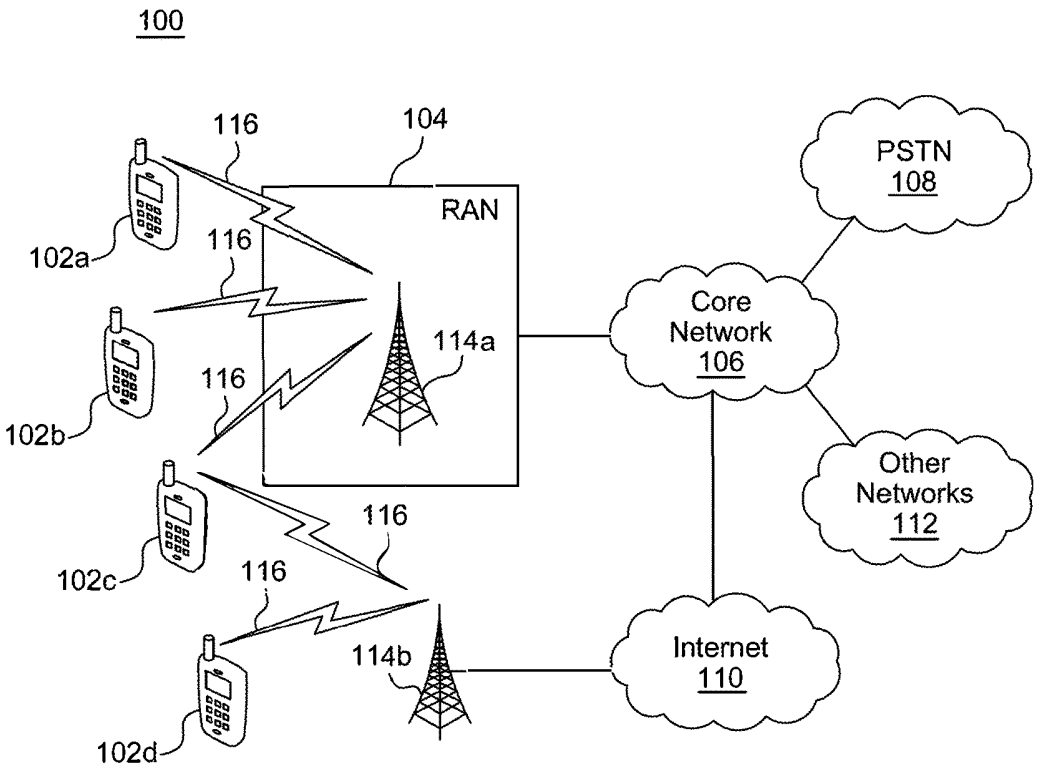

100
116
104
RAN
PSTN
108
102a
116
Core
Network
106
114a
102b
116
Other
Networks
112
116
102c
116
114b
Internet
110
102d

FIG. 1A

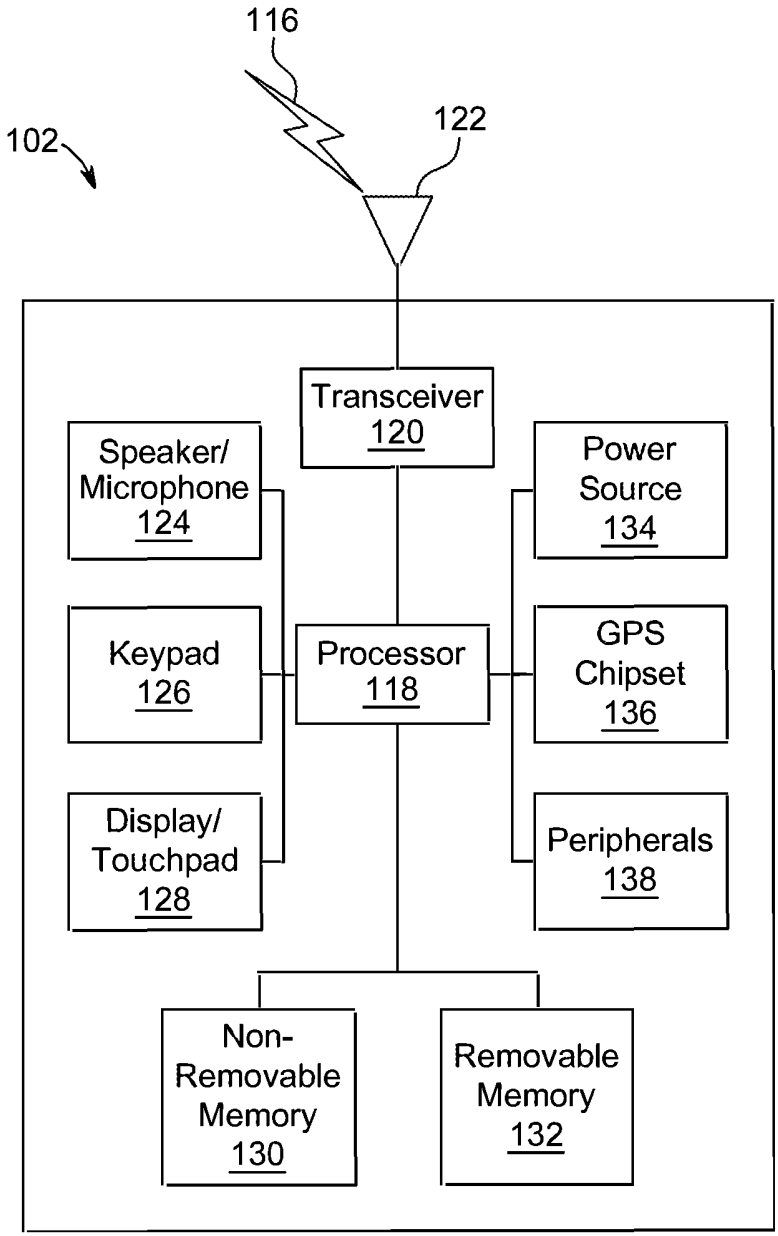

116
122
102
Transceiver
120
Speaker/
Microphone
124
Power
Source
134
Keypad
126
Processor
118
GPS
Chipset
136
Display/
Touchpad
128
Peripherals
138
Non-
Removable
Memory
130
Removable
Memory
132

FIG. 1B

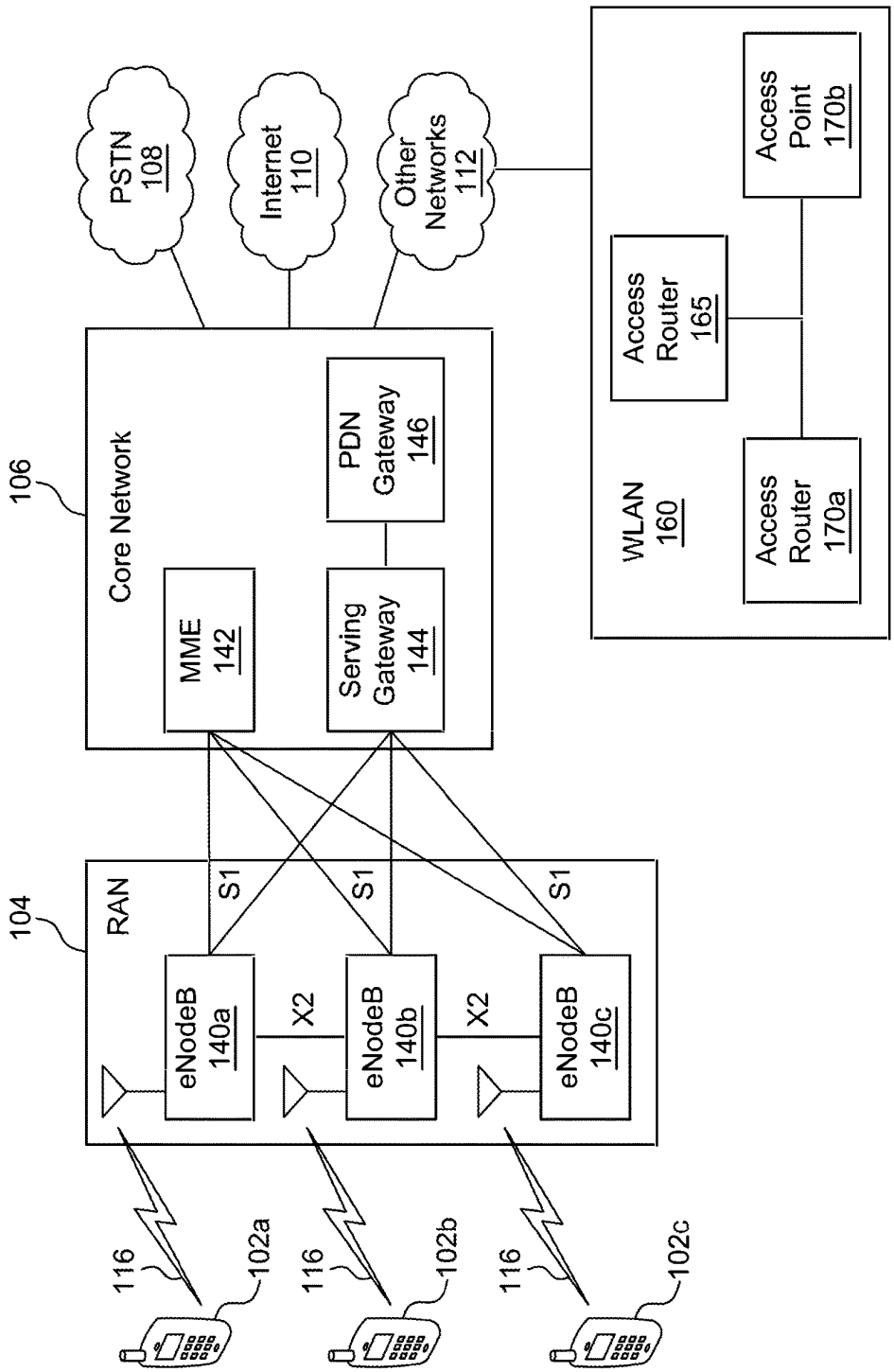

PSTN 108
Internet 110
Other Networks 112
Access Point 170b
Access Router 165
WLAN 160
Access Router 170a
106
Core Network
PDN Gateway 146
MME 142
Serving Gateway 144
104
RAN
S1
S1
S1
X2
X2
eNodeB 140a
eNodeB 140b
eNodeB 140c
116
116
116
102a
102b
102c

FIG. 1C

377

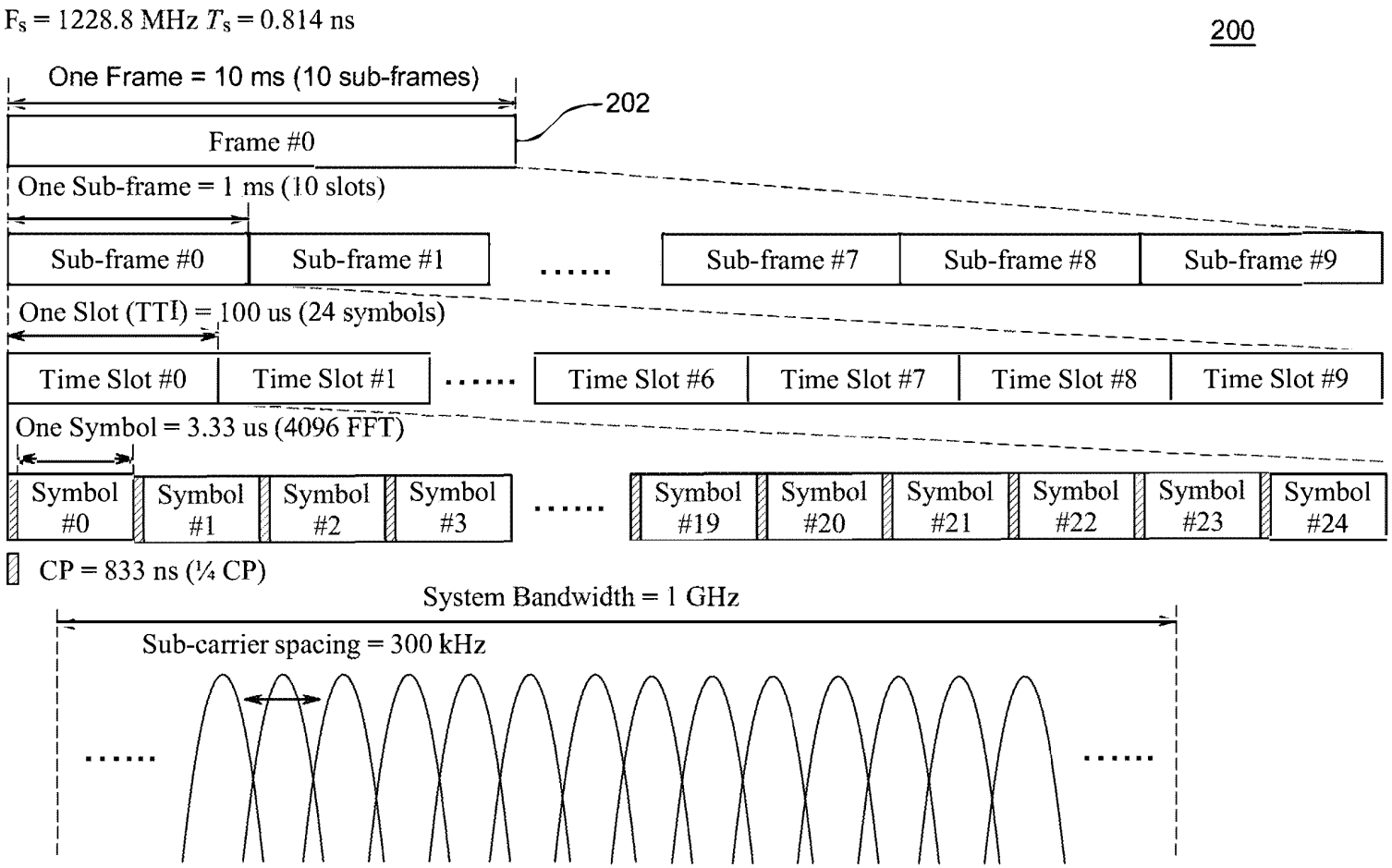

F_s = 1228.8 MHz T_s = 0.814 ns
200
One Frame = 10 ms (10 sub-frames)
202
Frame #0
One Sub-frame = 1 ms (10 slots)
Sub-frame #0
Sub-frame #1
.....
Sub-frame #7
Sub-frame #8
Sub-frame #9
One Slot (TTI) = 100 us (24 symbols)
Time Slot #0
Time Slot #1
.....
Time Slot #6
Time Slot #7
Time Slot #8
Time Slot #9
One Symbol = 3.33 us (4096 FFT)
Symbol #0
Symbol #1
Symbol #2
Symbol #3
.....
Symbol #19
Symbol #20
Symbol #21
Symbol #22
Symbol #23
Symbol #24
CP = 833 ns (¼ CP)
System Bandwidth = 1 GHz
Sub-carrier spacing = 300 kHz

FIG. 2

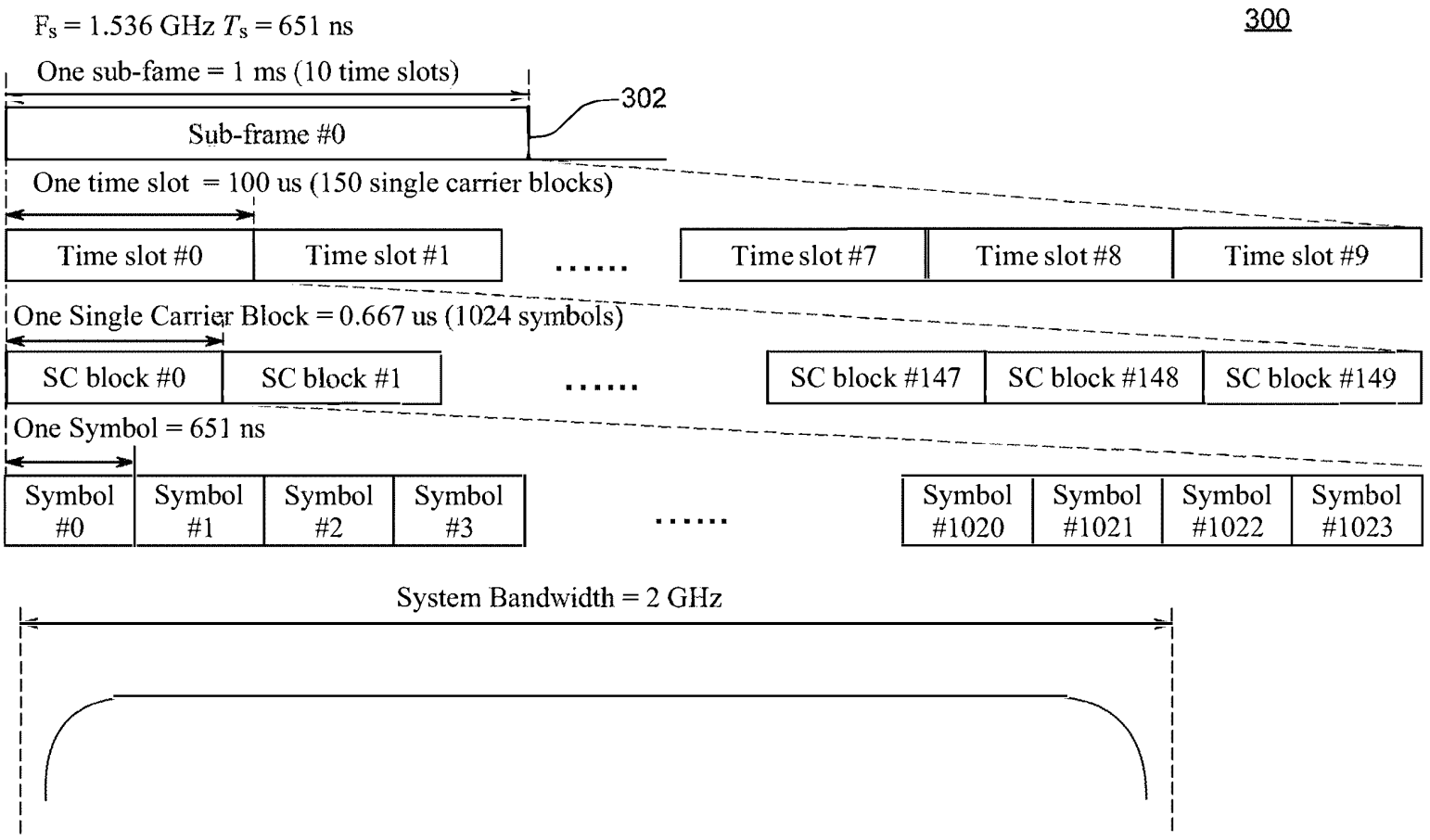

F_s = 1.536 GHz T_s = 651 ns
300
One sub-fame = 1 ms (10 time slots)
302
Sub-frame #0
One time slot = 100 us (150 single carrier blocks)
Time slot #0
Time slot #1
.....
Time slot #7
Time slot #8
Time slot #9
One Single Carrier Block = 0.667 us (1024 symbols)
SC block #0
SC block #1
.....
SC block #147
SC block #148
SC block #149
One Symbol = 651 ns
Symbol #0
Symbol #1
Symbol #2
Symbol #3
.....
Symbol #1020
Symbol #1021
Symbol #1022
Symbol #1023
System Bandwidth = 2 GHz

FIG. 3

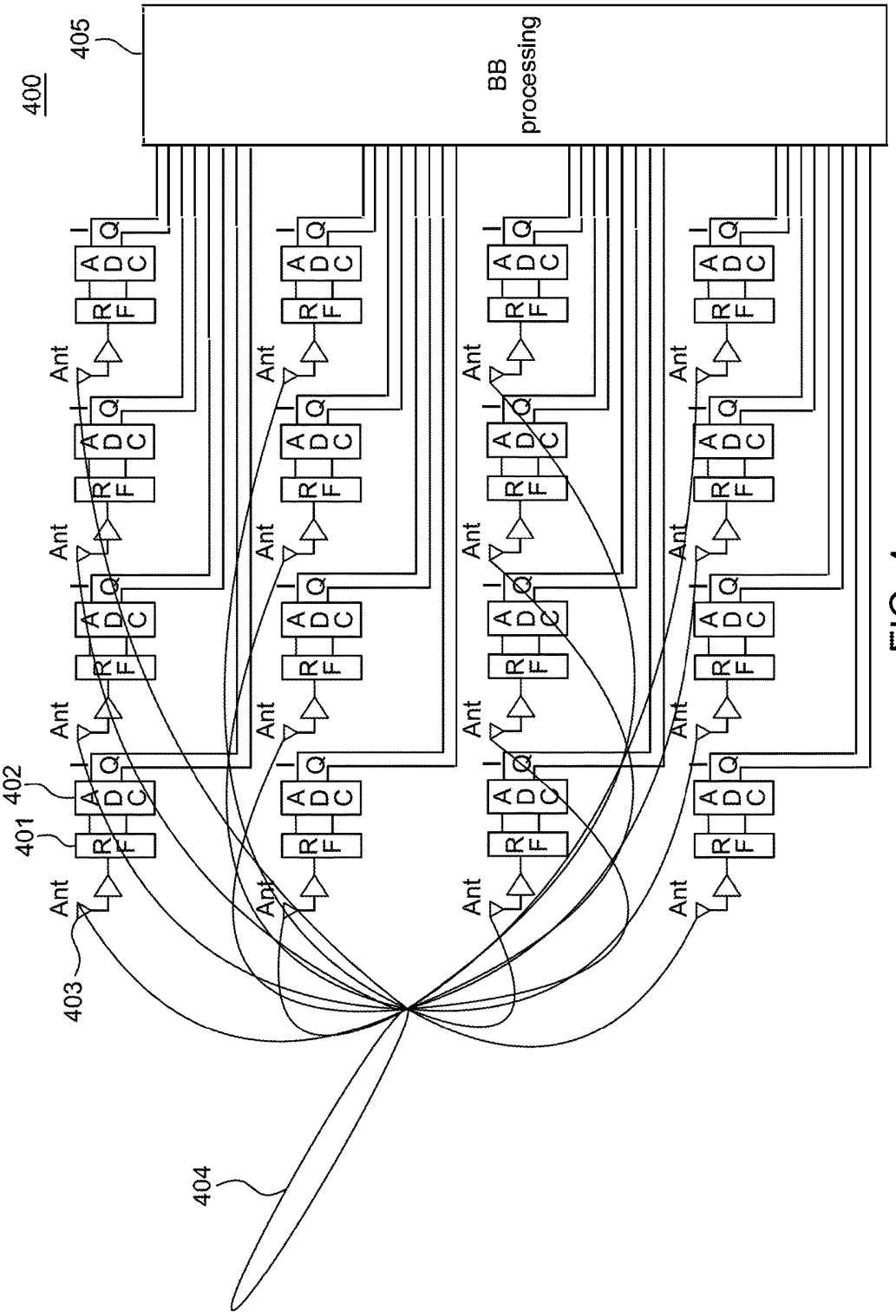


FIG. 4

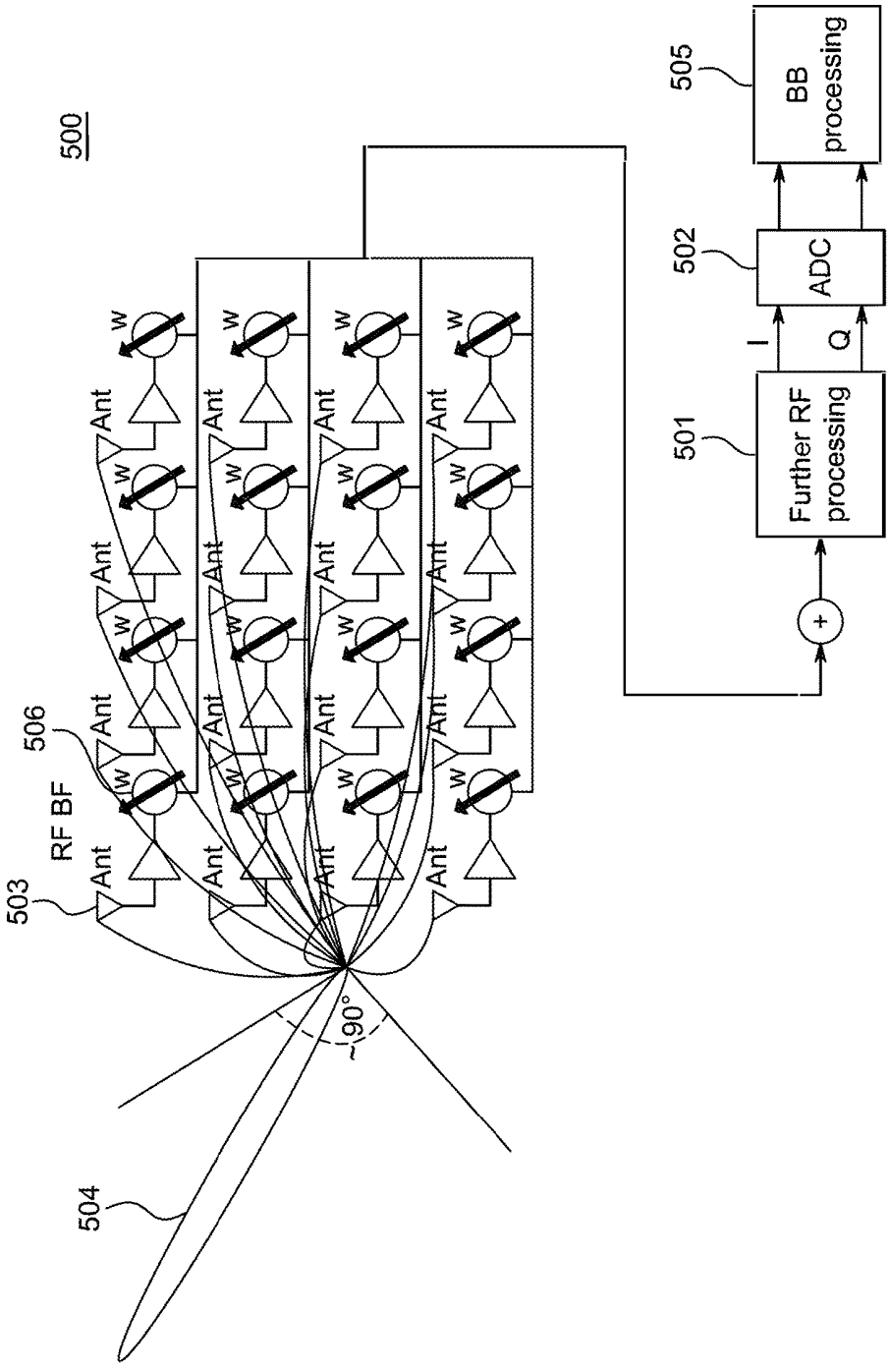

500
505
BB processing
502
ADC
I
Q
501
Further RF processing
+
506
RF BF
503
Ant
W
504
90°

FIG. 5

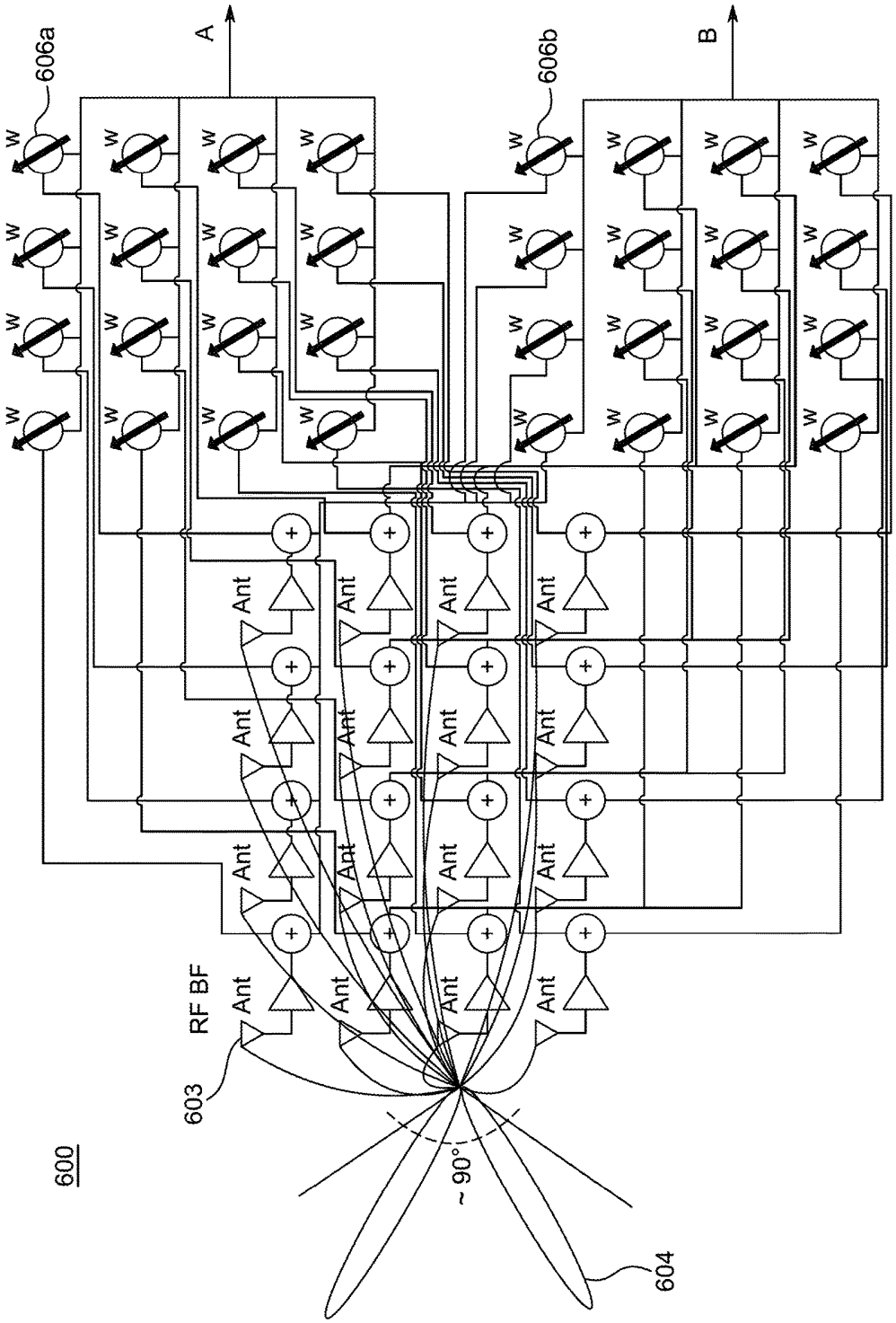


FIG. 6A

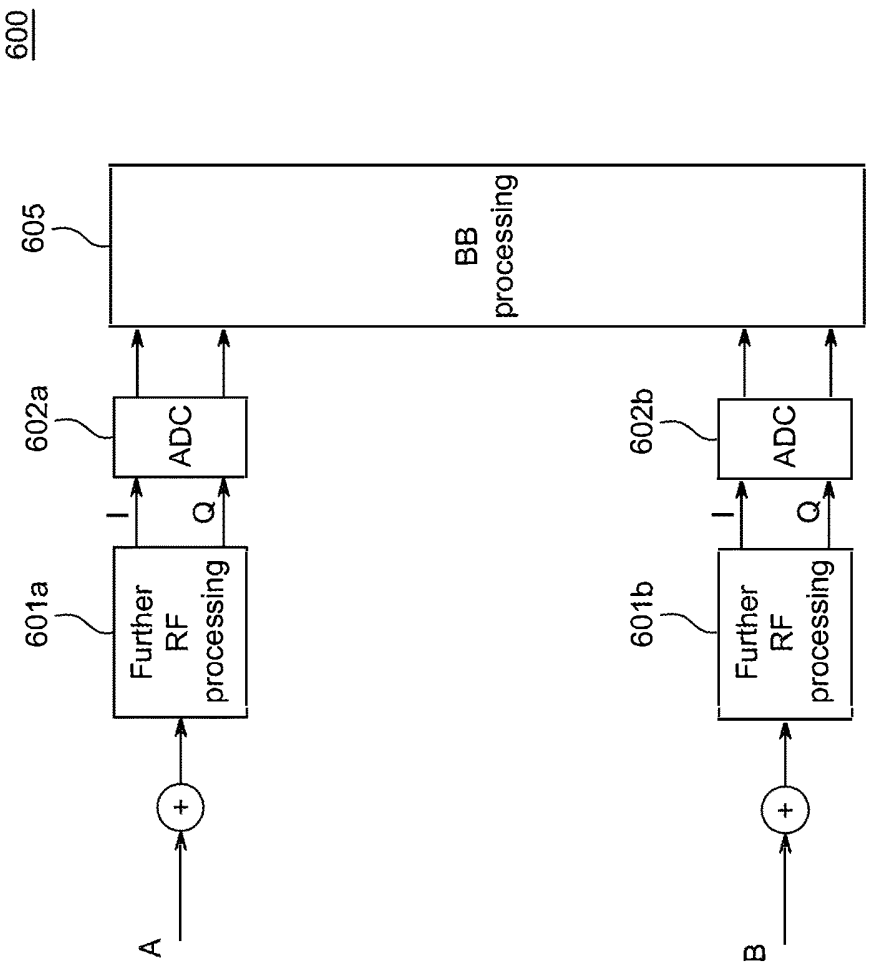

600
605
BB processing
602a
ADC
602b
ADC
I
Q
I
Q
601a
Further RF processing
601b
Further RF processing
A
B

FIG. 6B

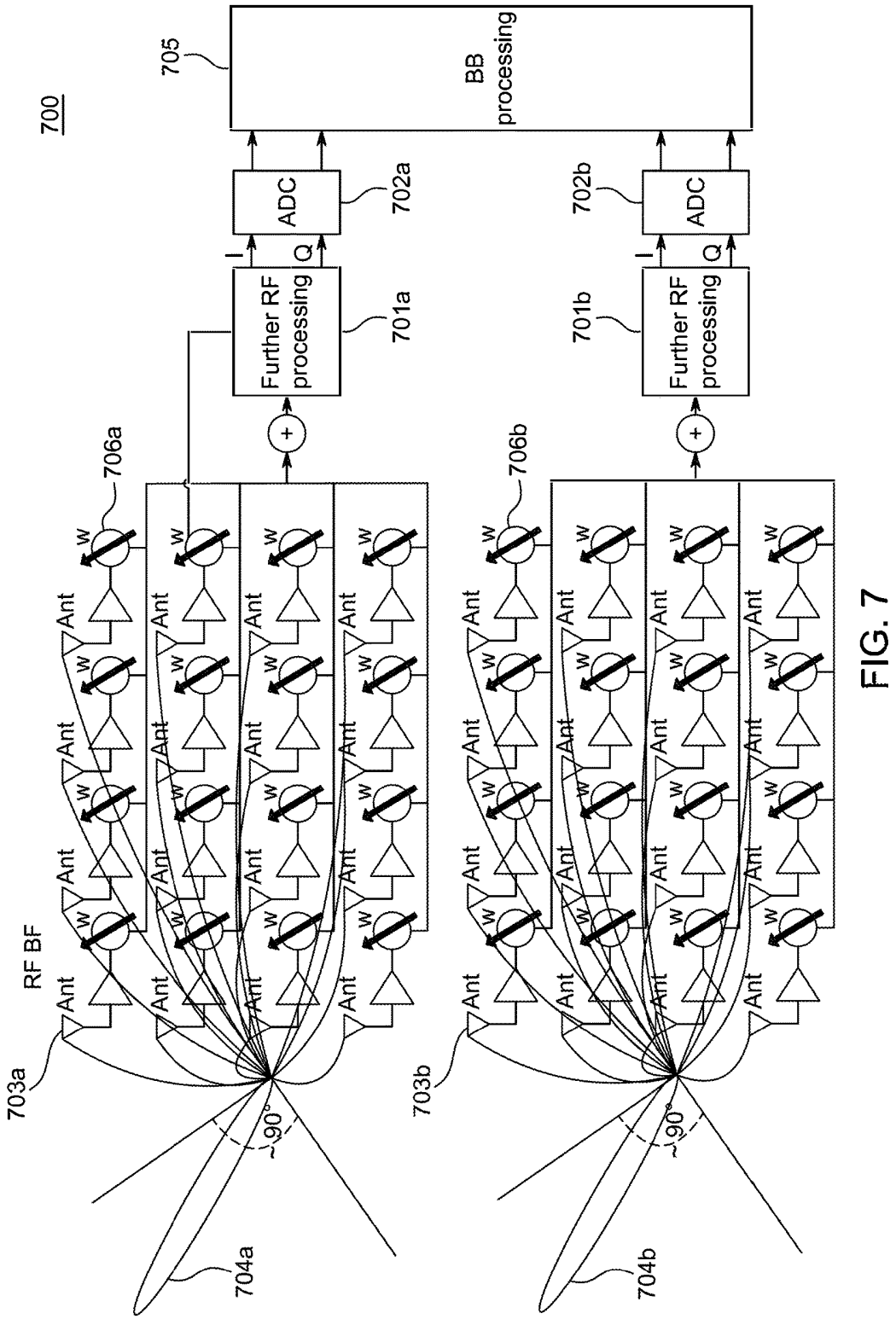

700
705
BB processing
ADC
702a
702b
I
Q
Further RF processing
701a
701b
706a
706b
RF BF
Ant
W
703a
703b
~90°
704a
704b

FIG. 7

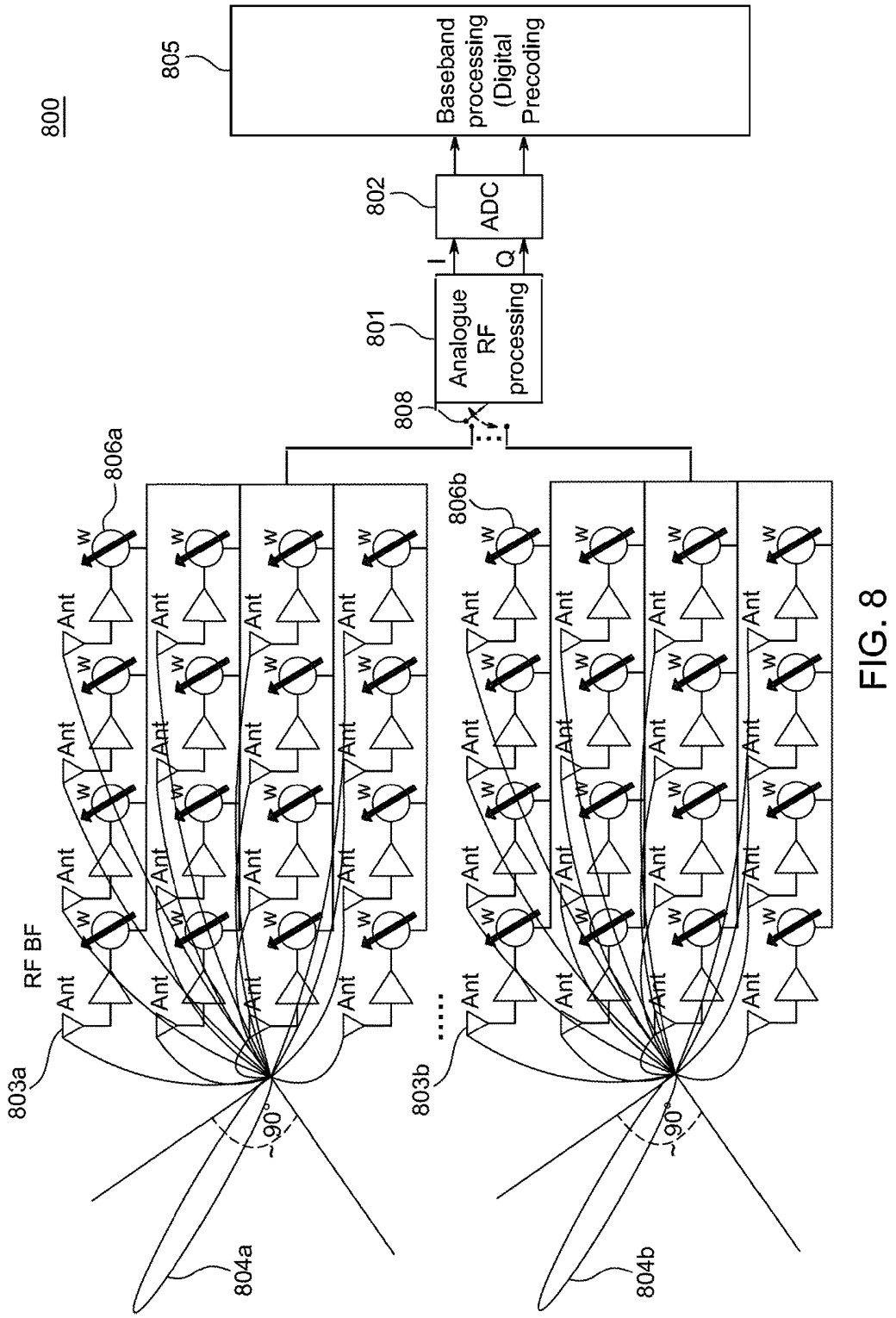

800
805
Baseband processing (Digital Precoding
802
ADC
I
Q
801
Analogue RF processing
808
806a
806b
RF BF
Ant
W
803a
803b
.....
~90°
804a
804b

FIG. 8

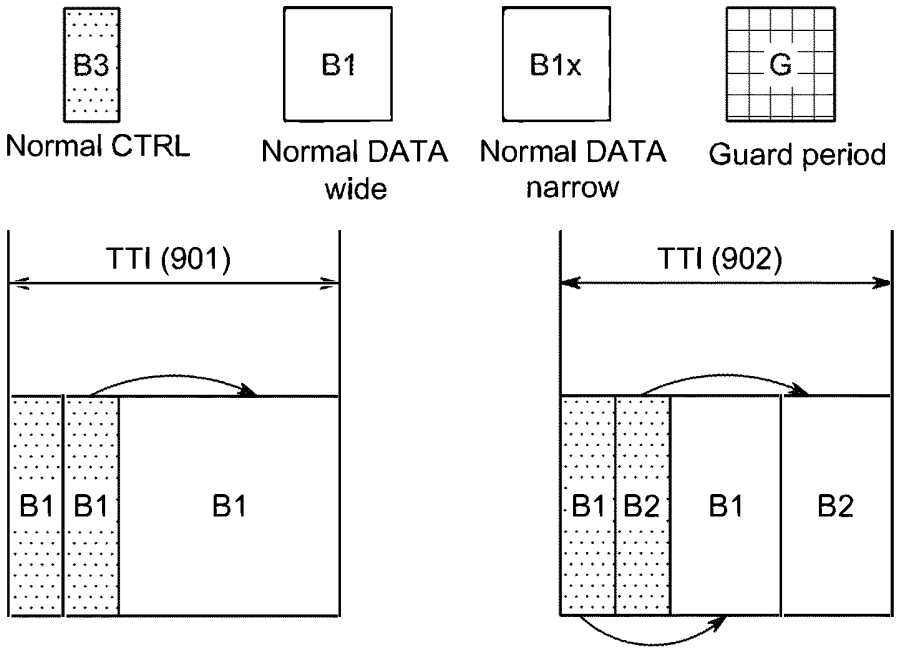

B3
Normal CTRL
B1
Normal DATA wide
B1x
Normal DATA narrow
G
Guard period
TTI (901)
B1
B1
B1
TTI (902)
B1
B2
B1
B2

FIG. 9

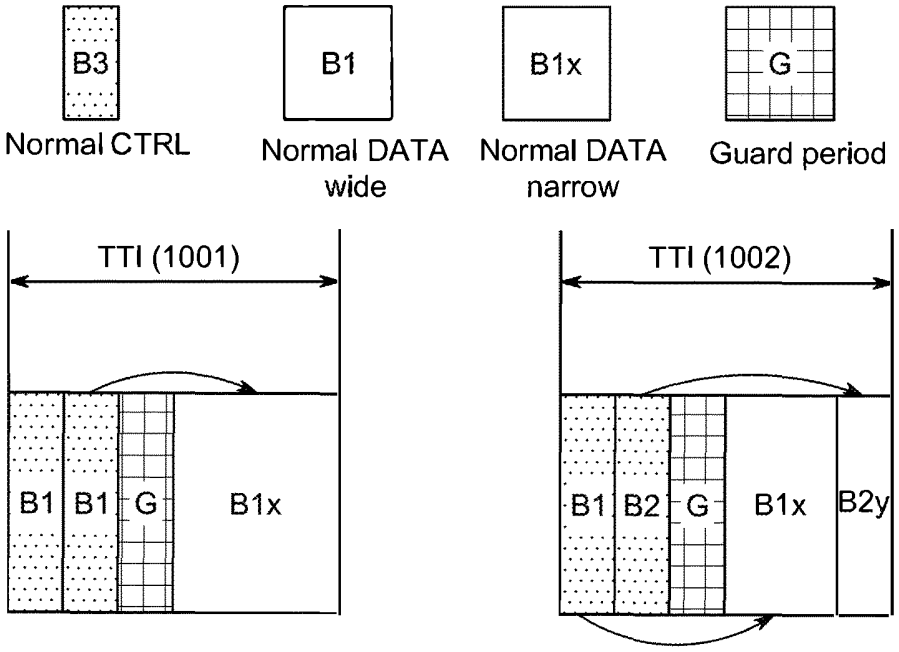

B3
Normal CTRL
B1
Normal DATA wide
B1x
Normal DATA narrow
G
Guard period
TTI (1001)
B1
B1
G
B1x
TTI (1002)
B1
B2
G
B1x
B2y

FIG. 10

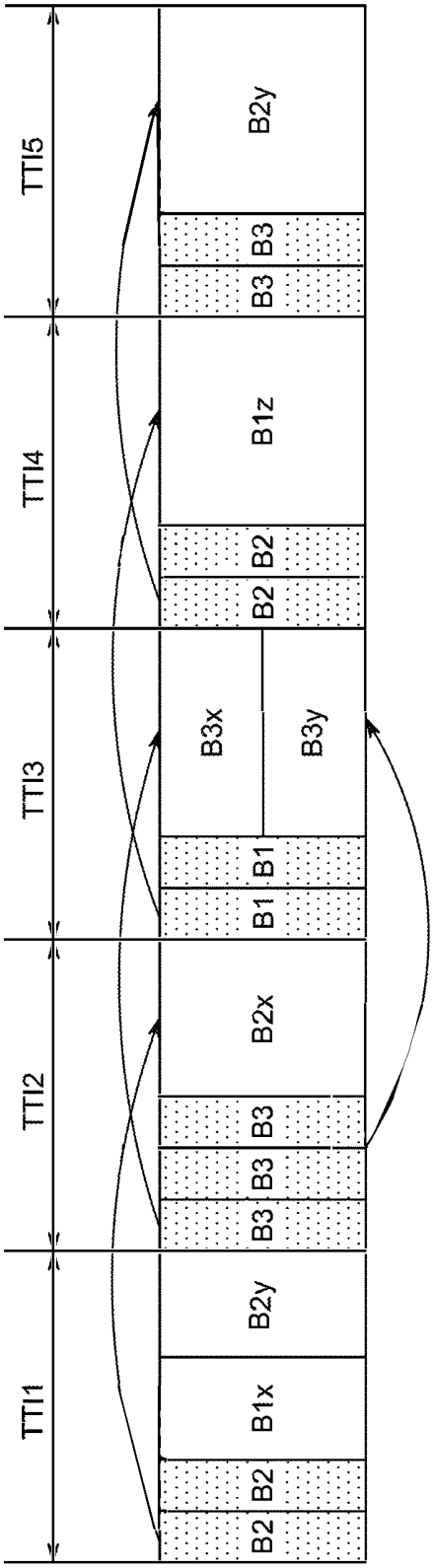

TTI5
TTI4
TTI3
TTI2
TTI1
B2y
B3
B3
B1z
B2
B2
B3x
B3y
B1
B1
B2x
B3
B3
B3
B2y
B1x
B2
B2

FIG. 11

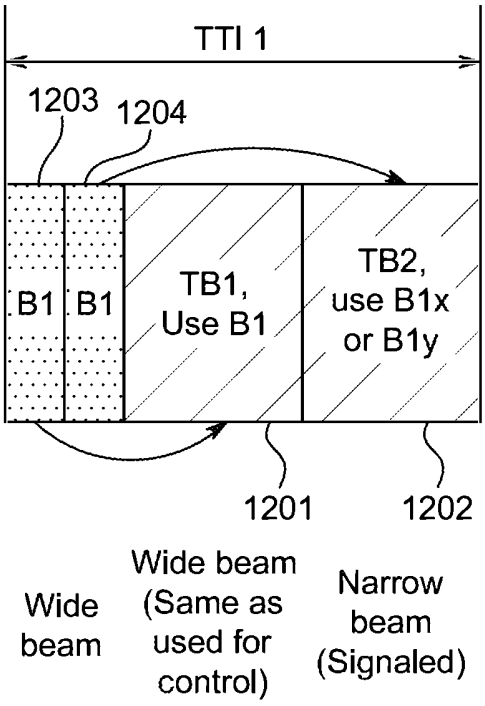

TTI 1
1203
1204
B1
B1
TB1,
Use B1
TB2,
use B1x
or B1y
1201
1202
Wide beam
Wide beam
(Same as
used for
control)
Narrow
beam
(Signaled)

FIG. 12

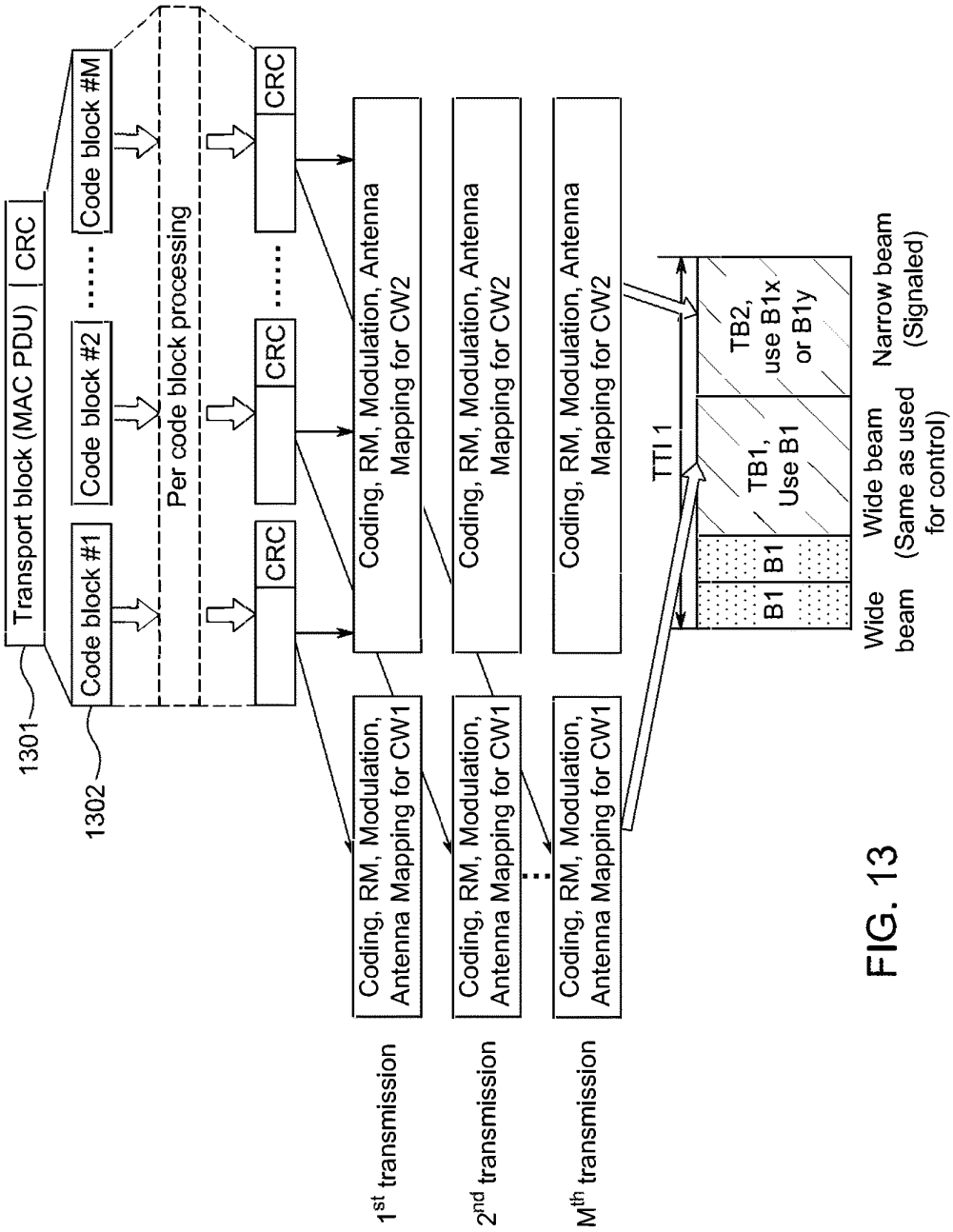

Transport block (MAC PDU)
CRC
Code block #1
Code block #2
Code block #M
Per code block processing
CRC
Coding, RM, Modulation, Antenna Mapping for CW1
Coding, RM, Modulation, Antenna Mapping for CW2
1st transmission
2nd transmission
Mth transmission
TTI 1
TB1, Use B1
TB2, use B1x or B1y
Wide beam
Wide beam (Same as used for control)
Narrow beam (Signaled)
1301
1302

FIG. 13

389

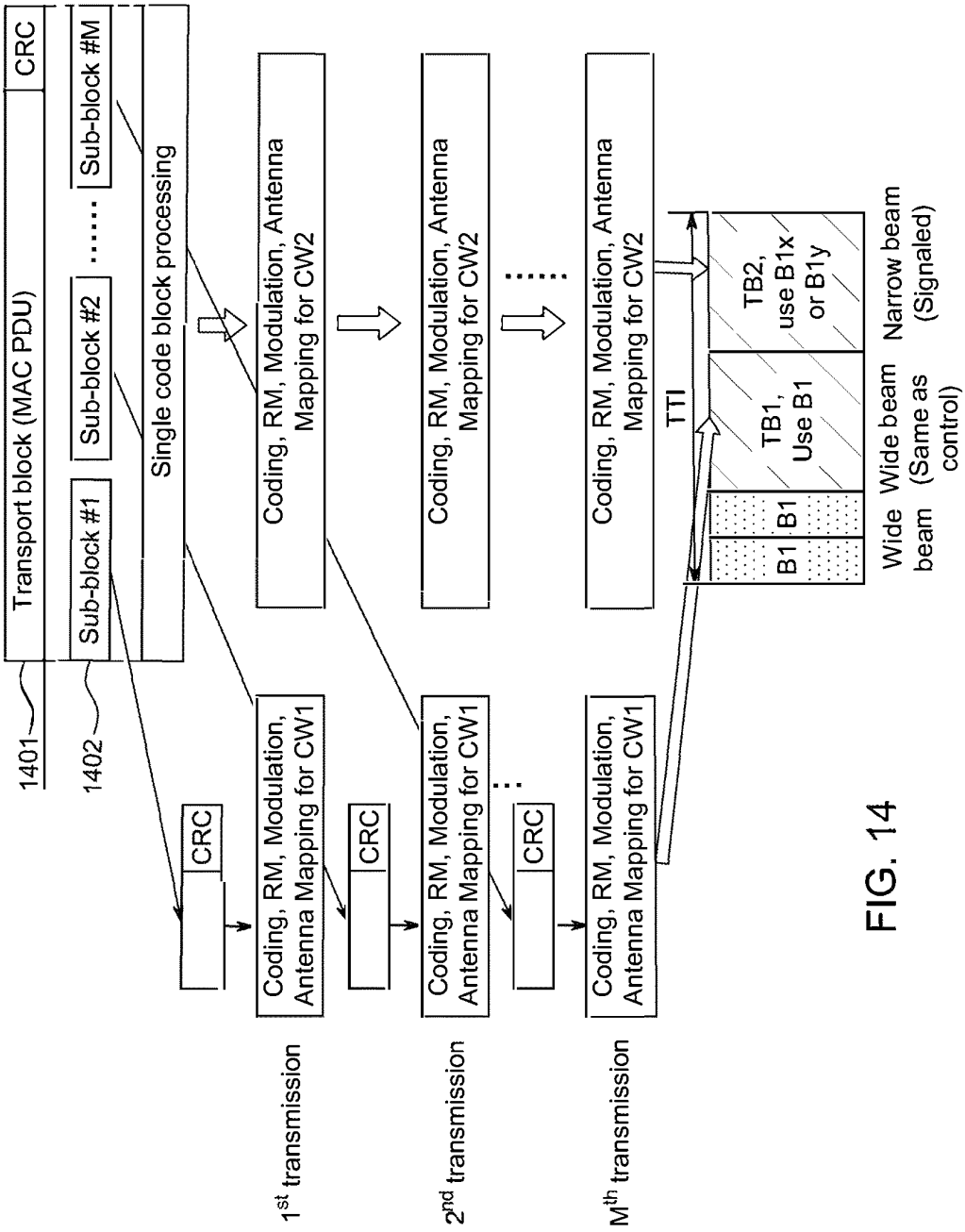

Transport block (MAC PDU)
CRC
Sub-block #1
Sub-block #2
Sub-block #M
Single code block processing
1401
1402
CRC
Coding, RM, Modulation, Antenna Mapping for CW1
Coding, RM, Modulation, Antenna Mapping for CW2
1st transmission
2nd transmission
Mth transmission
TTI
TB1, Use B1
TB2, use B1x or B1y
B1
B1
Wide beam
Wide beam (Same as control)
Narrow beam (Signaled)

FIG. 14

390

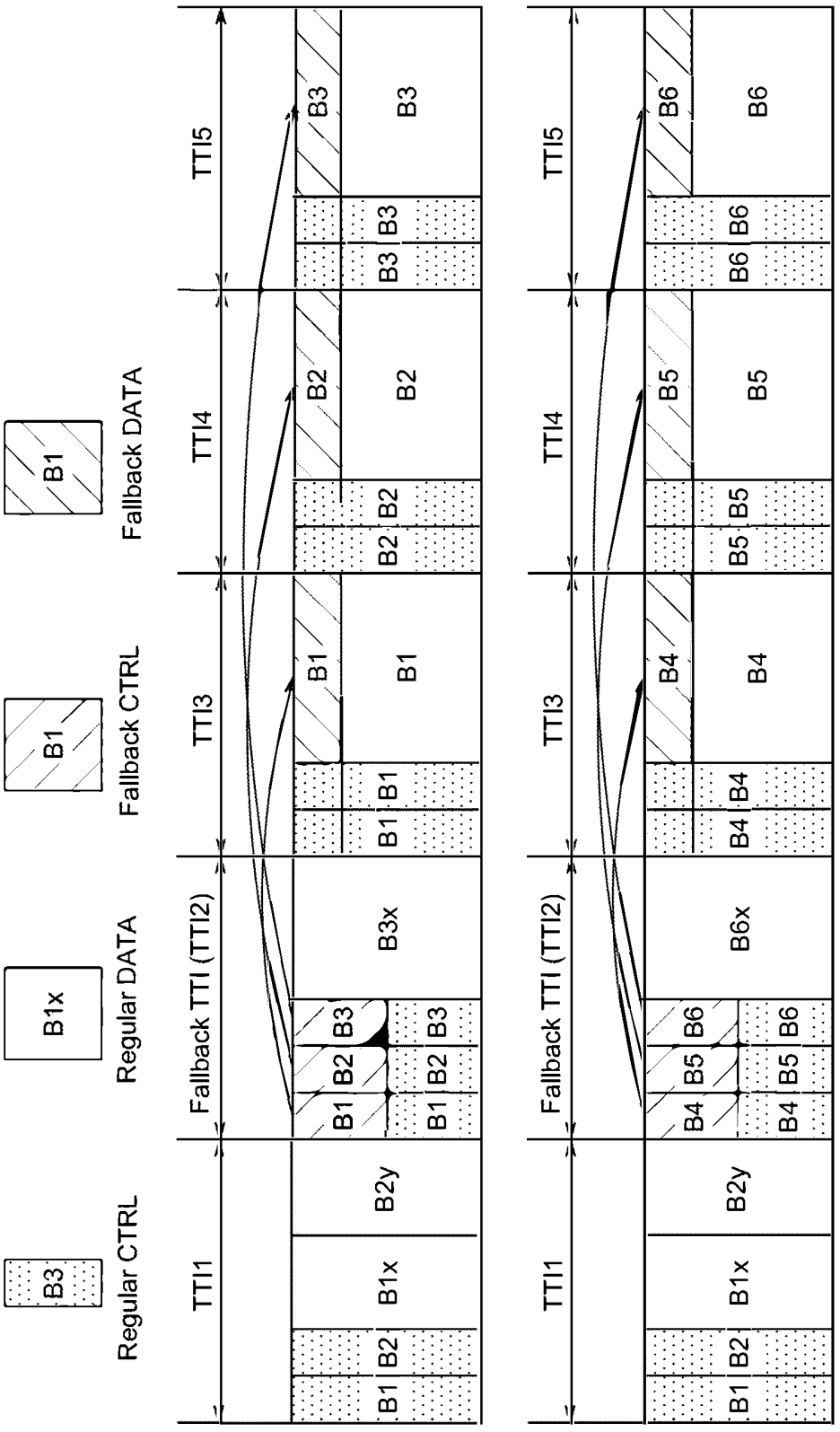

Regular CTRL
Regular DATA
Fallback CTRL
Fallback DATA
B3
B1x
B1
B1
TTI1
TTI2
TTI3
TTI4
TTI5
Fallback TTI (TTI2)
B1 B2
B1x
B2y
B1 B2 B3
B3x
B1 B1
B1
B2 B2
B2
B3 B3
B3
B4 B5 B6
B6x
B4 B4
B4
B5 B5
B5
B6 B6
B6

FIG. 15

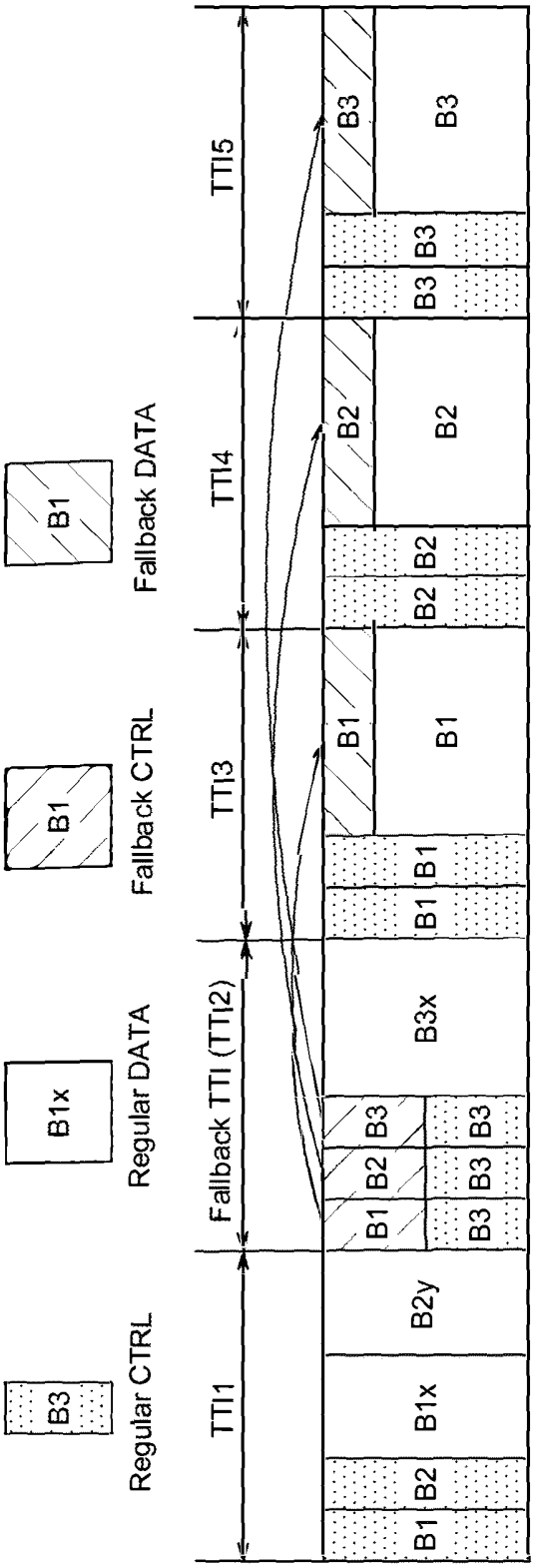

B3
Regular CTRL
B1x
Regular DATA
B1
Fallback CTRL
B1
Fallback DATA
TTI1
TTI2
TTI3
TTI4
TTI5
Fallback TTI (TTI2)
B1
B2
B1x
B2y
B3x
B1
B2
B3

FIG. 16

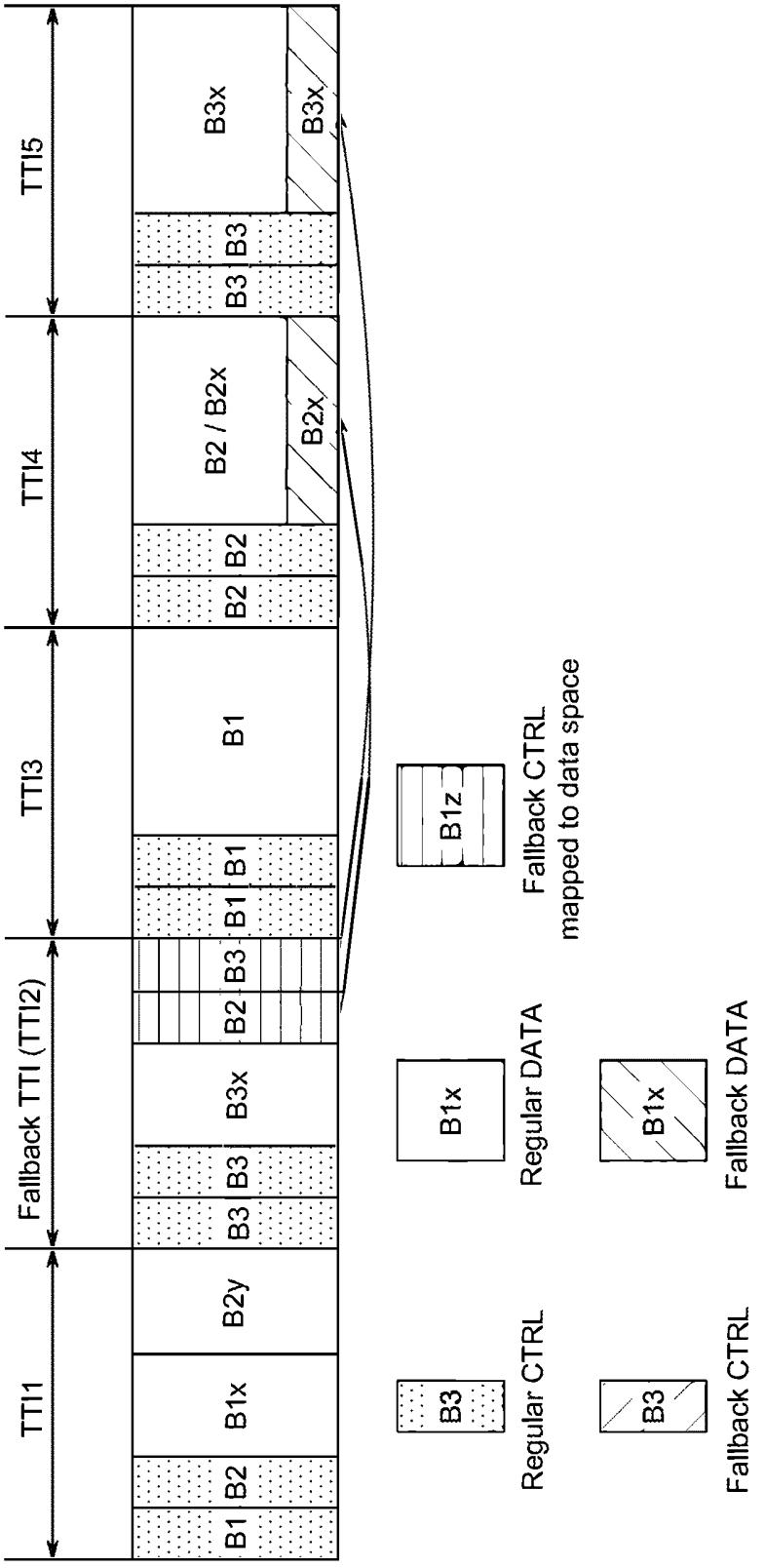

TTI1
TTI2
TTI3
TTI4
TTI5
Fallback TTI (TTI2)
B1
B2
B1x
B2y
B3
B3x
B1z
B2x
B3x
B2 / B2x
Regular CTRL
Regular DATA
Fallback CTRL
Fallback DATA
Fallback CTRL
mapped to data space

FIG. 17

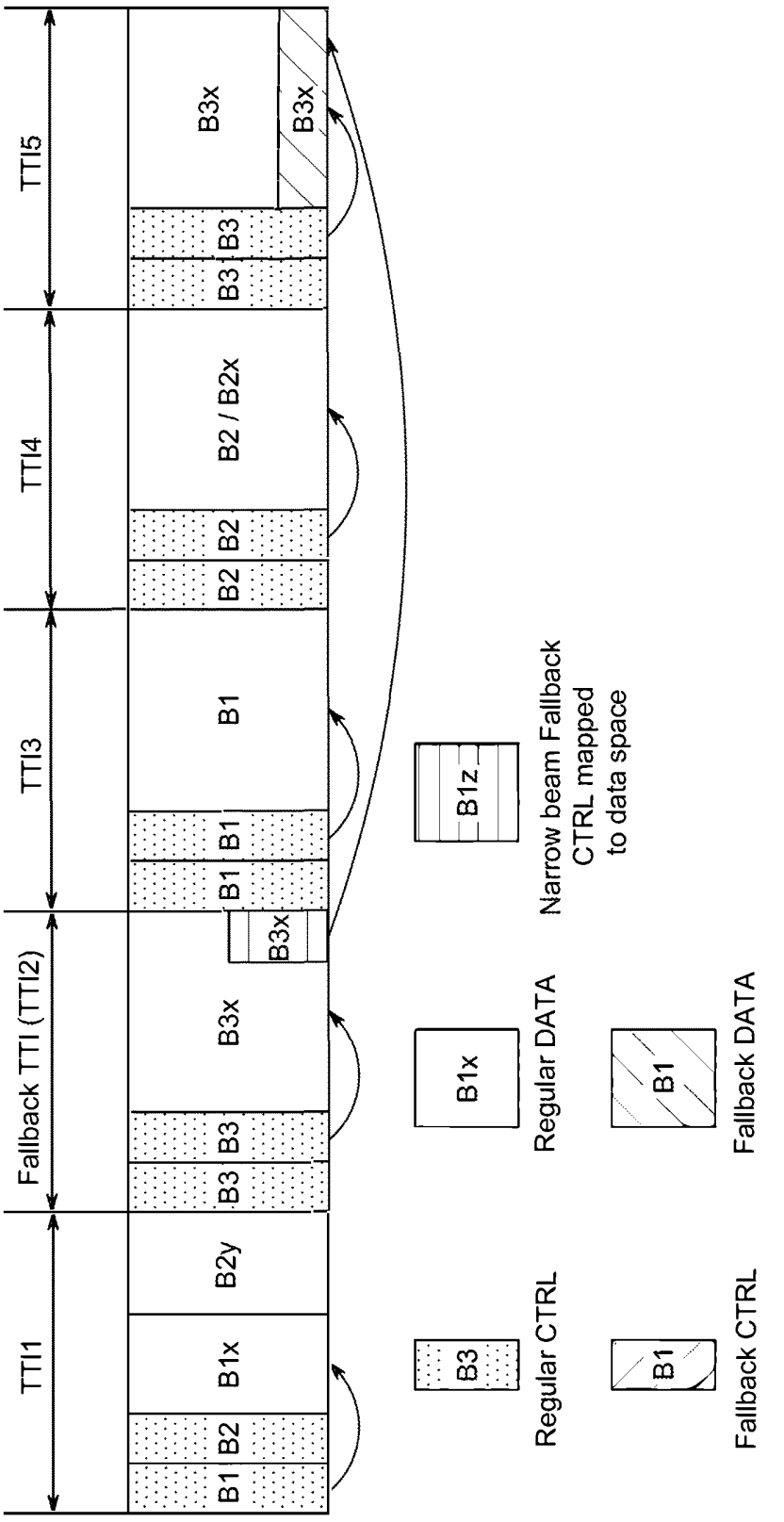

TTI1
TTI2
TTI3
TTI4
TTI5
Fallback TTI (TTI2)
B1
B2
B1x
B2y
B3
B3
B3x
B1
B1
B3x
B2
B2
B2 / B2x
B3
B3
B3x
B3x
B1z
B1x
B1
B3
B1
Narrow beam Fallback CTRL mapped to data space
Regular DATA
Fallback DATA
Regular CTRL
Fallback CTRL

FIG. 18

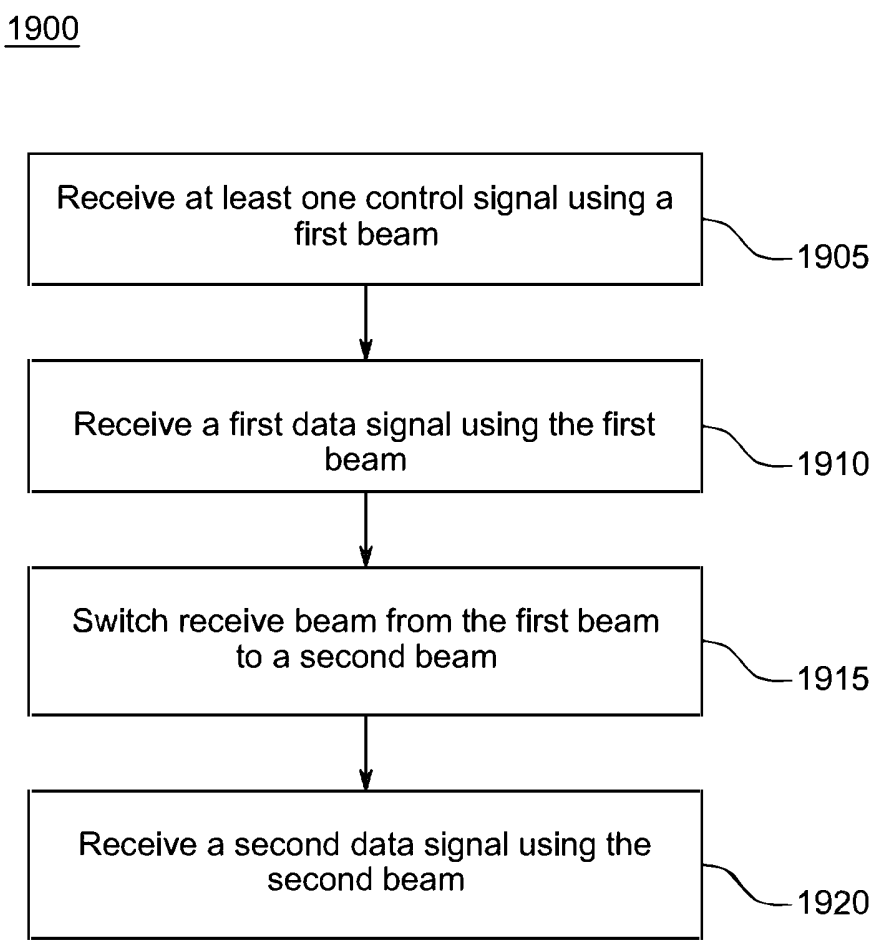

1900
Receive at least one control signal using a first beam
1905
Receive a first data signal using the first beam
1910
Switch receive beam from the first beam to a second beam
1915
Receive a second data signal using the second beam
1920

FIG. 19

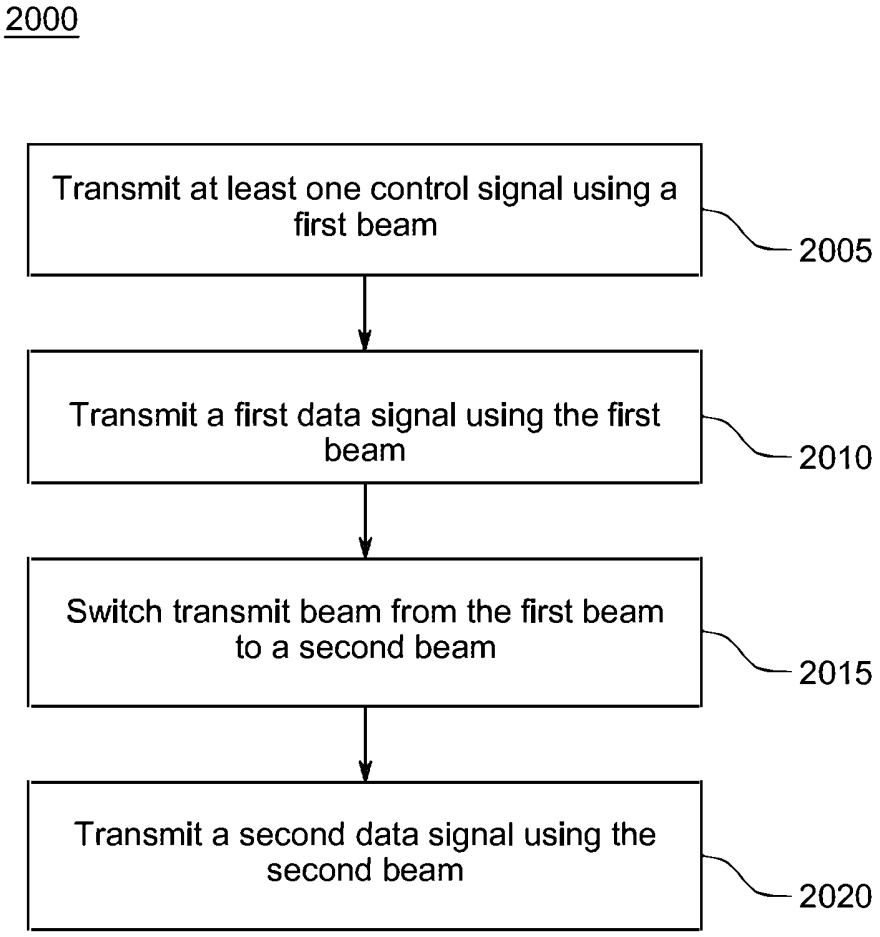

2000
Transmit at least one control signal using a first beam
2005
Transmit a first data signal using the first beam
2010
Switch transmit beam from the first beam to a second beam
2015
Transmit a second data signal using the second beam
2020

FIG. 20

TRANSMISSION SCHEMES AND MODES AND FALLBACK SCHEMES FOR THE ACCESS LINK OF SYSTEMS OPERATING IN HIGHER FREQUENCY BANDS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. provisional application No. 62/253,473 filed Nov. 10, 2015, the content of which is hereby incorporated by reference herein.

BACKGROUND

[0002] In order to meet the high data rate required for next generation of cellular communication systems, the wireless industry and academia have been exploring ways to leverage the large bandwidths available at above-6 GHz frequencies (e.g., centimeter wave (cmW) and millimeter wave (mmW) frequencies). One challenge of using these above-6 GHz frequencies may be issues with signal propagation, which has been considered unfavorable for wireless communication, especially in an outdoor environment.

[0003] The propagation of higher frequencies, such as these, may experience higher free space path loss. Rainfall and atmospheric gasses (e.g., oxygen, nitrogen, and hydrogen) may add further attenuation for above-6 GHz frequencies. In addition, foliage may cause attenuation and depolarization. Penetration and diffraction attenuation may also become more severe. As a result, Non Line-Of-Sight (NLOS) propagation path loss may be significant at above-6 GHz frequencies. For example, at mmW frequencies NLOS path loss may be more than 20 dB higher than Line-Of-Sight (LOS) path loss.

[0004] Outdoor mmW cellular networks may be feasible through the use of beamforming techniques. In addition, a large number of reflected and scattered multipath components (MPC) may be utilized to facilitate the mmW coverage in NLOS conditions.

SUMMARY

[0005] Embodiments provide a system, method, and apparatus for transmitting data between a wireless transmit/receive unit (WTRU) and a base station at a high carrier frequency.

[0006] According to an embodiment, a WTRU is configured to perform wireless communications in higher frequency bands using a fallback scheme. The WTRU includes a receiver configured to receive, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The WTRU further includes a processor configured to switch a receive beam of the receiver from the first beam to the second beam based on the second beam ID to receive the second data signal.

[0007] According to an embodiment, a method implemented by a WTRU includes receiving, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The method further includes switching a receive beam of the WTRU from the first beam to the second beam based on the second beam ID to receive the second data signal.

[0008] According to an embodiment, a wireless communication device is configured to perform wireless communications in higher frequency bands using a fallback scheme. The wireless communication device includes a transmitter configured to transmit, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The wireless communication device further includes a processor configured to switch a transmit beam of the transmitter from the first beam to the second beam based on the second beam ID to transmit the second data signal to a WTRU.

[0009] According to an embodiment, a method implemented in a wireless communication device includes a transmitting, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The method further includes switching a transmit beam of the wireless communication device from the first beam to the second beam based on the second beam ID to transmit the second data signal to a WTRU.

[0010] According to an embodiment, a WTRU is configured to perform wireless communications in higher frequency bands using a fallback scheme. The WTRU includes a receiver configured to receive, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are received using a first beam, and the second transport block is received using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block. The WTRU further includes a processor configured to switch a receive beam of the receiver from the first beam to the second beam, to receive the second transport block, based on beam information associated with the second beam received in one of the at least one control signal.

[0011] According to an embodiment, a method implemented by a WTRU includes receiving, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are received using a first beam, and the second transport block is received using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block. The method further includes switching a receive beam of the WTRU from the first beam to the second beam, to receive the second transport block, based on beam infor-

mation associated with the second beam received in one of the at least one control signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

[0013] FIG. **1**A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented;

[0014] FIG. **1**B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. **1**A;

[0015] FIG. **1**C is a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. **1**A;

[0016] FIG. **2** shows a diagram of an orthogonal frequency-division multiplexing (OFDM) frame structure over a 1-GHz system bandwidth according to one or more embodiments;

[0017] FIG. **3** shows a diagram of a single carrier frame structure over a 2-GHz system bandwidth according to one or more embodiments;

[0018] FIG. **4** shows a diagram illustrating a fully digitized beamforming system according to one or more embodiments;

[0019] FIG. **5** shows a diagram illustrating an analog beamforming system with one phase antenna array (PAA) and one radio frequency (RF) chain according to one or more embodiments;

[0020] FIGS. **6**A and **6**B show a diagram illustrating an analog beamforming system with one PAA and two RF chains according to one or more embodiments;

[0021] FIG. **7** shows a diagram illustrating an analog beamforming system with two PAAs and two RF chains according to one or more embodiments;

[0022] FIG. **8** shows a diagram illustrating an analog beamforming system with two PAAs and a single RF chain according to one or more embodiments;

[0023] FIG. **9** shows a diagram illustrating of a semi-static association between the control transmit (Tx) beam and data Tx beam according to one or more embodiments;

[0024] FIG. **10** shows a diagram illustrating an intra-transmission time interval (TTI) downlink (DL) assignment with a guard period according to one or more embodiments;

[0025] FIG. **11** shows a diagram illustrating a cross-TTI DL assignment with narrow beam indication according to one or more embodiments;

[0026] FIG. **12** shows a diagram for a dual transport block (TB) transmission scheme according to one or more embodiments;

[0027] FIG. **13** shows a diagram illustrating a use of a dual TB transmission scheme for data fallback according to one or more embodiments;

[0028] FIG. **14** shows a diagram illustrating another example of using a dual TB transmission scheme for data fallback according to one or more embodiments;

[0029] FIG. **15** shows a diagram illustrating an example of fallback TTI and linkage between fallback downlink control information (DCI) and fallback data, where the mB supports one RF chain according to one or more embodiments;

[0030] FIG. **16** shows a diagram illustrating an example of fallback TTI and linkage between fallback DCI and fallback data, where the mB supports multiple RF chains according to one or more embodiments;

[0031] FIG. **17** shows a diagram of fallback DCI mapped to the data region, and linkage to fallback data according to one or more embodiments;

[0032] FIG. **18** shows a diagram illustrating fallback DCI mapped to the data region using narrow beam transmission according to one or more embodiments;

[0033] FIG. **19** shows a flow diagram utilizing a dual TB transmission scheme according to one or more embodiments; and

[0034] FIG. **20** shows a flow diagram utilizing a dual TB transmission scheme according to one or more embodiments.

DETAILED DESCRIPTION

[0035] Embodiments described herein may define transmission modes (including reference signals and channel state information (CSI) feedback) and transmission schemes for operation of highly directional beamformed systems. In addition, embodiments may define how to mitigate control and/or data channel performance loss due to narrow beam misalignment, for systems operating in higher frequency bands (e.g. above-6 GHz frequencies).

[0036] The latter problem can further be broken down into two different scenarios. In the first scenario, a change in the wireless transmit/receive unit (WTRU) orientation may be such that the data channel performance using a narrow beam pair may be significantly degraded, while the downlink (DL) wide beam control channel may still be received by the WTRU. In the second scenario, the WTRU orientation change may be such that both the data and the control channels may not be received by the WTRU.

[0037] Embodiments may include downlink/uplink (DL/UL) transmission schemes for the access link of beamformed systems operating in the high frequency bands (e.g., above 6 GHz) using one or multiple radio frequency (RF) chains. In addition embodiments may define DL/UL transmission modes and modes of operations.

[0038] In addition to presenting transmission schemes and transmission modes for above 6 GHz systems, embodiments described herein may include various scenarios where significant degradation of the control and/or data channel performance may occur due to transmit-receive (Tx-Rx) beam misalignment. Embodiments may addresses techniques for control and data fallback to maintain connectivity until a transmission mode change or a beam change is performed.

[0039] FIG. **1**A is a diagram of an example communications system **100** in which one or more disclosed embodiments may be implemented. The communications system **100** may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system **100** may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems **100** may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), and the like.

[0040] As shown in FIG. **1**A, the communications system **100** may include wireless transmit/receive units (WTRUs)

102*a*, **102***b*, **102***c*, **102***d*, a radio access network (RAN) **104**, a core network **106**, a public switched telephone network (PSTN) **108**, the Internet **110**, and other networks **112**, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs **102***a*, **102***b*, **102***c*, **102***d* may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs **102***a*, **102***b*, **102***c*, **102***d* may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0041] The communications systems **100** may also include a base station **114***a* and a base station **114***b*. Each of the base stations **114***a*, **114***b* may be any type of device configured to wirelessly interface with at least one of the WTRUs **102***a*, **102***b*, **102***c*, **102***d* to facilitate access to one or more communication networks, such as the core network **106**, the Internet **110**, and/or the other networks **112**. By way of example, the base stations **114***a*, **114***b* may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a site controller, an access point (AP), a wireless router, and the like. While the base stations **114***a*, **114***b* are each depicted as a single element, it will be appreciated that the base stations **114***a*, **114***b* may include any number of interconnected base stations and/or network elements.

[0042] The base station **114***a* may be part of the RAN **104**, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station **114***a* and/or the base station **114***b* may be configured to transmit and/or receive wireless signals within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station **114***a* may be divided into three sectors. Thus, in one embodiment, the base station **114***a* may include three transceivers, i.e., one for each sector of the cell. In another embodiment, the base station **114***a* may employ multiple-input multiple-output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0043] The base stations **114***a*, **114***b* may communicate with one or more of the WTRUs **102***a*, **102***b*, **102***c*, **102***d* over an air interface **116**, which may be any suitable wireless communication link (e.g., radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface **116** may be established using any suitable radio access technology (RAT).

[0044] More specifically, as noted above, the communications system **100** may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station **114***a* in the RAN **104** and the WTRUs **102***a*, **102***b*, **102***c* may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface **116** using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0045] In another embodiment, the base station **114***a* and the WTRUs **102***a*, **102***b*, **102***c* may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface **116** using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0046] In other embodiments, the base station **114***a* and the WTRUs **102***a*, **102***b*, **102***c* may implement radio technologies such as IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1×, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0047] The base station **114***b* in FIG. **1**A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, and the like. In one embodiment, the base station **114***b* and the WTRUs **102***c*, **102***d* may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In another embodiment, the base station **114***b* and the WTRUs **102***c*, **102***d* may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station **114***b* and the WTRUs **102***c*, **102***d* may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, etc.) to establish a picocell or femtocell. As shown in FIG. **1**A, the base station **114***b* may have a direct connection to the Internet **110**. Thus, the base station **114***b* may not be required to access the Internet **110** via the core network **106**.

[0048] The RAN **104** may be in communication with the core network **106**, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs **102***a*, **102***b*, **102***c*, **102***d*. For example, the core network **106** may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. **1**A, it will be appreciated that the RAN **104** and/or the core network **106** may be in direct or indirect communication with other RANs that employ the same RAT as the RAN **104** or a different RAT. For example, in addition to being connected to the RAN **104**, which may be utilizing an E-UTRA radio technology, the core network **106** may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0049] The core network **106** may also serve as a gateway for the WTRUs **102***a*, **102***b*, **102***c*, **102***d* to access the PSTN **108**, the Internet **110**, and/or other networks **112**. The PSTN **108** may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet **110** may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and the internet protocol (IP) in the TCP/IP internet protocol suite. The networks **112** may include wired or wireless communications networks owned and/or operated by other service providers. For example, the

networks **112** may include another core network connected to one or more RANs, which may employ the same RAT as the RAN **104** or a different RAT.

[0050] One or more of the WTRUs **102***a*, **102***b*, **102***c*, **102***d* in the communications system **100** may include multi-mode capabilities, i.e., the WTRUs **102***a*, **102***b*, **102***c*, **102***d* may include multiple transceivers for communicating with different wireless networks over different wireless links. For example, the WTRU **102***c* shown in FIG. **1**A may be configured to communicate with the base station **114***a*, which may employ a cellular-based radio technology, and with the base station **114***b*, which may employ an IEEE 802 radio technology.

[0051] FIG. **1**B is a system diagram of an example WTRU **102**. As shown in FIG. **1**B, the WTRU **102** may include a processor **118**, a transceiver **120**, a transmit/receive element **122**, a speaker/microphone **124**, a keypad **126**, a display/touchpad **128**, non-removable memory **130**, removable memory **132**, a power source **134**, a global positioning system (GPS) chipset **136**, and other peripherals **138**. It will be appreciated that the WTRU **102** may include any sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0052] The processor **118** may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Array (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor **118** may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU **102** to operate in a wireless environment. The processor **118** may be coupled to the transceiver **120**, which may be coupled to the transmit/receive element **122**. While FIG. **1**B depicts the processor **118** and the transceiver **120** as separate components, it will be appreciated that the processor **118** and the transceiver **120** may be integrated together in an electronic package or chip.

[0053] The transceiver **120**, or any part thereof, may be configured to align its transmit beam, for transmitting an uplink transmission, with a receive beam of an eNode-B. Similarly, the transceiver **120**, or any part thereof, may be configured to align its receive beam, for receiving a downlink transmission, with a transmit beam of the eNode-B. The processor **118** may further be configured to determine a transmit beam and/or receive beam (e.g., based on received configuration or control information) for the transceiver **120** to use, and configure the transceiver **120** accordingly for communicating with the eNode-B.

[0054] The transmit/receive element **122** may be configured to transmit signals to, or receive signals from, a base station (e.g., the base station **114***a*) over the air interface **116**. For example, in one embodiment, the transmit/receive element **122** may be an antenna configured to transmit and/or receive RF signals. In another embodiment, the transmit/receive element **122** may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element **122** may be configured to transmit and receive both RF and light signals. It will be appreciated that the transmit/receive element **122** may be configured to transmit and/or receive any combination of wireless signals.

[0055] In addition, although the transmit/receive element **122** is depicted in FIG. **1**B as a single element, the WTRU **102** may include any number of transmit/receive elements **122**. More specifically, the WTRU **102** may employ MIMO technology. Thus, in one embodiment, the WTRU **102** may include two or more transmit/receive elements **122** (e.g., multiple antennas) for transmitting and receiving wireless signals over the air interface **116**.

[0056] The transceiver **120** may be configured to modulate the signals that are to be transmitted by the transmit/receive element **122** and to demodulate the signals that are received by the transmit/receive element **122**. As noted above, the WTRU **102** may have multi-mode capabilities. Thus, the transceiver **120** may include multiple transceivers for enabling the WTRU **102** to communicate via multiple RATs, such as UTRA and IEEE 802.11, for example.

[0057] The processor **118** of the WTRU **102** may be coupled to, and may receive user input data from, the speaker/microphone **124**, the keypad **126**, and/or the display/touchpad **128** (e.g., a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor **118** may also output user data to the speaker/microphone **124**, the keypad **126**, and/or the display/touchpad **128**. In addition, the processor **118** may access information from, and store data in, any type of suitable memory, such as the non-removable memory **130** and/or the removable memory **132**. The non-removable memory **130** may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory **132** may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor **118** may access information from, and store data in, memory that is not physically located on the WTRU **102**, such as on a server or a home computer (not shown).

[0058] The processor **118** may receive power from the power source **134**, and may be configured to distribute and/or control the power to the other components in the WTRU **102**. The power source **134** may be any suitable device for powering the WTRU **102**. For example, the power source **134** may include one or more dry cell batteries (e.g., nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NIMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0059] The processor **118** may also be coupled to the GPS chipset **136**, which may be configured to provide location information (e.g., longitude and latitude) regarding the current location of the WTRU **102**. In addition to, or in lieu of, the information from the GPS chipset **136**, the WTRU **102** may receive location information over the air interface **116** from a base station (e.g., base stations **114***a*, **114***b*) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU **102** may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0060] The processor **118** may further be coupled to other peripherals **138**, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals **138** may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs or video), a universal serial bus (USB) port, a

vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, and the like.

[0061] FIG. **1**C is a system diagram of the RAN **104** and the core network **106** according to an embodiment. As noted above, the RAN **104** may employ an E-UTRA radio technology to communicate with the WTRUs **102***a*, **102***b*, **102***c* over the air interface **116**. The RAN **104** may also be in communication with the core network **106**.

[0062] The RAN **104** may include eNode-Bs **140***a*, **140***b*, **140***c*, though it will be appreciated that the RAN **104** may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs **140***a*, **140***b*, **140***c* may each include one or more transceivers for communicating with the WTRUs **102***a*, **102***b*, **102***c* over the air interface **116**. In one embodiment, the eNode-Bs **140***a*, **140***b*, **140***c* may implement MIMO technology. Thus, the eNode-B **140***a*, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU **102***a*.

[0063] Each of the eNode-Bs **140***a*, **140***b*, **140***c* may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink and/or downlink, and the like. As shown in FIG. **1**C, the eNode-Bs **140***a*, **140***b*, **140***c* may communicate with one another over an X2 interface.

[0064] The core network **106** shown in FIG. **1**C may include a mobility management entity gateway (MME) **142**, a serving gateway **144**, and a packet data network (PDN) gateway **146**. While each of the foregoing elements are depicted as part of the core network **106**, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0065] The MME **142** may be connected to each of the eNode-Bs **140***a*, **140***b*, **140***c* in the RAN **104** via an S1 interface and may serve as a control node. For example, the MME **142** may be responsible for authenticating users of the WTRUs **102***a*, **102***b*, **102***c*, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs **102***a*, **102***b*, **102***c*, and the like. The MME **142** may also provide a control plane function for switching between the RAN **104** and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0066] The serving gateway **144** may be connected to each of the eNode Bs **140***a*, **140***b*, **140***c* in the RAN **104** via the S1 interface. The serving gateway **144** may generally route and forward user data packets to/from the WTRUs **102***a*, **102***b*, **102***c*. The serving gateway **144** may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs **102***a*, **102***b*, **102***c*, managing and storing contexts of the WTRUs **102***a*, **102***b*, **102***c*, and the like.

[0067] The serving gateway **144** may also be connected to the PDN gateway **146**, which may provide the WTRUs **102***a*, **102***b*, **102***c* with access to packet-switched networks, such as the Internet **110**, to facilitate communications between the WTRUs **102***a*, **102***b*, **102***c* and IP-enabled devices.

[0068] The core network **106** may facilitate communications with other networks. For example, the core network **106** may provide the WTRUs **102***a*, **102***b*, **102***c* with access to circuit-switched networks, such as the PSTN **108**, to facilitate communications between the WTRUs **102***a*, **102***b*, **102***c* and traditional land-line communications devices. For example, the core network **106** may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the core network **106** and the PSTN **108**. In addition, the core network **106** may provide the WTRUs **102***a*, **102***b*, **102***c* with access to the networks **112**, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0069] Other network **112** may further be connected to an IEEE 802.11 based wireless local area network (WLAN) **160**. The WLAN 160 may include an access router **165**. The access router may contain gateway functionality. The access router **165** may be in communication with a plurality of access points (APs) **170***a*, **170***b*. The communication between access router **165** and APs **170***a*, **170***b* may be via wired Ethernet (IEEE 802.3 standards), or any type of wireless communication protocol. AP **170***a* is in wireless communication over an air interface with WTRU **102***d*.

[0070] It should be noted that although 3GPP LTE may be used for example purposes, the techniques described herein may be applied to any other system.

[0071] The following list of definitions, although not intended to be limiting, may be helpful in understanding the following embodiments.

[0072] A "beam" may be one lobe (e.g. main/side/grating) of a transmit radiation pattern and receive gain pattern of an antenna array. The beam may also denote a spatial direction that may be represented with a set beamforming weights. The beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), and/or a scrambling sequence number. The beam may be transmitted and/or received at a specific time, frequency, code, and/or spatial resource. The beam may be formed digitally, in an analog manner, or both (i.e., hybrid beamforming). The analog beamforming may be based on fixed code-book or continuous phase shifting.

[0073] A "beam-specific reference signal" (BSRS) may be a sequence associated with a transmit beam used for beam acquisition, timing and/or frequency synchronization, channel estimation for a physical downlink directional control channel (PDDCCH), fine beam tracking, beam measurement, etc. BSRS may carry (e.g., implicitly carry) beam identity information. There may be different types of BSRS. For example, there may be BSRS for an mmW sector and its member segments. The segment may be referred as a beam direction (e.g., a narrow beam direction or a wide beam direction).

[0074] A "data channel beam" may be used to transmit a data channel, a Physical Downlink Shared Channel (PDSCH), a mPDSCH, a mmW PDSCH, a mmW data channel, a directional PDSCH, a beamformed data channel, a spatial data channel, a data channel slice, or a high frequency data channel. The data channel beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), and/or a scrambling sequence number. The data channel beam may be transmitted and/or received at a specific time, frequency, code, and/or spatial resource.

[0075] A "control channel beam" may be used to transmit a control channel, a control channel beam, a PDCCH, an mPDCCH, an mmW PDCCH, an mmW control channel, a

directional PDCCH, a beamformed control channel, a spatial control channel, a control channel slice or a high frequency control channel. A control channel beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), a scrambling sequence number and may be transmitted and/or received at a specific time and/or frequency and/or code and/or spatial resources.

[0076] A "measurement beam" may be used to transmit a signal or channel for beam measurement. This may include a beam reference signal, a beam measurement reference signal, Cell Specific Reference Signal (CRS), Channel State Information-Reference Signal (CSI-RS), CSI-interference measurement (CSI-IM), etc. The measurement beam may be identified or associated with a reference signal, an antenna port, a beam identity (ID), and/or a scrambling sequence number. The measurement beam may be transmitted and/or received at a specific time, frequency, code, and/or spatial resource.

[0077] A "control channel beam duration" may be the length of time, which may be referred to in units of OFDM symbols, used within a scheduling interval for the transmission of one control channel beam.

[0078] A "control region" may be the length in the of time domain, which may be referred to in units of OFDM symbols, used within a scheduling interval for the transmission of all the control channel beams in that scheduling interval. For example, a control region may be the number of OFDM symbols in a TTI occupied by all the control channel beams transmitted in the TTI.

[0079] A "data region" may be part of the scheduling interval in time domain, which may be referred to in units of OFDM symbols, used for the transmission of all data channel beams in that scheduling interval.

[0080] A "data fallback" may be an alternate scheme for data transmission, that may be used dynamically, irrespective of the transmission mode, to maintain the data communication between the base station and the WTRU. Data fallback schemes may be used in either downlink (DL), or uplink (UL), or both.

[0081] A "control fallback" may be an alternate scheme for signaling the control channel, that may be used dynamically, irrespective of the transmission mode, to maintain the control signaling between the base station and the WTRU.

[0082] In some embodiments described herein, the terms base station, eNode-B (eNB), mmW eNB (mB), Small Cell mmW eNB (SCmB), cell, small cell, primary cell (Pcell), and secondary cell (Scell) may be used interchangeably. In some embodiments, the term operate may be used interchangeably with transmit and/or receive. In some embodiments, the terms component carrier, mmW carrier may be used interchangeably with serving cell.

[0083] In some embodiments, the mB may transmit and/or receive one or more mmW channels and/or signals in a licensed band and/or an unlicensed band. In some embodiments, the WTRU may be substituted for eNB and/or vice versa and still be consistent with this disclosure. In some embodiments, UL may be substituted for DL and/or vice versa and still be consistent with this disclosure.

[0084] In some embodiments, a channel may refer to a frequency band that may have a center, or carrier frequency, and a bandwidth. Licensed and/or unlicensed spectrum may include one or more channels which may or may not overlap. Channel, frequency channel, wireless channel, and mmW channel may be used interchangeably. Accessing a channel may be the same as using (e.g., transmitting and/or receiving on or using) the channel.

[0085] In some embodiments, a channel refers to a mmW channel or signal, such as an uplink or downlink physical channel or signal. Downlink channels and signals may include one or more of the following: mmW synchronization signal, mmW broadcast channel, mmW cell reference signal, mmW beam reference signal, mmW beam control channel, mmW beam data channel, mmW hybrid automatic repeat request (ARQ) indicator channel, mmW demodulation reference signal, primary synchronization signal (PSS), secondary synchronization signal (SSS), demodulation reference signal (DMRS), CRS, CSI-RS, Physical Broadcast Channel (PBCH), Physical downlink Control Channel (PDCCH), Physical Hybrid ARQ Indicator Channel (PHICH), Enhanced Physical Downlink Control Channel (EPDCCH), and PDSCH. Uplink channels and signals may include one or more of the following: mmW Physical Random Access Channel (PRACH), mmW control channel, mmW data channel, mmW beam reference signal, mmW demodulation reference signal, PRACH, Physical Uplink Control Channel (PUCCH), sounding reference signal (SRS), DMRS and Physical Uplink Shared Channel (PUSCH). Channel and mmW channel may be used interchangeably. Channels and signals may be used interchangeably.

[0086] In some embodiments data/control may mean data and/or control signals and/or channels. Control may include synchronization. The data/control may be mmW data/control. Data/control and data/control channels and/or signals may be used interchangeably. Channels and signals may be used interchangeably. The terms control channel, control channel beam, PDCCH, mPDCCH, mmW PDCCH, mmW control channel, directional PDCCH, beamformed control channel, spatial control channel, control channel slice, high frequency control channel may be used interchangeably. The terms data channel, data channel beam, PDSCH, mPDSCH, mmW PDSCH, mmW data channel, directional PDSCH, beamformed data channel, spatial data channel, data channel slice, and high frequency data channel may be used interchangeably.

[0087] In some embodiments, channel resources may be resources (e.g., 3GPP LTE or LTE-A resources) such as time, frequency, code, and/or spatial resources, which may, at least sometimes, carry one or more channels and/or signals. In some embodiments, channel resources may be used interchangeably with channels and/or signals.

[0088] The terms mmW beam reference signal, mmW reference resource for beam measurement, mmW measurement reference signal, mmW channel state measurement reference signal, mmW demodulation reference signal, mmW sounding reference signal, reference signal, CSI-RS, CRS, DM-RS, DRS, measurement reference signal, reference resource for measurement, CSI-IM, and measurement RS may be used interchangeably. mmW cell, mmW small cell, SCell, secondary cell, license-assisted cell, unlicensed cell, and Licensed Assisted Access (LAA) cell may be used interchangeably. The terms mmW cell, mmW small cell, PCell, primary cell, LTE cell, and licensed cell may be used interchangeably.

[0089] The terms interference and interference plus noise may be used interchangeably.

[0090] Multiple above-6 GHz frequency bands have been evaluated for next generation cellular networks. For example, 10 GHz and 15 GHz bands have been evaluated at

the cmW frequency band. In addition, 28 GHz, 39 GHz, 60 GHz and 73 GHz bands have been evaluated at the mmW frequency band. These higher frequency bands may be allocated as licensed, lightly licensed, and unlicensed spectrums.

[0091] Depending on the allocation of the spectrum and its propagation characteristics, the above-6 GHz frequency bands may be deployed in various cellular network configurations. For example, mmW frequencies may be used for a homogenous network with mmW stand-alone Macro-, Micro- and Small Cell base stations. A heterogeneous network may consist of a mmW stand-alone small cell network overlaid with a LTE Macro- and/or Micro-network at sub-6 GHz frequencies. In such a network, a network node may be connected to both above-6 GHz frequencies (e.g., a mmW system) and below-6 GHz frequencies (e.g., a 2 GHz LTE system), which may be referred as Dual Connectivity. Carrier aggregation may be applied to combine above-6 GHz carriers (e.g., mmW) and sub-6 GHz carriers (e.g., 2 GHz LTE carriers).

[0092] Embodiments described herein may apply to any above-6 GHz cellular deployment.

[0093] Waveforms, such as, for example, orthogonal frequency-division modulation (OFDM), broad-band Single Carrier (SC), SC-OFDM, Generalized OFDM, Filter Bank Multicarrier (FBMC), and Multi-Carrier Code Division Multiple Access (MC-CDMA) may be used for above-6 GHz systems. Waveforms may have different Peak to Average Power Ratio (PAPR) performance, sensitivity to transmitter non-linearity, Bit Error Rate (BER) performance, resource channelization, and implementation complexity.

[0094] While frame structure may depend on the applied waveform, it may also be dimensioned to meet the above-6 GHz system requirement. For example, in order to achieve very low latency, a higher-frequency cellular system may have a subframe length of 100 μs.

[0095] Referring to FIG. **2**, FIG. **2** shows a diagram of an OFDM frame structure **200** over a 1-GHz system bandwidth. According to the OFDM-based frame structure **200** shown in FIG. **2**, a frame **202** includes 10 sub-frames, each sub-frame includes 10 slots, and each slot includes 24 symbols. The OFDM-based frame structure **200** may have, for example, a sub-carrier spacing of 300 kHz with a corresponding symbol length (T_{symbol}) of 3.33 μs. Considering a cyclic prefix (CP) length may span over the entire length of the channel time dispersion in order to eliminate the inter-symbol-interference, one example of CP for a T_{symbol} of 3.33 μs may be selected at ¼ of T_{symbol} (i.e., at 0.833 μs). This example numerology may be used for a range of above-6 GHz system bandwidths (e.g., from 50 MHz to 2 GHz) with corresponding Fast Fourier Transform (FFT) length.

[0096] Referring now to FIG. **3**, FIG. **3** shows a diagram of a single carrier frame structure **300** over a 2-GHz system bandwidth. Another frame structure may be based on single carrier over an entire system bandwidth. The system bandwidth may range from 50 MHz to 2 GHz. One such example may be based on 2 GHz bandwidth. The sampling frequency F_s may be 1.536 GHz with a 1024-FFT. A subframe **302** may include 10 time slots each of which may be 100 μs and may have 150 single carrier (FFT) blocks. Each single carrier block may have 1024 symbols that can be used for synchronization, reference, control, data, cyclic prefix or other system purposes.

[0097] An above-6 GHz system (e.g., cmW and mmW systems) may apply any waveform and frame structure or combination thereof as discussed above. Procedures described in this disclosure may apply to all these waveform and frame structure selections.

[0098] Above-6 GHz systems may use Frequency Division Duplex (FDD), Time Division Duplex (TDD), Spatial Division Duplex (SDD) or any combination of them in conjunction with either half-duplex or full-duplex mechanisms.

[0099] A full-duplex FDD system may use a duplex filter to allow simultaneous downlink and uplink operation at different frequencies separated by a duplex distance. A half-duplex FDD system may not use a duplex filter, as the downlink and uplink operation may take place at different time instance in its dedicated frequency. A TDD system may have the downlink and uplink operate at the same frequency at different time instances. A SDD system, for example, in a beamformed system, may enable a network node to transmit and receive at a same frequency and time instance but at different outgoing and incoming spatial directions.

[0100] An above-6 GHz network may use Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Spatial Division Multiple Access (SDMA), Code Division Multiple Access (CDMA), Non-Orthogonal Multiple Access (NOMA), or any combination thereof. FDMA, TDMA, SDMA and CDMA may be applied in an orthogonal manner to avoid interference.

[0101] Multiple network nodes may be assigned to use different frequency resources simultaneously in a FDMA system, or to access the system frequency resources at different time instances in a TDMA system. Moreover the network nodes may access the same frequency resources at the same time, but may use a different code in a CDMA system. A SDMA system may assign a spatial resource to network nodes to operate at same frequency, time, and code resource. In a beamformed network, WTRUs may use different beams.

[0102] In a NOMA system, multiple network nodes may be assigned overlapping or identical resources in frequency, time, code or spatial domain, but may apply additional mechanisms to remove interference caused by the non-orthogonal use of the resource between users. For example, two WTRUs may be located relatively far from each other, and the difference of their path loss to the base station may be large. They may be assigned with the same frequency resource in the same subframe with very different transport formats. Superposition coding and a Successive Interference Rejection (SIC) receiver may be used for a WTRU to remove the received signal intended for the other.

[0103] An above-6 GHz system (e.g., cmW and mmW systems) may apply any duplex scheme and multiple access or combination of them as discussed above. Embodiments described herein may apply to all these duplex schemes and multiple access schemes.

[0104] An above-6 GHz system may have a number of physical channels and signals for various system purposes. Certain signals may be used for multiple system procedures.

[0105] The following are examples of downlink physical channels and signals.

[0106] A synchronization signal may be a pre-defined signal that may be used for cell timing/frequency synchronization. It may be transmitted according to pre-defined

periodicity. In a beamformed system, the signal may provide beam timing and frequency acquisition.

[0107] A physical broadcast channel may carry broadcast information, such as cell specific system information.

[0108] A downlink reference signal may be a pre-defined sequence transmitted to enable various system procedures (e.g., channel estimation for control channel, channel statement measurement, timing and frequency fine-tuning, system measurement, and the like). There may be different types of reference signals. In a beamformed system, a downlink reference signal may be used for beam acquisition, beam pairing, beam tracking, beam switch, beam measurement, and the like.

[0109] A physical downlink control channel may carry data related control information to identify, demodulate and decode the associated data channel properly.

[0110] A physical downlink data channel may carry payload information in the form of Medium Access Control (MAC) Protocol Data Unit (PDU) from the MAC layer. The resource allocation of this channel may be carried in the scheduling information in the physical downlink control channel.

[0111] A data demodulation reference signal may have symbols that may be transmitted for channel estimation of downlink control or data channel. The symbols may be placed together with the associated control or data symbols in the time and frequency domain according to pre-defined pattern. This may ensure correct interpolation and reconstruction of the channel.

[0112] The following are examples of uplink physical channels and signals.

[0113] An uplink reference signal may be used for uplink channel sounding, uplink system measurement, etc. In a beamformed system, an uplink reference signal may be used for uplink beam acquisition, beam pairing, beam tracking, beam switch, beam measurement, etc.

[0114] A physical random access channel (PRACH) may carry a pre-defined sequence in connection with a random access procedure.

[0115] A physical uplink control channel may carry uplink control information, such as channel state information, data acknowledgement, scheduling request, etc.

[0116] A physical uplink data channel may carry payload information in the form of MAC PDU from a UE MAC layer. The resource allocation of this channel may be conveyed in the downlink control channel.

[0117] A data demodulation reference signal may have symbols that may be transmitted for channel estimation of uplink control or data channel. The symbols may be placed together with the associated data symbols in the time and frequency domain according to pre-defined pattern to ensure correct interpolation and reconstruction of the channel.

[0118] An above-6 GHz system (e.g., cmW and mmW systems) may deploy the signals and channels discussed above. Embodiments described herein may apply to these physical signals and channels.

[0119] Beamforming may be important in above-6 GHz systems. Outage studies conducted at 28 GHz and 38 GHz in an urban area using a steerable 100-beamwidth and a 24.5-dBi horn antenna have shown a consistent coverage may be achieved with a cell-radius of up to 200 meters. Currently, LTE WTRUs are assumed to have an Omni-directional beam pattern and may perceive a superimposed channel impulse response over the entire angular domain. Thus an aligned beam pair e.g., at mmW frequencies may provide an additional degree of freedom in the angular domain compared with the current LTE system.

[0120] Conventional LTE WTRUs may have an Omni-directional beam pattern and may perceive a superimposed channel impulse response over the entire angular domain. Thus, an aligned beam pair at, for example, mmW frequencies, may provide an additional degree of freedom in the angular domain compared with conventional LTE systems.

[0121] Referring now to FIG. **4**, FIG. **4** shows a diagram illustrating fully digitized beamforming system **400** according to one or more embodiments. A phase antenna array (PAA) may be used for beamforming with element spacing, e.g., at 0.5λ. The phase antenna may apply different beamforming algorithms. A fully digitized beamforming approach may have a dedicated RF chain including an RF processor **401** and an analog-to-digital converter (ADC) **402** for each antenna element **403**. The signal **404** processed by each antenna element **403** may be controlled independently in phase and amplitude to optimize the channel capacity. A baseband (BB) processor **405** is configured to perform BB processing on each dedicated RF chain based on the signals received from each ADC **402**.

[0122] Referring now to FIG. **5**, FIG. **5** shows a diagram illustrating analog beamforming system **500** according to one or more embodiments. In this embodiment, the analog beamforming may be with one PAA and one RF chain. The analog beamforming may apply one RF chain for a number of antenna elements **503** that process the signal **504**. Each antenna element **503** may be connected to a phase shifter **506** that may be used to set the weight for beamforming and steering. The RF chain further includes an RF processor **501** and an ADC **502** which provides an output to a BB processor **505**. The implemented number of RF chains may be significantly reduced as well as the energy consumption.

[0123] The phase shifting and combining may be implemented in different stages (e.g., at RF state, at BB analog stage, or at Local Oscillator (LO) stage). One example is a single-beam analog configuration. It may operate one beam at a time and the single beam may be placed at, for example, the strongest angular direction such as a LOS path obtained from beam measurement. A broad beam pattern may cover a range of angular directions at the expense of reduced beamforming gain.

[0124] A hybrid beamforming may combine digital precoding and analog beamforming. The analog beamforming may be performed over the phase array antenna elements each associated with a phase shifter and all connected to one RF chain. The digital precoding may be applied on the baseband signal of each RF chain.

[0125] Examples of system parameters of the hybrid beamforming may be number of data streams (N_{DATA}), number of RF chains TRX (N_{TRX}), number of antenna ports (N_{AP}), number of antenna elements (N_{AE}), and number of phase antenna arrays (N_{PAA}). The configuration of these parameters may impact on the system function and performance as discussed below.

[0126] Referring now to FIGS. **6**A and **6**B, FIGS. **6**A and **6**B show a diagram illustrating analog beamforming system **600** with one PAA and two RF chains. One antenna port may carry a beamformed reference signal uniquely associated with this antenna port that may be used to identify the antenna port. One PAA may be connected to one RF chain or multiple RF chains depending on the system requirement

and configuration. In FIGS. **6**A and **6**B, one PAA of size 4×4 with 16 antenna elements **603**, for receiving a signal **604**, may be connected to two RF chains and each RF chain may have a set of 16 phase shifters **606***a* and **606***b*. The PAA may form two narrow beam patterns within a +45° and −45° coverage in an azimuth plane. In this configuration, $N_{PAA}<N_{AP}=N_{TRX}<N_{AE}$. Each RF chain further includes an RF processor **601***a* or **601***b* and an ADC **602***a* or **602***b* which provide an output to a BB processor **605**.

[0127] Referring now to FIG. **7**, FIG. **7** shows a diagram illustrating analog beamforming system **700** with two PAAs and two RF chains. In an embodiment, there may two PAAs having a set of antenna elements **703***a* and **703***b*, respectively, for receiving signals **704***a* and **704***b*. Each antenna element **703***a*, **703***b* may be connected to a phase shifter **706***a*, **706***b*, respectively. Each PAA may have a dedicated RF chain, i.e., $N_{PAA}=N_{AP}=N_{TRX}$ N_{AE}, including an RF processor **701***a*, **701***b* and an ADC **702***a*, **702***b* which provide an output to a BB processor **705**. This configuration may allow spatial independence between the two simultaneous signals **704***a* and **704***b* by placing the PAAs at different orientations (e.g., in an azimuth plane). An aligned PAA arrangement may provide an aggregated larger coverage.

[0128] Both abovementioned example configurations with two RF chains may apply MIMO with two data streams.

[0129] Referring now to FIG. **8**, FIG. **8** shows a diagram illustrating analog beamforming system **800** with two PAAs having a set of antenna elements **803***a* and **803***b*, respectively, for receiving signals **804***a* and **804***b*. Each antenna element **803***a*, **803***b* may be connected to a phase shifter **806***a*, **806***b*, respectively. The PAAs are connected to a single RF chain that includes a switch **808**, an RF processor **801** and an ADC **802** that provides an output to a BB processor **805**. Multiple PAAs may be connected to a single RF chain by using the switch **808** (i.e., $N_{AE}>N_{PAA}>N_{AP}=N_{TRX}$). Each PAA may form a narrow beam pattern covering from +450 to −450 in an azimuth plane. They may be oriented separately so a single-beam network node may have a good coverage by using a beam at different direction at different time instances.

[0130] An above-6 GHz system may apply different beamforming techniques, such as analogue, hybrid and digital beamforming. Embodiments described herein may apply to these beamforming techniques.

[0131] One or more embodiments may address the transmission schemes and transmission modes for highly directional antenna systems, and define the BRS association, the resource allocation and configuration for the fallback schemes, as well as the necessary CSI feedback.

[0132] Another embodiment may address the scenario where the data channel may exhibit a significant degradation, while the control channel may still be received. This scenario may occur for several reasons. For example, the scenario may be due to a change in orientation of the mobile device, which causes misalignment of the previously paired Tx-Rx narrow beams for data transmissions. Embodiments addressing this issue may be based on the fact that the control channel may still be received, and therefore it may be used for the data transmission at a lower rate. In other words, a main principle may be the use of the active control wide beam for data fallback, which may include both DL and UL data. The embodiments may include, but are not limited to: fallback to wide beam (both DL & UL data), and/or fallback to dual transport block (TB) transmission using wide and narrow beams for UE data in the same transmission time interval (TTI).

[0133] Another embodiment may address the scenario where both the control and the data channels are lost due to the beam misalignment. In this case, a two-step solution may be needed: the first step may identify a fallback for the control channel, and once the control channel can be decoded, a fallback may be determined for the data channel. The embodiments may include: fallback for the DL control and the associated DL/UL data, using fallback TTI.

[0134] The following may provide details for embodiments of DL/UL transmission schemes for one and multiple RF chains.

[0135] Transmission schemes for a system operating at a high carrier frequency (e.g., above 6 GHz) may be defined as mapping of the modulated baseband symbols to the allocated space/time/frequency resources, individual transmit antenna(s), and the associated reference symbols.

[0136] As indicated above, systems operating at high carrier frequency (e.g., above 6 GHz) may need to use beamforming (analog, digital or hybrid) to compensate for a 20-30 dB pathloss since it becomes more significant as the carrier frequency becomes higher. The beamforming may be used at the transmitter and/or at the receiver. The highest beamforming may be achieved when both transmitter and receiver use beamforming and the beam directions are aligned (e.g., transmitter and receiver beams are paired). The transmit and receive beam widths may be determined as a function of the type, size and number of antenna elements of the phased array antenna (PAA).

[0137] A normal transmission scheme may be defined as a transmission scheme used when a transmitter and/or a receiver may control beams properly based on the current channel condition (e.g., wide or narrow transmit and/or receive beam pairing is complete). The system may operate within the expected SNR range. In a system, one or more normal transmission schemes may be defined.

[0138] A fallback transmission scheme may be defined as a transmission scheme used for one or more of following cases. A fallback transmission scheme may be used when the performance of the normal transmission scheme is significantly degraded. For example, a significant loss in SNR may occur due to a change of the WTRU orientation with respect to the mB or due to blocking. A fallback transmission scheme may be used when the channel status information (CSI) ages faster than a feedback cycle, so that a transmitter may not rely on the reported CSI. A fallback transmission scheme may be used when a CSI is not available at the transmitter. Fallback transmission schemes may be defined for data channels, and for control channels. The transmission schemes in this disclosure may be not limited to a system with a high carrier frequency and may be used for a system with any carrier frequency.

[0139] A normal transmission scheme may use a single transmit RF chain or multiple transmit RF chains. If a single transmit RF chain is used, the normal transmission scheme may use analog beamforming. On the other hand, if multiple RF chains are used, the normal transmission scheme may use analog, digital, or hybrid beamforming. Although the beamforming capability is determined based on the number of RF chain and/or number of antenna element, embodiments described herein may be used for a system with any number of transmit/receive RF chains and/or antenna elements and still be consistent with this disclosure.

[0140] The beamforming capability described herein may include one or more of following: a number of beams supported, a beamwidth, a beam control ability (e.g., analog, digital, and hybrid), and a beam measurement/reporting. The number of beams may be interchangeably used as a number of beam steering vectors and a number of precoding vectors. The beamwidth may be interchangeably used as a beam steering vector and as a precoding vector.

[0141] A normal transmission scheme may use analog beamforming and may operate using either wide or narrow beams, with or without channel state information (CSI) feedback from the receiver (i.e., closed loop or open loop transmission schemes).

[0142] In an example, a WTRU may not have a receiver beamforming capability and an analog beamforming may be used only at the transmitter. Therefore, the beam pairing between transmitter beam and receiver beam may not be used. A transmission scheme may be defined without a beam pairing process. Therefore, a transmitter may not provide a transmit beam information (e.g., the transmit beam ID) for a downlink transmission when a transmission scheme which may not support beam pairing process may be used.

[0143] In another example, a WTRU may have receiver beamforming capability and the analog beamforming may be used at both transmitter and receiver. A beam pairing scheme/process between transmitter beam and receiver beam may be used. A transmission scheme with beam pairing process may use one or more following methods. A downlink control channel may indicate the transmit beam information for the associated data channel. The downlink control channel may be, but is not limited to, a physical downlink control channel, MAC control message, higher layer radio resource control (RRC) signaling, or a broadcasting channel. A downlink control channel may indicate a receive beam information for the associated data channel. Therefore, a WTRU may use the receiver beam indicated from the downlink control channel. A transmitter may request a preferred transmit beam information from a receiver, or a receiver may be configured to report a preferred transmit beam information regularly.

[0144] The receiver beamforming may be indicated as a WTRU capability and a transmission scheme may be determined as a function of the receiver beamforming capability. For example, if a WTRU indicates no receiver beamforming support, a transmission scheme without beam pairing process may be used. On the other hand, if a WTRU indicates receiver beamforming support, a transmission scheme with beam pairing process may be used. For the transmission scheme determination according to the WTRU receiver beamforming capability, one or more of following operations may apply. Existence of a bit field in a downlink control channel may be used to indicate the transmit beamforming information may be determined as a function of the WTRU receiver beamforming capability. A downlink control information (DCI) format may be determined as a function of the WTRU receiver beamforming capability. A channel status information (CSI) reporting type may be determined as a function of the WTRU receiver beamforming capability. A downlink control type may be determined as a function of the WTRU receiver beamforming capability. The relative timing between a downlink control channel and the associated data channel may be determined as a function of the WTRU beamforming capability.

[0145] Referring now to FIG. **9**, FIG. **9** illustrates a diagram of a semi-static association between the control transmit (Tx) beam and data Tx beam. While the beams shown in FIG. **9** are described in the context of Tx beams used by a transmitter, it will be appreciated that a receiver uses a corresponding Rx beam in a similar manner. Therefore, Tx and Rx may be used interchangeably in the context of a transmitter or a receiver, respectively.

[0146] In FIG. **9**, two TTIs **901** and **902** are shown. In TTI **901**, a normal control Tx beam B**1** (i.e., wide beam) is associated with a normal data Tx beam B**1**, which is a wide beam. In TTI **902**, normal control Tx beams B**1** and B**2** (i.e., wide beams) are associated with normal data Tx beams B**1** and B**2**, respectively, where the normal data Tx beams B**1** and B**2** are wide beams. A transmission scheme may use an implicit beam association between control channel and data channel, where a same transmit beam may be used for both the control channel and the associated data channel, as illustrated in FIG. **9**. A WTRU or receiver may assume that a same transmit beam is used for the control channel and the associated data channel. A WTRU may use the same receiver beam for the control channel and the associated data channel as a WTRU may assume the same transmit beam is used. A WTRU may determine a preferred receiver beam during the control channel reception and use the determined receiver beam for the associated data channel.

[0147] For a transmission scheme which may use the same transmit beam for a control channel and the associated data channel, or may require the same receiver beam for a control channel and the associated data channel, the transmit beam information may not be indicated from the control channel. The transmit beam may be adapted either semi-statically or dynamically without the downlink beam indication. The beam may be changed semi-statically and the beam information may be transparent to a WTRU. The beam information for the control channel and/or the associated data channel may be indicated via higher layer signaling. The beam may be changed dynamically without beam indication in the downlink control channel. The beam information for the control channel and/or the associated data channel may be determined based on the search space of the control channel. The beam information for the control channel and/or the associated data channel may be determined as a function of the location of the control channel within a search space. A beam index may be determined as a function of the starting control channel element (CCE) or enhanced control channel element (ECCE) index of the control channel. A beam index may be determined as a function of BRS used to demodulation the control channel.

[0148] A transmission scheme may use explicit beam association between control channel and the associated data channel, where the transmit beam for the control channel and the associated data channel may be determined independently (or separately). The transmit beam used for the data channel may be explicitly indicated from the corresponding control channel. The transmit beam described herein may include one or more of following parameters: Tx or Rx beam width (e.g., beam subgroup), Tx or Rx beam direction (e.g., beam index) within the beam width, and a time-frequency resource associated with the beam. The beam index may be indicated as antenna port or reference signal sequence.

[0149] In an example, the transmission scheme using explicit beam association may dynamically switch the Tx

beam within a TTI from the wide beam used for control channel to a narrow beam used for the associated data channel. The narrow beam may reside within the wide beam as a subset of the wide beam. As the transmit node dynamically switches from a wide to a narrow beam within a TTI, the receive node may need to also steer its receive beam to ensure that it can receive the narrow Tx beam correctly from the transmitter (e.g., mB). That is, the receiver configures its receive beam to be aligned with the narrow transmit beam. The DCI in the control channel may carry one or more of following parameters for the transmission scheme using explicit beam association: HARQ process number, transport block information, antenna configuration (as needed), downlink assignment index (DM), and/or power control indicator.

[0150] The DCI in the control channel may carry a beam ID or a beam index for the data channel. The beam ID or beam index may be interpreted differently according to the beam used for the control channel. For example, one or more wide beams may be used for the control channel. Additionally, a group of narrow beams, which may be associated with a wide beam, may be used for the associated data channel. Therefore, according to the wide beam used for the control channel, the narrow beam ID or beam index for the associated data channel may be different. The beam ID or beam index may be an index of a narrow beam within the group of narrow beams associated with the wide beam.

[0151] The wide beam for the control channel may be determined in a semi-static manner. For example, a higher layer signaling may be used to determine the wide beam and, based on the higher layer configured wide beam for control channel, the group of the narrow beam may be determined. The wide beam for the control channel may be determined as a function of the location of a WTRU-specific search space and/or location within the search space. The wide beam for the control channel may be determined during initial access procedure, random access procedure, and/or cell (re)selection procedure.

[0152] The DCI in the control channel may carry a bit field to request preferred beam reporting. If a WTRU receives an indication of preferred beam reporting, the WTRU may report a preferred narrow beam index in the corresponding uplink resource.

[0153] The DCI in the control channel may carry a bit field to request beam p airing.

[0154] Referring now to FIG. **10**, FIG. **10** shows a diagram illustrating an intra-TTI DL assignment with a guard period to detect the Tx beam for data and switch the Rx beam. While the beams shown in **10** are described in the context of Tx beams used by a transmitter, it will be appreciated that a receiver uses a corresponding Rx beam in a similar manner. Therefore, Tx and Rx may be used interchangeably in the context of a transmitter or a receiver, respectively.

[0155] In FIG. **10**, two TTIs **1001** and **1002** are shown. In TTI **1001**, a normal control Tx beam B**1** (i.e., wide beam) is associated with a normal data Tx beam B**1***x*, which is a narrow beam. A guard period G is present between the control Tx beam B**1** and the normal data Tx beam B**1***x*. In TTI **1002**, normal control Tx beams B**1** and B**2** (i.e., wide beams) are associated with normal data Tx beams B**1***x* and B**2***y*, respectively, where the normal data Tx beams B**1***x* and B**2***y* are narrow beams. A guard period G is present between control Tx beam B**2** and the data Tx beam B**1***x*.

[0156] Spatially, narrow beams B**2***x*, B**2***y*, etc., are within the area of wide beam B**2**. Similarly, a number of narrow beams B**1***x*, B**1***y*, etc., reside within the area of wide beam B**1**. Thus, narrow beams B**2***x*, B**2***y*, etc., are associated with wide beam B**2** and narrow beams B **1***x*, B**1***y*, etc., are associated with wide beam B**1**.

[0157] The WTRU may need to decode the control channel, and may extract from the DCI, the ID of the Tx beam (and thus information on the BRS) of the data channel. This may require a guard time G to be used between the end of the control region B**1** and the start of the associated data Tx beam B**1***x*, to allow the WTRU enough time to correctly steer its receive beam to receive the data channel (i.e., to align its (narrow) receive beam with the mB's transmit beam). Within a TTI, a guard period G may be achieved by creating a gap between the end of the control region and the start of the data region, as illustrated in FIG. **10**. The length of the guard period may need to be set such that the WTRU may be able to decode the control channel and switch its receive beam before the start of the data region.

[0158] A guard period G may be present between the control channel and its associated data channel in a certain DCI format in which beam index is provided for the associated data channel. One or more of following parameters may apply.

[0159] A guard period G may be used for a WTRU with a certain receiver beamforming capability. For example, if a WTRU indicated that the WTRU has analog beamforming capability only at the receiver, the guard period G may be configured by the base station via higher layer signaling. Alternatively, a WTRU may indicate a required guard period for the receiver beamforming adaptation.

[0160] A guard period G may include the control channel reception time and receiver beam switching time. Therefore, the portion of control channel reception time may be used, depending on the WTRU receiver beamforming cap abilities.

[0161] A guard period G may be present if the DCI in the control channel indicates that the beam index of the associated data channel is changed from the latest beam index. Alternatively, the guard period G may be present if the DCI in the control channel indicates that the beam index of the associated channel is different from the beam index of the control channel. A single bit or state in the DCI may indicate the beam index change confirmation, or guard period indication. Other bits or states may also indicate the beam index change.

[0162] If the length of the guard period G is smaller than the CP length, no explicit guard period may be used. If a system supports two or more CP lengths (e.g., a normal CP length and an extended CP length), the guard period G may be used in the normal CP case, while no guard period is used in the extended CP case. Therefore, the guard period G may be considered as '0' in FIG. **10** if the CP length is larger than beam switching time and the decoding time.

[0163] It should be noted that CP length and guard time can be interchangeably used. For example, CP length may be used in a certain waveform (e.g., OFDM) and guard time may be used in another waveform (e.g., single carrier modulation) but is not limited to a specific waveform. The CP may be used between modulation symbols and the guard period may be used between the control channel and the associated data channel.

[0164] Referring now to FIG. **11**, FIG. **11** shows a diagram illustrating a cross-TTI DL assignment with narrow beam indication. Instead of creating guard periods within a TTI,

cross-TTI DL assignments may be used where a control Tx beam in one TTI is associated with a data Tx beam in a subsequent TTI. The subsequent TTI may immediately follow the corresponding TTI, or may follow by one or more TTIs. Suffixes "x", "y" and "z" are further used to identify different narrow data Tx beams associated with different wide control Tx beams. For example, B1*x*/My/B1*z* denote narrow beams associated to wide beam B **1**, B2*x*/B2*y* denote narrow beams associated to wide beam B**2**, and so on. In one or more instances, narrow data Tx beams (e.g., B1*x* and B2*y*) may be sequentially transmitted in the same TTI (e.g., TTI**1**). In other instances, narrow data Tx beams (e.g., B3*x* and B3*y*) may be transmitted in parallel in the same TTI (e.g., TTI**3**)

[0165] For the cross-TTI assignments, the control channel signaled during TTI "n" may point to DL data assignments for TTI "n+k". In this case, both the offset "k" and the narrow beam for data transmission may need to be signaled in the DCI in addition to the default information fields that may need to be carried in the DCI.

[0166] The above examples illustrate schemes using a single transport block (TB) per TTI. In another example, a transmission scheme may use two or more transport blocks (TBs) within a TTI.

[0167] Referring now to FIG. **12**, FIG. **12** shows a diagram for a dual TB transmission scheme. Two or more transport blocks may be transmitted with a same beam as the control channel, or may be transmitted with different beams. For example, FIG. **12** illustrates two transport blocks **1201** and **1202** transmitted (multiplexed) in a TDM fashion within a single TTI (e.g., TTI**1**). The transmission of the individual transport blocks may use the same beam as the control channel (e.g., transport block **1201** which uses a wide beam), or may use a different beam (e.g., transport block **1202** which uses a narrow beam). In the latter case, the narrow beam ID may need to be signaled in the control region of the TTI.

[0168] In particular, as shown in FIG. **12**, a first TB (TB**1**) may use the same wide beam or the same beam ID as the control channel, and a second TB (TB**2**) may use a narrow beam or a beam ID that is different from the beam ID used by the control channel. The beam ID for TB**2** may be signal in a DCI transmitted in control data B**1** that is associated with TB**2**. In addition, the dual TB transmission scheme shown in FIG. **12** may be used to carry out a fallback transmission, to be described in more detail below. As a fallback mechanism, data carried by TB**1** may be a subset of the data carried by TB**2**, and TB**1** may use a lower modulation and coding scheme (MCS) value than TB**2**.

[0169] In an example which the two transport blocks may be transmitted in a TDM fashion, the control channel and the DL data assignment may be in the same TTI. For example, transport block **1201** may be associated with control Tx beam **1203** and transport block **1202** may be associated with control Tx beam **1204**. The first transport block may be mapped on to a first codeword provided in the control Tx beam **1203** and the second transport block may be mapped on to a second codeword provided in control Tx beam **1204**. The codeword may be associated with: a specific beam or beam ID, a BRS, and/or a time/frequency location. As used herein, a codeword represents user data before it is formatted for transmission.

[0170] There may be a one-to-one mapping between the transport block and the codeword. The mapping rule may be fixed. For instance, the first transport block may be mapped onto the first codeword and the second transport block may be mapped onto the second codeword. Alternatively, the mapping rule may be dynamically indicated. For instance, the first transport block may be mapped onto one of the codeword according to the indication. The number of codeword(s) could be equal to or smaller than the number of the transport block(s). If a single codeword is defined, irrespective of the number of transport block, the same beam may be used. Therefore, the transport blocks within a TTI may be mapped on to a single codeword.

[0171] Furthermore, the first codeword (codeword #1) may be transmitted on the same wide beam as the control channel, and the second codeword (codeword #2) may be transmitted on a narrow beam. In this case, mapping of codeword #2 in the data region of the TTI may be done such that the WTRU has enough time to decode the control channel and switch its receive beam before it may start buffering and receiving the symbols corresponding to codeword #2.

[0172] In another example in which the two transport blocks are transmitted in a TDM fashion, the control channel and the DL data assignment may be in different TTIs. In this case, the network (e.g., mB) may include in the DCI the following information: the relative TTI offset of the DL data assignment and/or the Tx beam index (or beam ID) for both codewords. In this example, codeword #1 and codeword #2 may be mapped anywhere in the data region of the TTI (i.e., flexible mapping).

[0173] In an example, a normal transmission scheme in DL may use an open loop wide beam transmission with channel quality indication (CQI) only reporting for link adaptation purposes. For this scheme, the WTRU may use the BRS associated to the mB DL Tx wide beam, to perform channel estimation, receive the data channel and measure the CQI.

[0174] In another example, a normal Tx scheme may use closed loop narrow beam transmission. The WTRU may report, in addition to the CQI for the active beam, measurements on other detected narrow beams. For this scheme, the WTRU may use the BRS associated to the active narrow beam to perform channel estimation, receive the data channel, and report the CQI. Additionally, the WTRU may use BRS of other beams to perform and report other narrow beam measurements and report the beam ID of its preferred narrow beam.

[0175] One or more fallback transmission schemes are provided herein. The term "fallback transmission scheme" may be interchangeably used with the following: open-loop transmission scheme, coverage enhanced transmission scheme, beam diversity transmission scheme, beam sweeping transmission scheme, and transmit diversity scheme.

[0176] In one or more embodiments, a fallback transmission scheme may be defined as a transmission scheme which may not require a beam pairing process, WTRU reporting assistance for beam pairing, and/or beam ID indication for the associated data channel. One or more of following parameters may apply for fallback transmission scheme. A certain DCI format may be used for fallback transmission scheme which may not include beam ID for the associated data channel. The control channel and/or data channel may be transmitted with one or more beams. A single wide beam may be used. Two or more wide beams may be used, where the two or more wide beams may be configured for a control

channel and/or a data channel transmission. Two or more narrow beams associated with a wide beam which may be used in the normal transmission configured or used.

[0177] The control channel and/or data channel may be transmitted with repetitions. Two or more TTIs may be used for repetitions. A different beam may be used in each TTI. The beam ID in each TTI may be predefined or configured by higher layer signaling. Alternatively, the beam ID in each TTI may be determined as a function of the subframe number and/or SFN. The number of repetition of the fallback transmission scheme may be determined by one or more of following: configuration via higher layer signaling and/or broadcasting channel, a function of number of wide beams and/or number of narrow beams, an indication from the associated DCI, the time/frequency resource used during random access procedure, and/or system parameters.

[0178] In another example, a fallback transmission scheme may be defined as a transmission scheme which may be transmitted in a subset of the TTIs. A subset of TTIs may be defined or configured for the fallback transmission. A subset of TTIs may be defined or configured to monitor control channel associated with a fallback transmission. The subset of TTIs may be configured via higher layer signaling. The subset of TTIs may be determined as a function of the wide beam index associated with the control channel which is used for normal transmission. The subset of TTIs may be determined as a function of one or more of system parameters including physical cell ID, SFN number, and/or system bandwidth.

[0179] There may be a BRS association for normal and fallback transmission schemes. Each of two or more BRSs may be defined with a BRS index associated with a beam. The BRS index may be defined according to the beam width. In an example, a BRS index associated with wide beam may be defined as W_x, where $x \in \{1, 2, \ldots, N\}$, and a BRS index associated with narrow beam may be defined as N_y, where $y \in \{1, 2, \ldots, M\}$. N wide beams and M narrow beams are used in the system with a BRS index. A WTRU may determine an associated receiver beam for each BRS index. The wide beams and the narrow beams may be independently defined. Alternatively, a wide beam may be associated with two or more narrow beams.

[0180] In another example, the BRS index may be defined in a hierarchical manner. For example, B_x, where $x \in \{1, 2, \ldots, N\}$ may be defined as BRS index associated with a wide beam and each wide beam may be associated with two or more narrow beams B_xy, where $y \in \{1, 2, \ldots, M\}$. Each wide beam may have two or more associated narrow beams. The number of narrow beam may be different according to the wide beam index.

[0181] According to the BRS index used, a WTRU may determine a receive beam to receive the signal and perform signal reception procedures. For example, the WTRU may form a receiver beam in analog, digital, or hybrid domain to receive the signal and buffer the signals before it starts demodulation.

[0182] In one or more embodiments, a first BRS index may be used to monitor and/or receive a control channel and a second BRS index may be used to receive an associated data channel. One or more of following parameters may apply.

[0183] The first BRS index may be associated with a wide beam and the second BRS index may be associated with a narrow beam. The first BRS index may be one of the beam indexes of wide beams. The second BRS index may be a narrow beam index associated with the first BRS index. For example, if the first BRS index is B_x, the narrow beam index may be B_xy, where the x is the same for both first BRS index and the second BRS index.

[0184] The first BRS index may be determined during random access procedures and the second BRS index may be determined by a transmitter (e.g., a mB). For example, the first BRS index may be determined as a function of the PRACH resource used and the second BRS index may be indicated in the associated DCI.

[0185] The first BRS index may be determined during initial access procedures including cell selection/reselection procedures. The first BRS index may be determined as a function of the physical cell ID. The first BRS index may be determined based on the downlink measurement which may be used for cell selection/reselection. The first BRS index may be determined based on the time location of the synchronization signal received.

[0186] In one or more embodiments, a first BRS index may be used to monitor and/or receive a first type of control channel and a second BRS index may be used to monitor and/or receive a second type of control channel. One or more of following parameters may apply. The first BRS index and the second BRS index may be associated with a wide beam. The first BRS index may be associated with a wide beam and the second BRS index may be associated with a narrow beam. The second BRS index may be one of the narrow beams associated with the first BRS index. The second BRS index may be one of the narrow beams which may be independent from the wide beam index.

[0187] The first type of control channel may be a broadcasting/multi-casting channel and the second type of control channel may be a WTRU-specific control channel. For example, the first type of control channel may be defined as a common search space and the second type of the control channel may be defined as a WTRU-specific search space. A WTRU may monitor the first type of control channel in a common search space to receive a multi-casting and broadcasting channels including system information, group power control, paging, and MBMS. A WTRU may monitor the second type of control channel in a WTRU-specific search space to receive unicast traffic.

[0188] In one or more embodiments, the WTRU and the mB may operate using multiple transmission schemes. For example, both wide beams and narrow beams may be used in a first transmission scheme and wide beams may be only used in a second transmission scheme. One or more of following parameters may apply. The first transmission scheme may be a normal transmission scheme and the second transmission may be a fallback transmission scheme.

[0189] The first transmission scheme may use one beam for a single transmission while the second transmission scheme may use beams available for a single transmission. The single transmission may be a control channel transmission or a data channel transmission. The single transmission may be a single transport block transmission for the data channel. In case of the control channel, the single transmission may be a single DCI transmission. The second transmission scheme may use beams available with repetitions. For example, N repetitions may be used with N beams. Therefore, one BRS index associated with a repetition transmission and all BRS indices are used with N repetitions, where N wide beams may be used in the system.

[0190] The first transmission scheme may use the BRS index indicated from a transmitter while the second transmission scheme may use a predefined BRS index. The predefined BRS index may be determined by one or more of following: a fixed number, a predefined sequence, a subframe number and/or frame number, time/frequency location, a WTRU ID, and/or system parameters.

[0191] In one or more embodiments, a WTRU may report downlink reference signal received power (e.g., RSRP) for one or more BRS in order to provide physical layer (i.e., layer 1 (L1)) measurement and CSI feedback. For example, a hierarchical BRS structure may be used, wherein N wide beams may be used with M narrow beams for each N wide beams. It should be noted that the terms reference signal received power, downlink pathloss, pathloss, channel quality indicator, wideband channel quality indicator, RSRP and downlink measurement may be used interchangeably.

[0192] One or more of following parameters may apply for the downlink measurement reporting. A downlink measurement may be reported for the currently configured or used wide beam. A downlink measurement may be reported for a subset of N wide beams wherein the subset may be determined based on currently configured or used wide beam. For example, adjacent wide beams of the currently configured or used wide beam may be determined as the subset. The downlink measurement reporting for a subset of N wide beams may include individual downlink measurement value for each wide beam within the subset. The downlink measurement reporting for a subset of N wide beams may include an index of the wide beam within the subset of N wide beams, which may provide the highest value and its associated downlink measurement value.

[0193] A downlink measurement may be reported for all N wide beams configured by mB. A WTRU may report one downlink measurement for a wide beam at a time. A reporting cycle (e.g., duty cycle) may be determined or configured for each wide beam. Therefore, each wide beam may have a same or a different reporting cycle. A time offset (e.g., TTIs) may be used for downlink measurement reporting for each wide beam.

[0194] In one or more embodiments, a WTRU may send a beam pairing, or beam re-pairing, request to a mB. For example, if a currently configured or used downlink transmit beam is below a predefined threshold, the WTRU may send a request of beam pairing between transmit and receive beams. The beam pairing request information may be transmitted in a higher layer configured uplink control resource. The higher layer configured uplink control resource may be the same as the uplink control resource configured for scheduling request. The beam pairing request information may be interchangeably used by a fallback transmission request.

[0195] The following provides a description of DL/UL transmission modes and modes of operation. In the current 3GPP specifications, the transmission modes may only be applicable to a downlink shared channel (DL-SCH) transmission, and may define the single or multi antenna transmission scheme, the specific antenna mapping, the reference symbols used for demodulation (e.g., CRS or DM-RS), and the associated CSI feedback. For systems operating at frequencies above 6 GHz, there may be a need to expand the concept of transmission mode to address aspects of the propagation channel specific to the use of directional antennas (i.e., narrow and wide beams), such as: effects of change in the WTRU orientation, blocking effects, delay and angle spread, and so on.

[0196] One or more transmission modes may be used in a system and a transmission mode may use one or more transmission schemes. A WTRU may be configured with a transmission mode in a semi-static manner and the transmission schemes used within a transmission mode may be switched dynamically (e.g., according to a dynamic switching transmission mode). A transmission mode may be configured via higher layer signaling. A transmission mode may be determined as a function of at least one of the number of antenna ports, WTRU capability, and system parameters. A transmission mode may be determined based on the beamforming capability of a WTRU which may include the number of RF chains, number of receive beams, and/or beam switching time.

[0197] For example, a transmission mode may use two transmission schemes where a normal transmission scheme and a fallback transmission scheme may be used. One or more of following parameters may apply. Within a transmission mode, a transmission scheme used in a TTI may be determined by a DCI format received in the control region. A first transmission scheme may be used if a first DCI format (e.g., DCI format-A) is received in the control region and a second transmission scheme may be used if a second DCI format (e.g., DCI format-B) is received in the control region. The first transmission scheme may be a normal transmission scheme and the second transmission scheme may be a fallback transmission scheme.

[0198] The transmission scheme used in the TTI may be determined by a TTI type associated with a transmission. Each TTI may be associated with a transmission among the transmission schemes associated with the transmission mode. Therefore, the transmission scheme may be determined as a function of the subframe number and/or frame number.

[0199] The transmission scheme used in the TTI may be determined by a search space of the control channel. The control channel monitored by WTRU may be split into multiple subsets and each subset may be associated with a certain transmission scheme.

[0200] The transmission scheme used in the TTI may be determined by an indication in the DCI.

[0201] A WTRU may monitor a control channel according to a first transmission scheme in all TTIs, while the WTRU may monitor a control channel according to a second transmission scheme in a subset of TTIs. The first transmission scheme may be a normal transmission scheme and the second transmission scheme may be a fallback transmission scheme. A WTRU may monitor the control channel for the second transmission scheme if one or more of the following applies: the WTRU is not scheduled for a certain number of consecutive TTIs, the WTRU sends a certain number of consecutive negative ACK corresponding to downlink transmissions, or a downlink measurement is below a predefined threshold.

[0202] A WTRU receiver may use a narrow beam in the first transmission scheme and the WTRU may use a wide beam in the second transmission.

[0203] A WTRU receiver may use a beam ID indicated in the associated control channel to receive the corresponding data channel for the first transmission scheme, and the WTRU may use a predefined beam to receive the corre-

sponding data channel for the second transmission scheme. The predefined receiver beam for the second transmission scheme may be the same receiver beam used for the associated control channel. Alternatively, a sequence of beams may be predefined.

[0204] The following embodiments may include switching (in a semi-static or dynamic fashion) between fallback and normal transmission schemes and may address the following aspects: DCI and UE monitoring behavior, and WTRU behavior for switching between fallback and normal transmission schemes.

[0205] In one of more embodiments, it may be assumed that the WTRU may be connected to the mB via a narrow beam pair for the DL and UL data, and that the mB may use a wide beam for the DL control channel transmission. Thus, an operation with data fallback to a wide beam is described such that, as the orientation of the WTRU may change, the paired narrow beams used for data transmission may become misaligned, and the data link may experience a sudden and significant drop in signal-to-noise ratio (SNR). If the change in the WTRU orientation does not exceed a certain value, the DL control channel transmissions using wide beams may still be received by the WTRU. This scenario may trigger the mB to dynamically switch the WTRU to a data fallback scheme that uses the same wide beam as for the DL control channel. The data fallback scheme may allow the WTRU to maintain connection using the current transmission mode, while the mB may perform a RRC reconfiguration of the transmission mode until the mB may perform a beam switch, or until the operating SNR using the current transmission mode may improve.

[0206] The following embodiments may address triggers that initiate the mB to use the data fallback, how the DL data fallback scheme is signaled to the WTRU, and how the WTRU data fallback scheme is signaled to the WTRU.

[0207] In one or more embodiments, signaling the DL data fallback to wide beam is described such that the mB may use the same wide beam as used for the control channel for the transmission of the DL fallback data. One or more of following parameters may apply. The WTRU may need to switch its receive beam for data to the beam used to receive the control channel. If control and fallback data are scheduled in the same TTI, a guard time may be needed between the control and the data regions of the TTI, as shown in FIG. **10**. The fallback data may be scheduled for a subsequent TTI. The offset of the TTI carrying fallback data may be signaled in the DCI, may be pre-defined, or may be semi-statically configured.

[0208] A different DCI format may be used for fallback and normal transmission. For example, DCI-A may be used for normal transmission and DCI-B may be used for fallback transmissions. In the embodiment described above, the use of fallback DCI (DCI-B) may implicitly indicate the fallback data is transmitted on the same wide beam as the control. In this case, the fallback DCI may not include the BRS and beam ID.

[0209] In another embodiment, the fallback DCI may explicitly indicate the data fallback beam. The fallback DCI may include at least one of the following pieces of information: BRS, beam ID, and the offset (in TTIs) of the DL data assignment. The fallback DCI may also include the preferred WTRU transmit beam for UL data fallback.

[0210] In another embodiment, the data fallback beam may be determined implicitly during the reception of the associated control channel. For example, a WTRU may perform a blind decoding of the associated control channel with one or more BRS candidates. The WTRU may determine one BRS for the associated control channel decoding. Based on the determined BRS for the associated control channel, the WTRU may determine the data fallback beam. In another example, a WTRU may perform a blind decoding of the associated control channel with one or more control channel candidates. The WTRU may determine the control fallback beam as a function of the control channel candidate. Based on the determined control fallback beam, the WTRU may determine the data fallback beam.

[0211] A WTRU may monitor for both a first DCI format (e.g. DCI-A) and a second DCI format (e.g., DCI-B) in each TTI. Alternatively, the WTRU may monitor for DCI-B only in configured TTIs. The use of DCI-A versus DCI-B may implicitly indicate a different timing rule for the associated data channel reception. In one example, the data channel associated to DCI-A may be transmitted in TTI n+k1 for a DCI-A signaled in TTI n, while the fallback data channel associated to DCI-B may be transmitted in TTI n+k2 for a DCI-B signaled in TTI n. The offset values k1 and k2 may be either explicitly included in the DCI, or the offset of the fallback data, k2, may be implicitly derived from the fallback DCI-B type.

[0212] Upon the detection of the fallback DCI-B on the control wide beam in TTI #n, the WTRU may configure its receive beam for DL data in TTI #n+k2, where k2 may be explicitly signaled in DCI-B or implicitly derived from the fallback DCI-B type. This may be done using the appropriate BRS, which may be either the same BRS as used for the wide beam control, or determined based on the beam ID that may be signaled in DCI-B.

[0213] Additionally, the WTRU may transmit the UL Acknowledgment-Negative Acknowledgment (A/N) feedback using an UL beam that has the same orientation as the DL beam used for the data fallback reception. The timing for the transmission of the UL A/N feedback may be determined implicitly based on the TTI index (n+k2) of the fallback data transmission. For example, the UL A/N corresponding to the DL fallback data on TTI #n+k2 may be transmitted in TTI #n+k2+m. During TTI #n+k2+m, the mB may monitor the WTRU UL A/N feedback using an UL Rx beam with the same orientation as the DL Tx beam used for DL data fallback transmission during TTI #n+k2.

[0214] In an embodiment, a mB may indicate a fallback for UL data transmission. The fallback for UL data transmission may have at least one of the following parameters. First, a predefined wide beam may be used for uplink transmission. The predefined wide beam may be based on the beam used for UL control. The predefined wide beam may be a beam index. Second, a wider beam, which may be associated with the most recent narrow beam, may be used. For example, a wider beam may consist of one or more narrow beams that may be used for normal UL data transmission, and if a fallback UL transmission is triggered or indicated, the wider beam may be used for the UL fallback data transmission. Third, repetitions of the UL data transmission may be used. Fourth, the UL data transmission may be within a narrower bandwidth. Fifth, a higher transmission power may be used.

[0215] In an embodiment, the indication of a fallback UL data transmission may be transmitted in a DCI. For example, a reserved bit in a DCI, which may be used for uplink grant,

may be used to indicate a fallback UL data transmission. In another example, a fallback DCI may be used and a WTRU may monitor for the fallback DCI as well as for a normal DCI for normal UL data transmission (e.g., normal DCI). One or more of the following parameters may apply.

[0216] The fallback DCI may be monitored for in a subset of resources in which a WTRU may monitor for normal DCI. For example, if a WTRU monitors for normal DCI in every TTI, the WTRU may monitor for the fallback DCI in a subset of TTIs. A WTRU may monitor for both normal DCI and fallback DCI in a TTI, which may be a subset of TTIs determined for the fallback DCI.

[0217] The fallback DCI and the normal DCI may be monitored in a disjoint set of TTIs. For example, a first set of TTIs may be used for normal DCI and a second set of TTIs may be used for fallback DCI, and there may be no overlap between the first set and the second set. The first set of TTIs may be larger than the second set of TTIs. A transmission scheme for the associated UL data transmission may be different for the first set of TTIs and the second set of TTIs.

[0218] A fallback DCI may be received over multiple TTIs while a normal DCI may be received within a single TTI. For example, the fallback DCI may be transmitted with repetitions with multiple (e.g., consecutive) TTIs, while the normal DCI may be transmitted within a TTI.

[0219] When the fallback DCI is transmitted with repetitions, at least one of following parameters may apply. A different transmit beam (e.g., beam ID) may be used for each repetition. For example, if the number of repetitions (i.e., number of TTIs) is N, the transmit beam may change in each repetition. Therefore, N transmit beams may be used for a single fallback DCI transmission. If a total number of transmit beams at a transmitter is M and M is smaller than N, the M transmit beams may be cyclically used with N repetitions. Therefore, M transmit beams may be used for a single fallback DCI transmission with N repetitions. If a different transmit beam (e.g., beam ID) may be used for each repetition, a corresponding receiver beam may be used at a receiver.

[0220] The embodiments described herein may be used for the DCI that is used for normal and fallback downlink data transmissions, although an uplink transmission beam may be replaced by a downlink receiver beam and still be consistent with the embodiments.

[0221] In one or more embodiments, the dual TB transmission scheme described above (see e.g., FIG. **12**) may be used as a fallback transmission while operating in the dynamic switching transmission mode. Thus, an operation with dual TB based fallback Tx scheme is provided. As used herein, transport block and codeword may be used interchangeably.

[0222] When the mB detects that a particular WTRU needs data fallback, it may partition the transmission of the next transport block (MAC PDU) into two physical layer code words, which may be transmitted on a single spatial layer, in a TDM fashion within the TTI. The first codeword may use the same wide beam as the control channel, while the second codeword may use a narrow beam, with the beam ID or the beam index signaled by the mB in the DCI (see e.g., FIG. **12**).

[0223] In an embodiment, the first codeword may use a robust coding and modulation scheme, and the data carried in the first codeword may be a subset of the data in the second codeword (current MAC PDU being transmitted). The WTRU may use the data that is correctly decoded in the first codeword to decode the second codeword.

[0224] Referring now to FIG. **13**, FIG. **13** shows a diagram illustrating using a dual TB transmission scheme for data fallback. In an embodiment according to FIG. **13**, the size of a MAC PDU **1301** to be transmitted may exceed a max Turbo coder block size and code block segmentation with M code blocks **1302** may be used. In this scenario, in a first transmission, the data transmitted by the first codeword may be a full code block of the MAC PDU carried in the second codeword, as illustrated in FIG. **13**. The next (e.g., second) transmission of fallback data using this scheme may transmit, in the first codeword, the next code block of the current MAC PDU, and may re-transmit the full MAC PDU in the second codeword. This transmission scheme may continue (e.g., for M transmissions) until the WTRU correctly decodes the MAC PDU and the mB receives an ACK for the current MAC PDU transmission. The A/N signaling for this scheme will be described in more detail below. Thus, a wide data Tx beam B**1** may be used for transmitting TB**1** (i.e., first codeword) of a transmission and a narrow data Tx beam B**1***x* or B**1***y* may be used for transmitting TB**2** (i.e., second codeword).

[0225] Referring now to FIG. **14**, FIG. **14** shows a diagram illustrating another example of using the dual TB transmission scheme for data fallback. In an embodiment according to FIG. **14**, if a size of the MAC PDU does not exceed the max Turbo coder block size, the MAC PDU **1401** may be partitioned in M sub-blocks **1402**. The first codeword may be used for sequential transmission of independently coded sub-blocks and the second codeword may be used for the transmission (and re-transmission) of the entire MAC PDU, as shown in FIG. **14**. For example, for the first transmission of the fallback data, codeword #1 may transmit sub-block #1 of the MAC PDU, and codeword #2 may transmit the entire MAC PDU. For the first re-transmission (e.g., second transmission) of the fallback data, codeword #1 may carry sub-block #2, and codeword #2 may carry the full MAC PDU. The process may continue for a next transmission (e.g., third transmission) until the WTRU ACKs codeword #2. Thus, a wide data Tx beam B**1** may be used for transmitting TB**1** (i.e., first codeword) of a transmission and a narrow data Tx beam B**1***x* or B**1***y* may be used for transmitting TB**2** (i.e., second codeword).

[0226] DL assignment for the dual TB transmission may be provided such that the dual TB transmission may be used as a normal transmission scheme, or as a fallback scheme. The DCI for the dual TB transmission scheme may include the default information: resource assignment information for each codeword (e.g., resource block allocation), HARQ process number, transport block information (modulation and coding scheme (MCS), redundancy version (RV), new data indicator (NDI), etc.), antenna configuration (as needed), DAI, power control indicator, and other flags as needed. Additionally, the DCI may include beam ID or beam index for each TB. In one or more embodiments, the beam ID or beam index of the first codeword may implicitly be set to the beam ID or beam index used for the control channel transmission, and thus it may not be included in the DCI.

[0227] As the segmentation of the MAC PDU may be different for the fallback scheme as compared to the normal scheme, the segmentation configuration may be signaled to the WTRU. The type of segmentation may be indicated in

the DCI, or may be included in the MAC header. For the case where the type of segmentation is included in the DCI, the DCI format for the dual TB scheme used for fallback may be different from the DCI format for the dual TB scheme used for normal transmission.

[0228] In one example, for the data fallback transmission, the DCI may include the following: a field indicating that a single MAC PDU is transmitted using the 2 CW scheme, a field indicating the number M of sub-blocks (or code blocks) the MAC PDU is partitioned in for mapping to codeword #1 (see e.g., FIG. **13** and FIG. **14**), and the index (in the range **1** to M) of the sub-block (or code block) transmitted in the current TTI. The maximum value of M may be pre-defined. The choice for the maximum value of M may be a trade-off between the maximum transport block size to be transmitted with the fallback scheme, and the maximum number of TTIs the MAC PDU may be transmitted due to sub-block or code-block partitioning for transmission on codeword #1.

[0229] The dual TB transmission scheme may be used in all TTIs, or may be used in configured TTIs. When the scheme is used in all TTIs, the WTRU may need to monitor the normal DCI as well as the fallback DCI in all TTIs. When the scheme is used in configured TTIs, the WTRU may monitor the normal DCI and the fallback DCI during the configured TTIs, and may monitor the normal DCI only for the rest of the TTIs.

[0230] In one or more embodiments, HARQ retransmissions may be used when using the dual TB scheme. For example, when the dual TB scheme is used for fallback data, the mB may transmit in the first codeword, consecutive code blocks (or sub-blocks) of the original MAC PDU (as shown in FIG. **13** and FIG. **14**). The WTRU may only transmit UL A/N signals for the second codeword. The mB may sequentially transmit code block (or sub-block) index 1, 2, . . . M of the current MAC PDU on codeword #1 and the full MAC PDU on codeword #2. This may be done until the WTRU correctly decodes the MAC PDU on codeword #2. Due to HARQ processing latencies, and depending on how the DL fallback data transmissions are scheduled, it may happen that the mB transmits code block (or sub-block) k+1 after the WTRU has ACK-ed the MAC PDU after receiving code block (or sub-block) k. In this case, the WTRU may discard all the subsequent received buffers for the current MAC PDU.

[0231] In another embodiment, when the dual TB scheme is used for normal data transmission, the WTRU may transmit UL A/N signals for each codeword. In this case, if the WTRU correctly decodes codeword #1, but not codeword #2, the WTRU may send an ACK for codeword #1 and a NACK for codeword #2. When the mB receives an ACK for codeword #1 and a NACK for codeword #2, for the next transmission to the WTRU, the mB may transmit the next code block (or sub-block) of the sequence in codeword #1, and re-transmit the entire MAC PDU in codeword #2.

[0232] A control channel fallback operation is described such that fallback TTIs may be pre-defined TTIs within sub-frames, which may be used by the mB to transmit the control channel on multiple wide beams (i.e., perform wide beam sweeping) to WTRUs that may need control fallback. For example, for cases where the WTRU may change its orientation, or when blockage of an active beam pair may occur, the mB may determine the need to use a fallback transmission scheme for the control channel and the data channel of a specific WTRU. In this case, during the fallback TTIs, the mB may repeat the transmission of the control channel on several spatial beams, to enable the WTRU to correctly receive the control channel in one or more beams. The one or more beams may be different from the original active beam of the active beam pair. The mB may use a fallback DCI (e.g., DCI-B) to transmit the fallback control channel during the fallback TTIs.

[0233] To make efficient use of the spectrum resources, the fallback TTIs may be used for regular transmissions when fallback schemes are not used. Thus, the mB may use fallback schemes only if the mB determines it needs to. In this case, the mB may use normal DCI (e.g., DCI-A) for the control channel transmissions. During fallback TTIs, the WTRU may monitor for both the normal DCI (e.g., DCI-A) and the fallback DCI (e.g., DCI-B).

[0234] In one or more embodiments, when the mB determines the need for control fallback for a WTRU, it may use the same reference signal (BRS) for all control beams that it re-transmits to the WTRU. In this case, the WTRU may need knowledge of the number of repetitions of the control channel, as well as of the time and frequency resources that may be assigned to the fallback TTI. Accordingly, the WTRU may monitor the fallback TTIs using the same reference signals (BRS) as used for the normal transmission scheme.

[0235] In another embodiment, the mB may use different BRSs for each beam, which may enable the WTRU to perform beam measurements. In this case, a mapping of the mB Tx beam ID (or beam index, or BRS) to time-frequency resources within the fallback TTIs may need to be known at the WTRU. This mapping may be either cell-specific (in which case, it may be signaled on broadcast), or WTRU specific, which may be configured via RRC signaling.

[0236] Mapping of Tx beam for fallback DCI to resources (TTI/OFDM symbol) is provided according to one or more embodiments. As previously indicated, the first element that enables the control channel fallback operation may be the provisioning of fallback TTIs. The fallback TTIs may be either cell specific or WTRU specific.

[0237] In addition to provisioning the fallback TTIs, the WTRU may need to be able to find and decode the fallback control channel within the fallback TTIs. Therefore, a mapping between the mB transmit beam and the resources used for the fallback control channel may need to be defined. The mapping may be cell specific or WTRU specific and may be signaled to the WTRU via broadcast signals or RRC signaling. The signaling may include information on the number of Tx wide beams supported by the mB, the number of fallback TTIs per sub-frame, the length of the control region in the fallback TTIs.

[0238] In one or more mapping embodiments, the number of mB Tx wide beams is denoted by Nwb, the size (in OFDM symbols) of the control region within a TTI is denoted by Lc, and the number of fallback TTIs per sub-frame is denoted by Nf. The mapping may be static, and pre-defined, as follows.

[0239] The sub-frame pattern periodicity, T, may be determined as the ratio between the number of mB wide beams (Nwb) and the number of OFDM symbols per sub-frame that may be used for fallback control signaling (L_cN_f).

[0240] The index of the fallback TTI (t_f) within a sub-frame may be fixed (pre-defined), or it may be WTRU

specific. If the index of the fallback TTI is WTRU specific, in one example, the index may be set as:

$$t_f = \mathrm{mod}\left(\frac{UE_{ID}}{N_f}\right)$$

If more than one fallback TTIs per sub-frame are assigned to a WTRU, the index of the first fallback TTI may be calculated as indicated above. The indices of the subsequent fallback TTIs in the sub-frame may be at a fixed offset (pre-defined or signaled) with respect to the first fallback TTI.

[0241] The mapping between the mB Tx wide beam b, $(0 \le b \le N_{wb}-1)$, the fallback TTI index n, $(0 \le n \le N_f-1)$ within sub-frame k, $(0 \le k \le T-1)$, and the OFDM symbol index (l), may be expressed as: $b=k \cdot N_f \cdot L_c+n \cdot L_c+l$.

[0242] In this example, the mB would transmit the fallback DCI on wide beam index b in sub-frame k, fallback TTI index n within sub-frame k, and OFDM index 1 within the fallback TTI. FIG. **15** shows a diagram of a mapping of Tx beams for fallback DCI to resources for a single RF chain mB. According to this mapping, Nwb=6, Nf=1 and Lc=3 and a WTRU and mB behavior during fallback TTI is provided according to such mapping.

[0243] In particular, FIG. **15** shows a diagram illustrating an example of fallback TTI and linkage between fallback DCI and fallback data, where the mB has one RF chain. In particular, a control channel fallback transmission scheme using fallback TTIs is shown such that a DL control channel in a fallback TTI may be repeated for one or more beam identities in a TDM manner. A WTRU may monitor and/or attempt to decode one or more of the control channels. Furthermore, the WTRU may use one Rx beam or sweep its Rx beam over a set of predefined or configured beam indices for monitoring/decoding the control channels.

[0244] During the TTIs that the mB configures as fallback, the mB may sweep the wide beam control channel using fallback DCI (DCI-B) for the WTRUs that may need control fallback. During the TTIs configured for fallback, the WTRU may monitor for both the regular DCI (DCI-A) and the fallback DCI (DCI-B). During the TTIs not configured for fallback (i.e., non-fallback TTIs), the WTRU may monitor for the regular DCI (DCI-A). The WTRU may not monitor for the fallback DCI (DCI-B) during the non-fallback TTIs.

[0245] The fallback DCI (DCI-B) may point to the DL resource assignment (time, frequency and beam) for fallback data. The mB may schedule fallback data repeated on multiple wide beams (e.g., B**1**, B**2**, B**3** in FIG. **15**), using smaller TBs (i.e., a smaller TB size).

[0246] In one example, the association between the fallback control (DCI-B) and the fallback data is shown in FIG. **15**. The fallback data may be assigned on the same wide beam as the wide beam used for signaling the fallback control (DCI-B). In this case, in addition to the regular information carried in the DCI, DCI-B may also signal the offset (in TTIs) of the TTI that carries the fallback data, with respect to the current TTI (the offset may also be set to zero). Alternatively, the DCI-B may signal the beam ID or the beam index, and correspondingly the BRS of the beam that carries the fallback data.

[0247] Referring now to FIG. **16**, FIG. **16** shows a diagram illustrating an example of fallback TTI and linkage between fallback DCI and fallback data, where the mB supports multiple RF chains. Since the mB may support multiple Tx RF chains, the mB may simultaneously transmit multiple beams during either the control region of the TTI, or the data region, or both. For example, in FIG. **16**, the mB may simultaneously transmit control channels on beams B**1** and B**3** during the first time resource of the fallback TTI, followed by control channel on beams B**2** and B**3** during the second time resource of the fallback TTI, and so on. The time-frequency resources may be used across different beams in a SDM fashion. For this example, the mB may insert beam-specific reference signals (BRS) in the appropriate time-frequency resources to enable correct reception by the WTRU.

[0248] Uplink A/N feedback may be signaled by a WTRU that received fallback DCI-B using an UL Tx wide beam that matches the DL Rx beam that the fallback DCI-B was received on (as an example, use the same steering vector).

[0249] The WTRU may transmit UL A/N feedback for the fallback data that corresponds to the fallback DCI-Bs that the WTRU decoded. For example, if in FIG. **15**, the UE successfully decoded DCI-B transmitted on beams B**2** and B**3** in the fallback TTI, but it did not decode DCI-B transmitted on beam B**1**, it may transmit UL A/N corresponding to the fallback data on Tx beam B**2** in TTI**4** and UL A/N corresponding to the fallback data on Tx beam B**3** in TTI**5**.

[0250] The timing of the UL A/N feedback may be derived by the WTRU according to the duplexing mode that the system operates on. For example, if the system operates in a TDD mode (including dynamic or enhanced TDD operation), the UL A/N feedback for data received on Tx beam B**2** in TTI**4** may be transmitted in the UL transmission opportunity that meets the HARQ timing requirements. The mB may use the timing of the ACK transmitted by the WTRU, to determine the DL Tx beam ID of the successful reception of fallback control and data. Corresponding to that TTI, and in order to monitor for the UL A/N transmission from the WTRU, the mB may configure the UL Rx beam to match DL Tx beam B**2**.

[0251] The mB may continue transmitting fallback control (DCI-B) during the configured fallback TTIs, until either it receives a positive ACK for the current transport block, or a fallback timer expires.

[0252] If the WTRU correctly decodes a fallback DCI-B and its associated fallback data on a beam that is different from the current active beam, the mB may issue a measurement request for that different beam, or the WTRU may send a measurement report of the (preferred) different beam. If a measurement (e.g., signal quality or strength) in the measurement report is above a threshold, the mB may issue a beam switch command to the WTRU, while maintaining the same transmission mode. In another solution, if the WTRU correctly decodes the fallback data on only one of the fallback beams used for re-transmission, the mB may directly issue a beam switch command to the WTRU for the ACK'ed beam, and maintain the same transmission mode.

[0253] Fallback DCI using wide beam sweeping in the PDSCH region may be provided in one or more embodiments. For example, FIG. **17** shows a diagram of fallback DCI mapped to the data region, and linkage to fallback data, where the mB supports one or more RF chains. Accordingly, the fallback TTIs may be still be defined and assigned as described above, but within the fallback TTIs, the fallback

DCI (DCI-B) may be mapped to the data region. This approach may be used for scenarios that require control channel congestion mitigation. To enable the WTRU to decode the fallback DCI (DCI-B), the mapping between the transmitted beam and the specific time-frequency resources may need to be known by the WTRU. This mapping may be cell-specific or WTRU specific, and may be signaled to the WTRU via broadcast signaling (MIB or SIB) or via RRC signaling.

[0254] In the example illustrated in FIG. **17**, the end of the data region (and the start of the region that may be used for the fallback control channel) may be indicated explicitly via signaling, implicitly to the WTRU, or may be pre-defined. For single Tx RF chain mBs, the mB may sweep the fallback DCI (DCI-B) on multiple beams in a TDM fashion, according to the beam to resource mapping. In this case, the mB may apply beam-specific reference signals (BRS) to the time-frequency resources used for each beam. In the fallback TTI (TTI**2**) of FIG. **17**, fallback DCI-B may be transmitted on Beam B**2** during the data region of the TTI. BRS specific to beam B**2** may need to be inserted in the time-frequency resources used for the DCI-B transmission with beam B**2**. Furthermore, BRS specific to beam B**3** may need to be inserted in the time-frequency resources used for the DCI-B transmission with beam B**3**.

[0255] The mB may transmit fallback DCI in that data region if it determines the need to do so. If no WTRUs need fallback transmissions, the mB may reuse the time-frequency resources to schedule regular data. The WTRUs that may monitor for the fallback DCI during the fallback TTI may still attempt to blind decode the fallback control channel, but may not successfully detect the fallback control channel.

[0256] Referring now to FIG. **18**, FIG. **18** shows a diagram illustrating fallback DCI mapped to the data region using narrow beam transmission. Accordingly, the fallback DCI may be transmitted in a narrow band within the assigned time-frequency resources in the data region of the TTI. This may allow the mB to use the rest of the frequency resource (s) for data transmission to the WTRUs operating in normal transmission mode. Mapping between the fallback TTI & time resource within a TTI and the mB DL beam for fallback DCI transmission may be done in a similar fashion as described above.

[0257] FIG. **19** shows a flow diagram utilizing a dual TB transmission scheme, for example, as shown in FIG. **12**, according to one or more embodiments. While FIG. **12** may serve as an example of a dual TB transmission scheme, process **1900** shown in FIG. **19** can be applied to any dual TB transmission scheme.

[0258] The process **1900**, implemented by a WTRU while operating in the high frequency bands (e.g., above 6 GHz), includes receiving multiple signals in a time transmission interval (TTI) (operations **1905**, **1910** and **1920**). In particular, the receiving of multiple signals includes receiving at least one control signal (operation **1905**) using a first beam associated with a first beam identifier (ID), receiving a first data signal (operation **1910**) using the first beam associated with the first beam ID, and receiving a second data signal (operation **1920**), subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The process **1900** further includes switching a receive beam of the WTRU from the first beam to the second beam based on the second beam ID to receive the second data signal (operation **1915**).

[0259] According to another embodiment, a method implemented by a WTRU includes receiving, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are received using a first beam, and the second transport block is received using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block. The method further includes switching a receive beam of the WTRU from the first beam to the second beam, to receive the second transport block, based on beam information associated with the second beam received in one of the at least one control signal.

[0260] FIG. **20** shows a flow diagram utilizing a dual TB transmission scheme, for example, as shown in FIG. **12**, according to one or more embodiments. While FIG. **12** may serve as an example of a dual TB transmission scheme, the process shown in FIG. **20** can be applied to any dual TB transmission scheme.

[0261] The process **2000**, implemented by wireless communication device (e.g., a base station, eNB, mB, or the like) while operating in the high frequency bands (e.g., above 6 GHz), includes transmitting multiple signals in a time transmission interval (TTI) (operations **2005**, **2010** and **2020**). In particular, the transmitting of multiple signals includes transmitting at least one control signal (operation **2005**) using a first beam associated with a first beam identifier (ID), transmitting a first data signal (operation **20910**) using the first beam associated with the first beam ID, and transmitting a second data signal (operation **2020**), subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID. At least one of the control signal(s) indicates the second beam ID. The process **2000** further includes switching a transmit beam of the wireless communication device from the first beam to the second beam based on the second beam ID to transmit the second data signal (operation **2015**).

[0262] According to another embodiment, a method implemented by a wireless communication device includes transmitting, in a time transmission interval (TTI), at least one control signal, a first transport block and a second transport block. The at least one control signal and the first transport block are transmitted using a first beam, and the second transport block is transmitted using a second beam that has a beam width that is more narrow than a beam width of the first beam. In addition, the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is transmitted subsequent to the first transport block. The method further includes switching a transmit beam of the wireless communication from the first beam to the second beam, to transmit the second transport block, based on beam information associated with the second beam transmitted in one of the at least one control signal.

[0263] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be

implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

1. A wireless transmit/receive unit (WTRU) configured to perform wireless communications, comprising:

a receiver configured to receive, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID, wherein one of the at least one control signal indicates the second beam ID; and

a processor configured to switch a receive beam of the receiver from the first beam to the second beam based on the second beam ID to receive the second data signal.

2. The WTRU of claim **1**, wherein the first data signal is carried in a first transport block in the TTI and the second data signal is carried in a second transport block in the TTI.

3. The WTRU of claim **2**, wherein the first transport block uses a lower modulation and coding scheme value than the second transport block.

4. The WTRU of claim **2**, wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block.

5. The WTRU of claim **4**, wherein the receiver is configured to receive the at least one control signal in a control region of the TTI that precedes the first and the second transport blocks.

6. The WTRU of claim **1**, wherein the one of the at least one control signal includes downlink control information (DCI) that indicates the second beam ID.

7. The WTRU of claim **1**, wherein the second beam is a subset of the first beam such that a beam width of the second beam is more narrow than a beam width of the first beam.

8. The WTRU of claim **1**, wherein first data received in the first data signal is a subset of second data received in the second data signal.

9. The WTRU of claim **8**, wherein the processor is configured to decode the second data using the received first data.

10. The WTRU of claim **1**, wherein the at least one control signal includes a first control signal associated with the first data signal and a second control signal associated with the second data signal, wherein first control signal includes control information that indicates the first beam ID and the second control signal includes control information that indicates the second beam ID.

11. A method implemented by a wireless transmit/receive unit (WTRU) configured to perform wireless communications, the method comprising:

receiving, in a time transmission interval (TTI), at least one control signal and a first data signal using a first beam associated with a first beam identifier (ID) and a second data signal, subsequent to the first data signal, using a second beam associated with a second beam ID different from the first beam ID, wherein one of the at least one control signal indicates the second beam ID; and

switching a receive beam of the WTRU from the first beam to the second beam based on the second beam ID to receive the second data signal.

12. The method of claim **11**, wherein the first data signal is carried in a first transport block in the TTI and the second data signal is carried in a second transport block in the TTI.

13. The method of claim **12**, wherein the first transport block uses a lower modulation and coding scheme value than the second transport block.

14. The method of claim **12**, wherein the first transport block and the second transport block are multiplexed using time division multiplexing such that the second transport block is received subsequent to the first transport block.

15. The method of claim **14**, further comprising:

receiving the at least one control signal in a control region of the TTI that precedes the first and the second transport blocks.

16. The method of claim **11**, wherein the one of the at least one control signal includes downlink control information (DCI) that indicates the second beam ID.

17. The method of claim **11**, wherein the second beam is a subset of the first beam such that a beam width of the second beam is more narrow than a beam width of the first beam.

18. The method of claim **11**, wherein first data received in the first data signal is a subset of second data received in the second data signal.

19. The method of claim **18**, further comprising:

decoding the second data using the received first data.

20. The method of claim **11**, wherein the at least one control signal includes a first control signal associated with the first data signal and a second control signal associated with the second data signal, wherein first control signal includes control information that indicates the first beam ID and the second control signal includes control information that indicates the second beam ID.

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(54) METHOD AND APPARATUS FOR VIRTUALIZING ANTENNA IN WIRELESS COMMUNICATION SYSTEM

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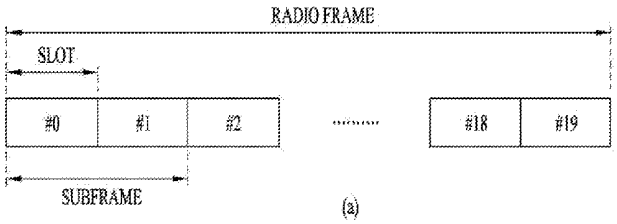
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(57) **ABSTRACT**

The present invention relates to a wireless communication system, and more specifically, disclosed are a method and an apparatus for virtualizing an antenna. A method for communicating using a virtual antenna of a terminal in the wireless communication system, according to one embodiment of the present invention, comprises the steps of: configuring one or more virtual antennas according to an antenna virtualization pattern that is determined based on information indicating a movement status of the terminal and/or information indicating a communication status of the terminal; and communicating with the base station by using the one or more virtual antennas, wherein one or more physical antennas that are mapped to the one or more virtual antennas can be determined base on the direction of movement of the terminal.



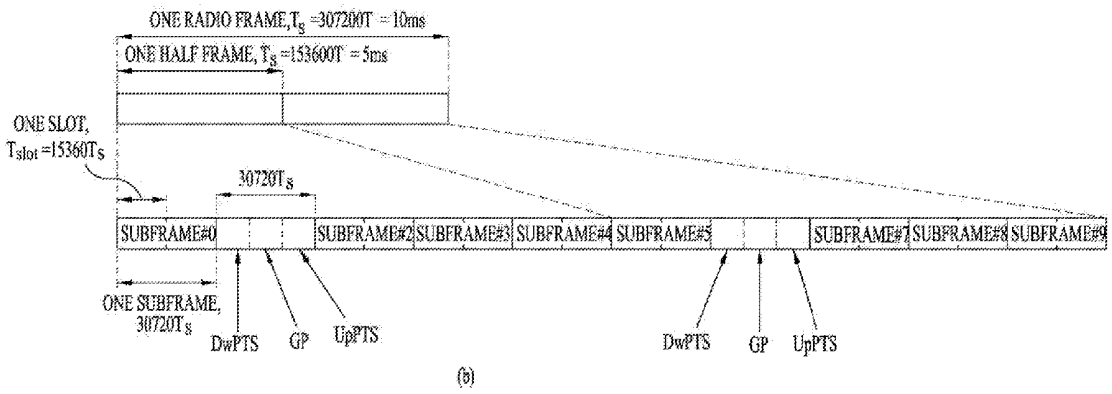
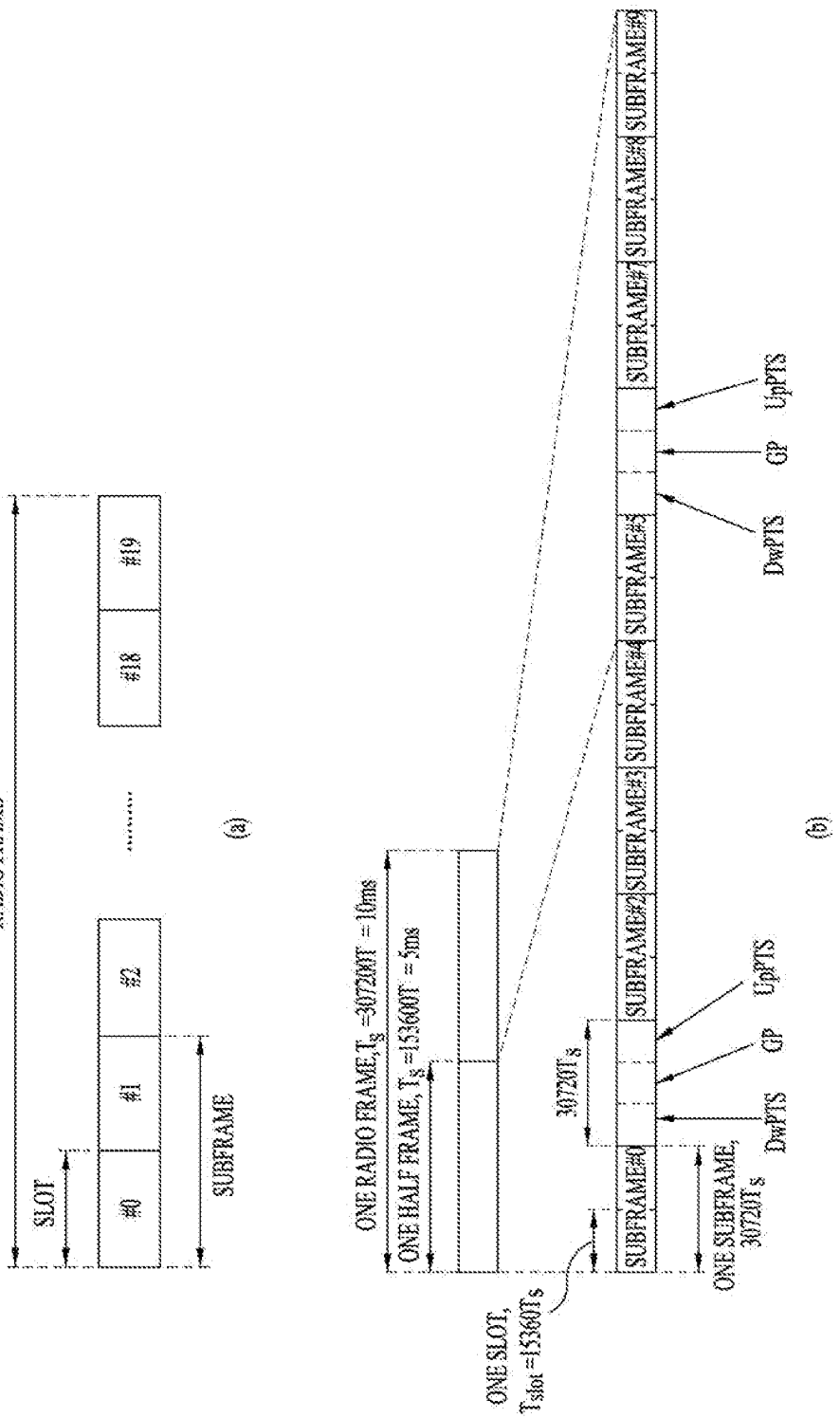


FIG. 1


RADIO FRAME
SLOT
#0
#1
#2
.....
#18
#19
SUBFRAME
(a)
ONE RADIO FRAME, T_s =30720T_s = 10ms
ONE HALF FRAME, T_s =15360T_s = 5ms
ONE SLOT, T_{slot} =15360T_s
30720T_s
ONE SUBFRAME, 30720T_s
SUBFRAME#0
SUBFRAME#1
SUBFRAME#2
SUBFRAME#3
SUBFRAME#4
SUBFRAME#5
SUBFRAME#6
SUBFRAME#7
SUBFRAME#8
SUBFRAME#9
DwPTS
GP
UpPTS
DwPTS
GP
UpPTS
(b)

418

FIG. 2

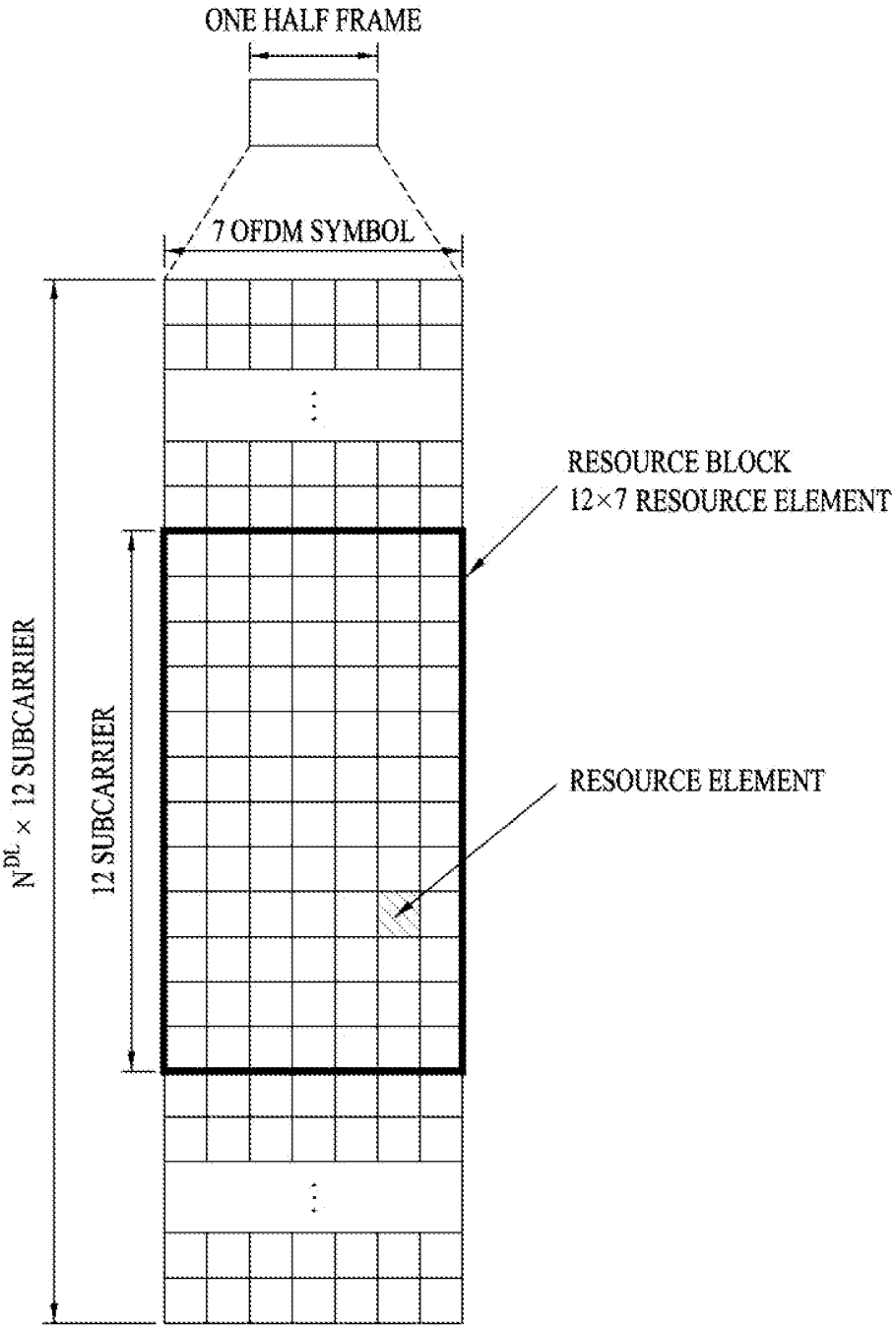

ONE HALF FRAME
7 OFDM SYMBOL
RESOURCE BLOCK
12×7 RESOURCE ELEMENT
RESOURCE ELEMENT
$N^{DL} \times 12$ SUBCARRIER
12 SUBCARRIER

FIG. 3

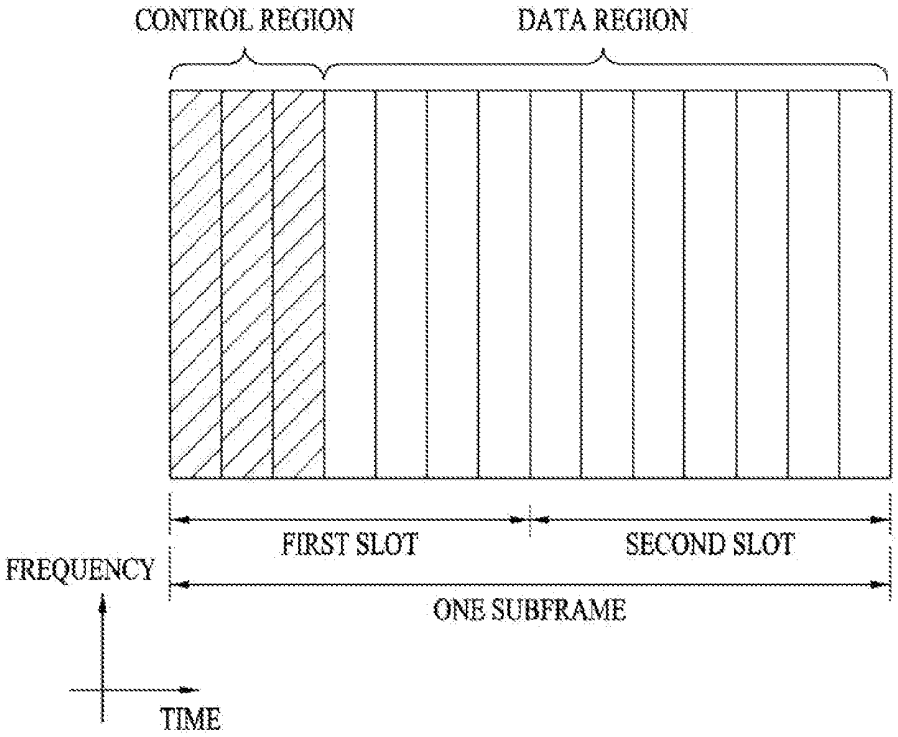

CONTROL REGION
DATA REGION
FIRST SLOT
SECOND SLOT
FREQUENCY
ONE SUBFRAME
TIME

FIG. 4

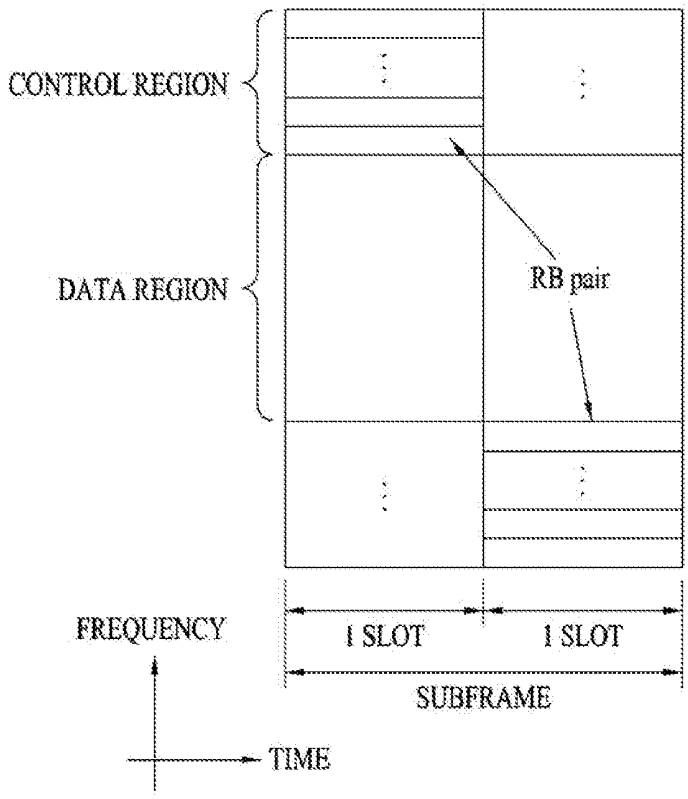
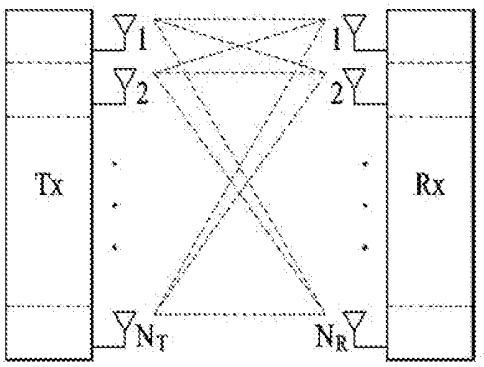
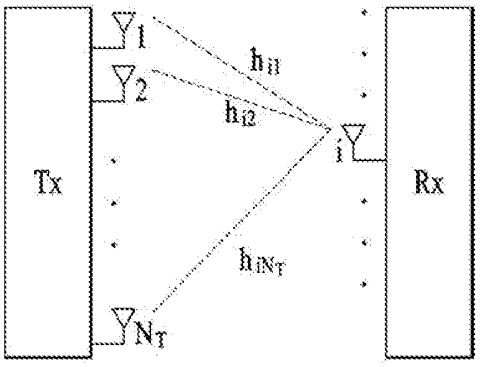

CONTROL REGION
DATA REGION
RB pair
FREQUENCY
1 SLOT
1 SLOT
SUBFRAME
TIME

FIG. 5



(a)



(b)

FIG. 6

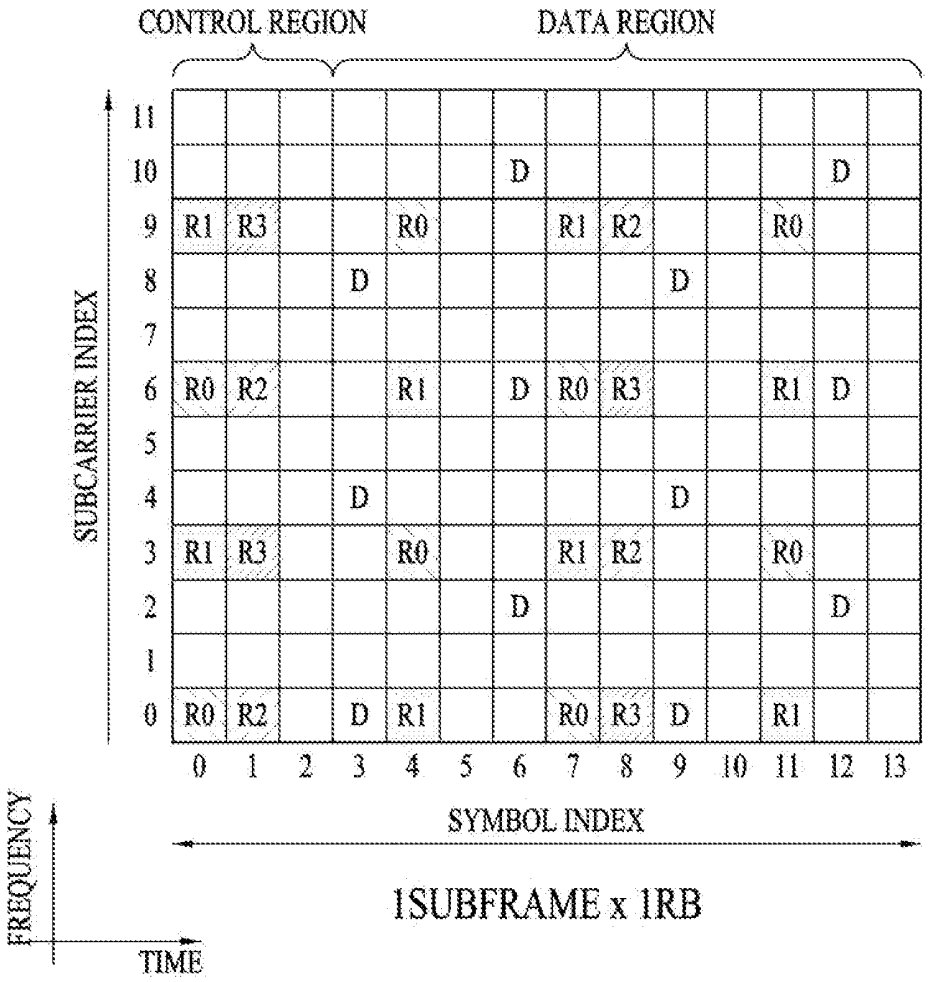

CONTROL REGION
DATA REGION
SUBCARRIER INDEX
SYMBOL INDEX
FREQUENCY
TIME
1SUBFRAME x 1RB

FIG. 7

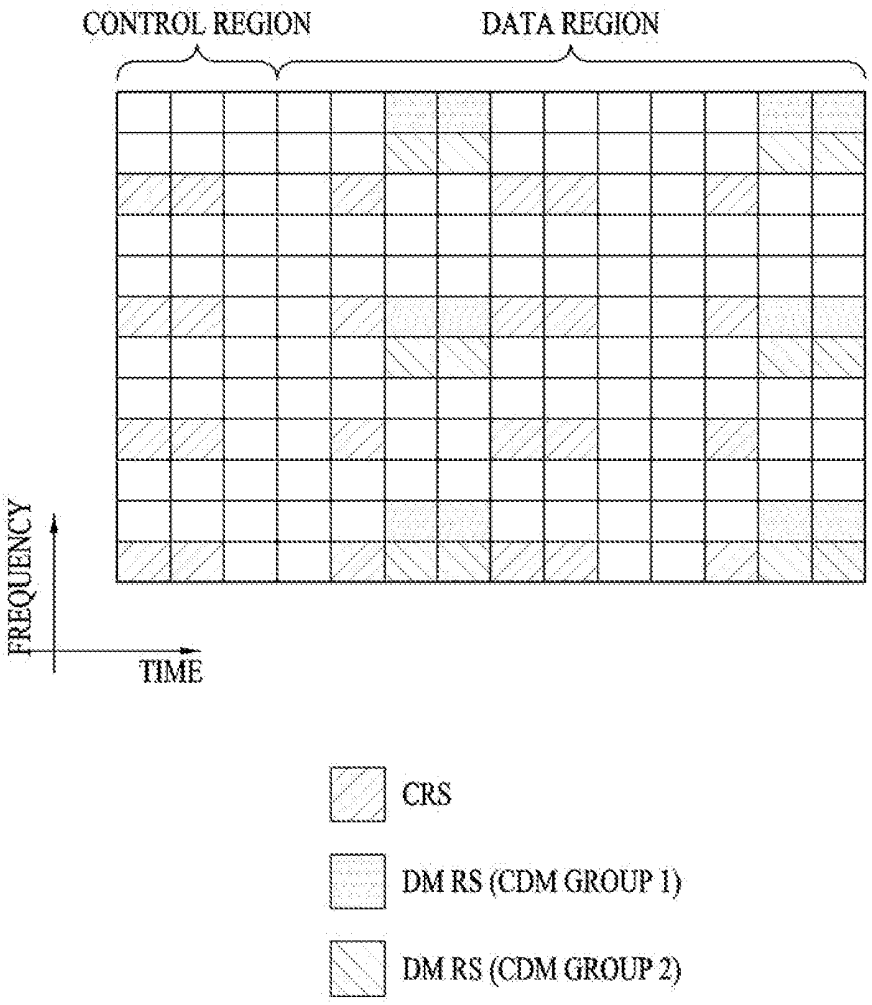

CONTROL REGION
DATA REGION
FREQUENCY
TIME
CRS
DM RS (CDM GROUP 1)
DM RS (CDM GROUP 2)

FIG. 8

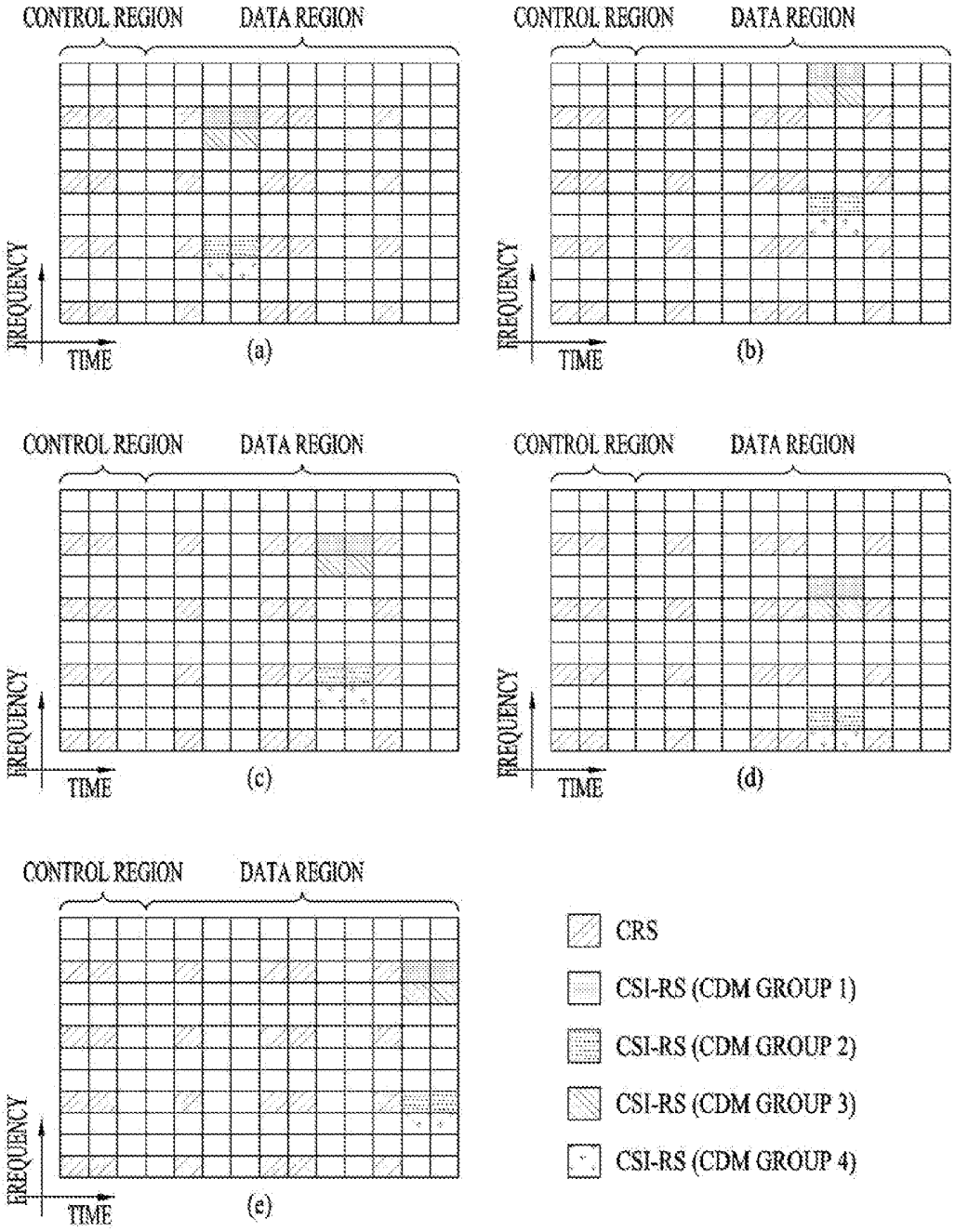
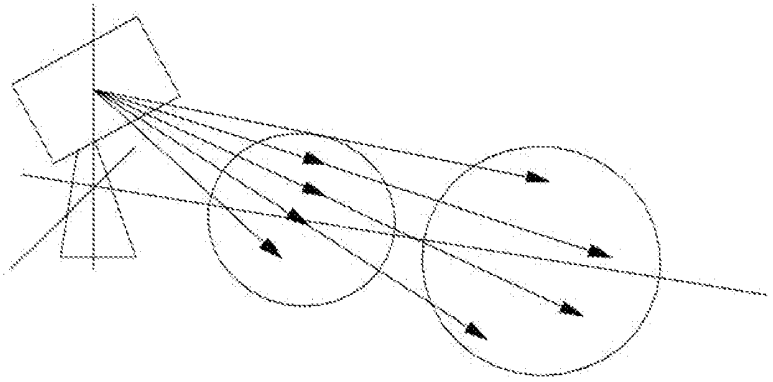
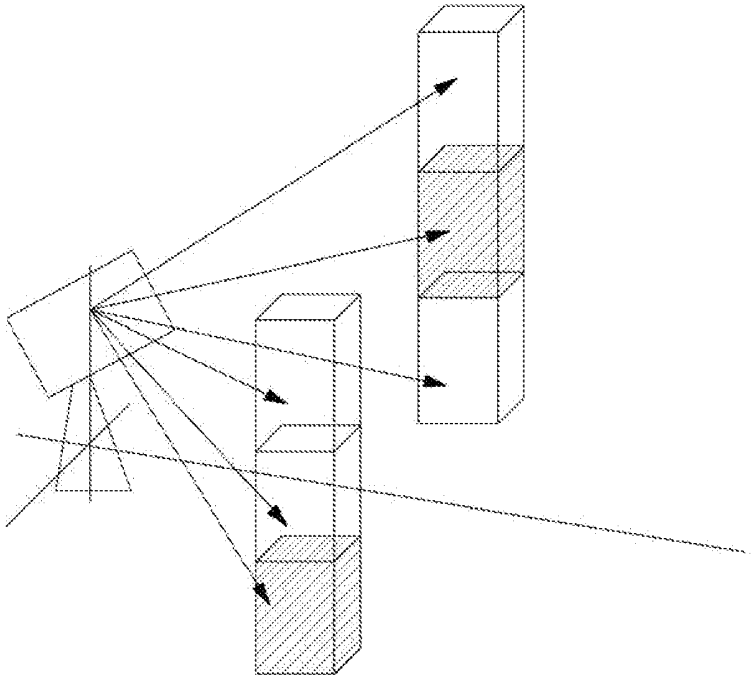

CONTROL REGION
DATA REGION
FREQUENCY
TIME
(a)
(b)
(c)
(d)
(e)
CRS
CSI-RS (CDM GROUP 1)
CSI-RS (CDM GROUP 2)
CSI-RS (CDM GROUP 3)
CSI-RS (CDM GROUP 4)

FIG. 9



(a)



(b)

FIG. 10

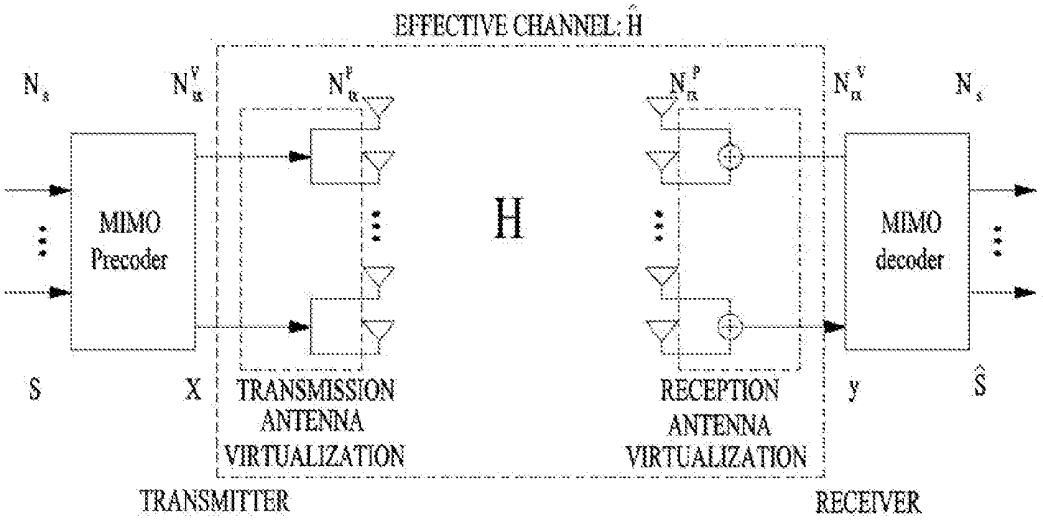

EFFECTIVE CHANNEL: Ĥ
N_s
N_{tx}^V
N_{tx}^P
N_{rx}^P
N_{rx}^V
N_s
MIMO Precoder
H
MIMO decoder
S
X
TRANSMISSION ANTENNA VIRTUALIZATION
RECEPTION ANTENNA VIRTUALIZATION
y
$\hat{S}$
TRANSMITTER
RECEIVER

FIG. 11

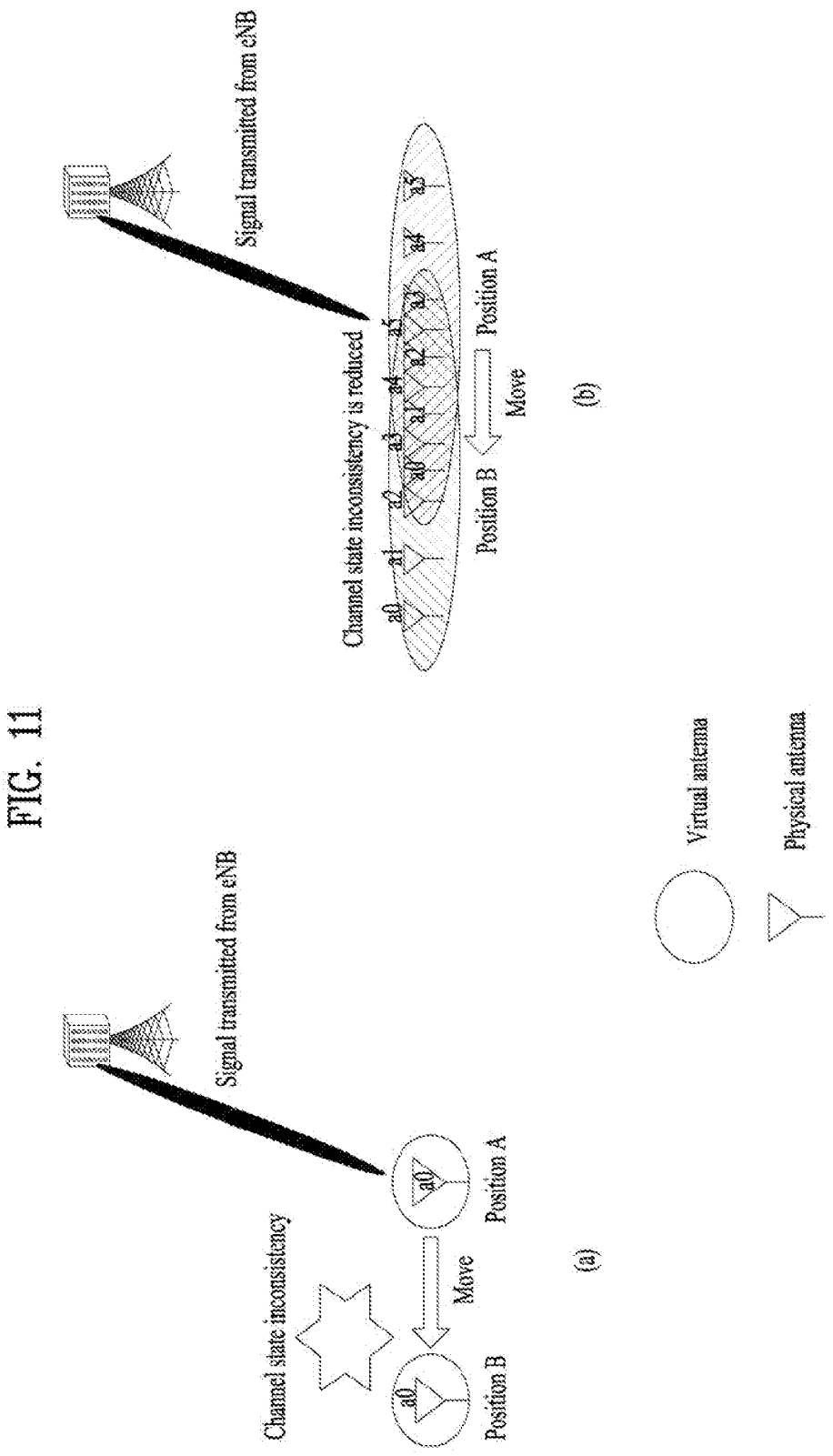

Signal transmitted from eNB
Channel state inconsistency
Position A
Move
Position B
(a)
Signal transmitted from eNB
Channel state inconsistency is reduced
Position A
Move
Position B
(b)
Virtual antenna
Physical antenna

FIG. 12

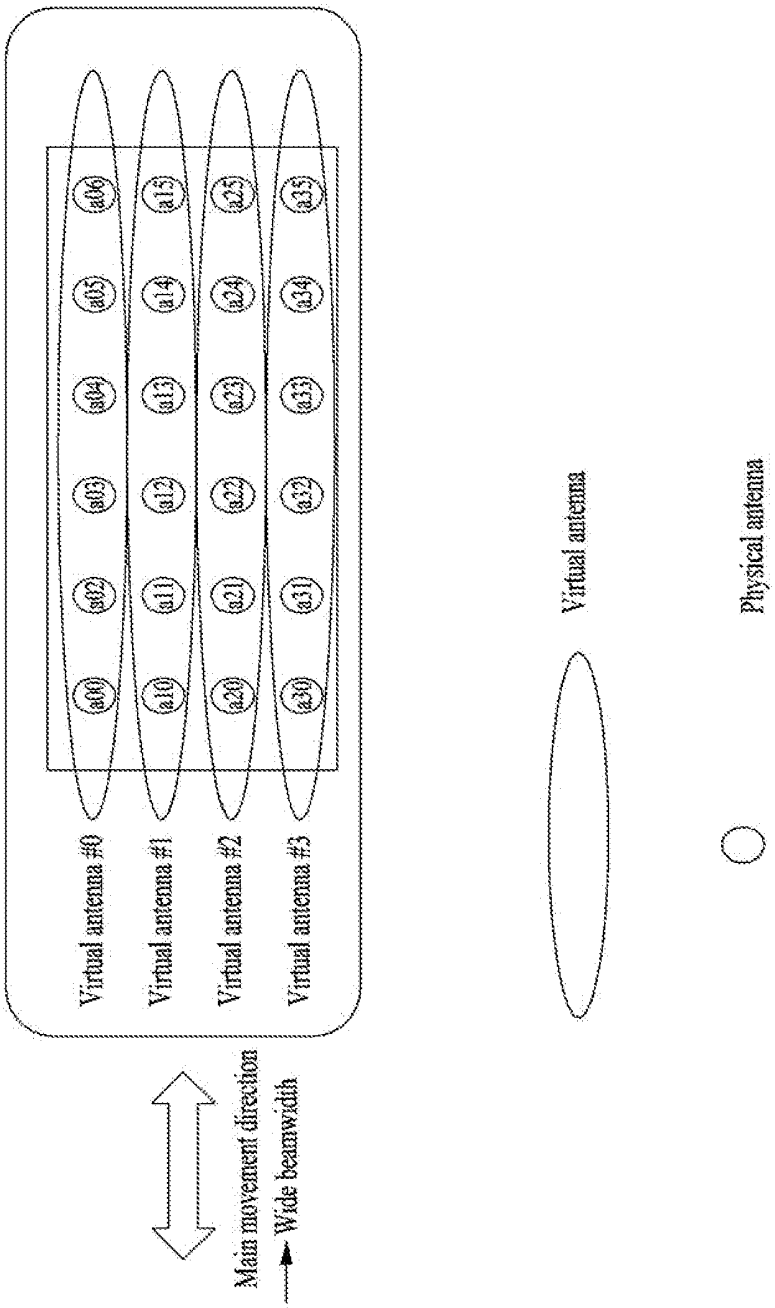

a00
a01
a02
a03
a04
a05
a06
a10
a11
a12
a13
a14
a15
a20
a21
a22
a23
a24
a25
a30
a31
a32
a33
a34
a35
Virtual antenna #0
Virtual antenna #1
Virtual antenna #2
Virtual antenna #3
Main movement direction
Wide beamwidth
Virtual antenna
Physical antenna

FIG. 13

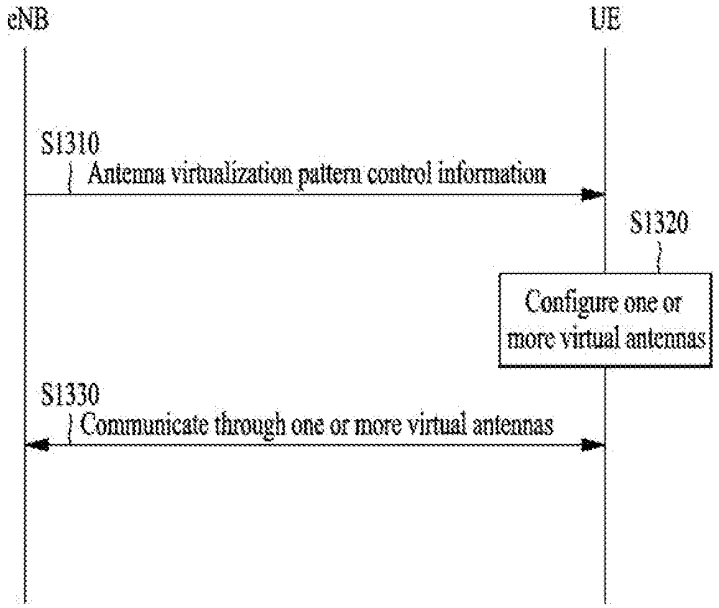
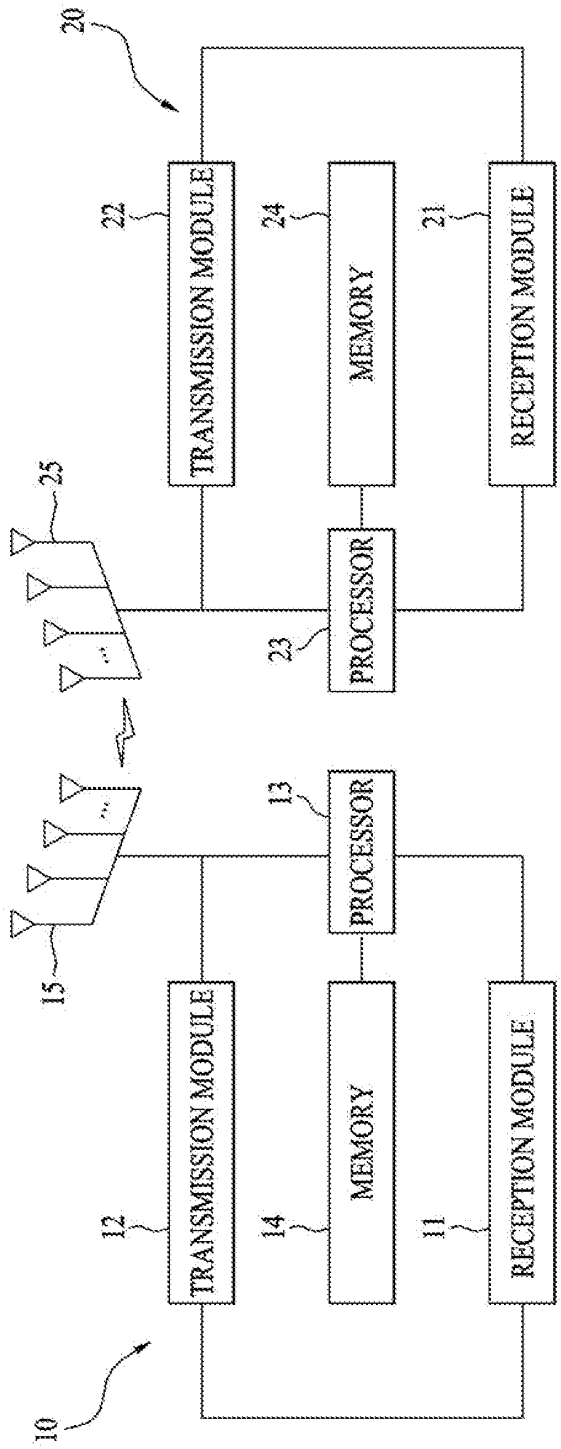

eNB
UE
S1310
Antenna virtualization pattern control information
S1320
Configure one or more virtual antennas
S1330
Communicate through one or more virtual antennas

FIG. 14


20
22
TRANSMISSION MODULE
24
MEMORY
21
RECEPTION MODULE
25
23
PROCESSOR
13
PROCESSOR
15
12
TRANSMISSION MODULE
14
MEMORY
11
RECEPTION MODULE
10

430

METHOD AND APPARATUS FOR VIRTUALIZING ANTENNA IN WIRELESS COMMUNICATION SYSTEM

TECHNICAL FIELD

[0001] The following description relates to a wireless communication system and, more specifically, to a method and apparatus for virtualizing an antenna.

BACKGROUND ART

[0002] MIMO (multiple-input multiple-output) refers to a method for improving data transmission/reception efficiency by adopting multiple transmit (Tx) antennas and multiple receive (Rx) antennas instead of a single Tx antenna and a single Rx antenna. When a single antenna is used, a receiver receives data through a single antenna path. However, when multiple antennas are used, the receiver receives data through multiple paths. Accordingly, a data transfer rate, throughput or signal-to-interference-and-noise-ratio (SINR) can be increased and coverage can be improved. A case in which both a transmitter and a receiver use a single antenna is referred to as SISO (Single-Input Single-Output), a case in which only the transmitter uses a plurality of antennas is referred to as MISO (Multiple-Input Single-Output), and a case in which only the receiver uses a plurality of antennas is referred to as SIMO (Single-Input Multiple-Output). In general, MIMO, SIMO, MISO and SISO schemes are commonly called MIMO technology.

[0003] To increase a multiplexing gain of MIMO operation, channel state information (CSI) can be fed back from an MIMO receiver and used for a MIMO transmitter. The receiver can determine the CSI by performing channel measurement using a predetermined reference signal (RS).

DISCLOSURE

Technical Problem

[0004] In enhanced wireless communication systems, support for more accurate beamforming is considered. As beamforming resolution increases, performance deterioration due to channel aging may be aggravated. Furthermore, as a moving speed of a UE increases, a channel that the UE suffers remarkably changes and thus performance deterioration due to channel aging may become serious.

[0005] An object of the present invention devised to solve the problem lies in a method and apparatus for virtualizing an antenna to minimize performance deterioration due to channel aging even when channel aging occurs due to precise beamforming and/or high-speed movement.

[0006] The technical problems solved by the present invention are not limited to the above technical problems and those skilled in the art may understand other technical problems from the following description.

Technical Solution

[0007] In an aspect of the present invention, a communication method using a virtual antenna of a terminal in a wireless communication system includes: configuring one or more virtual antennas according to an antenna virtualization pattern determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and communicating with a base station using the one or more virtual antennas, wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

[0008] In another aspect of the present invention, provided herein is a method for supporting, by a base station, communication using a virtual antenna of a terminal in a wireless communication system, including: transmitting, to the terminal, control information with respect to an antenna virtualization pattern of the terminal, determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and communicating with the terminal through one or more virtual antennas of the terminal, configured according to the control information with respect to the antenna virtualization pattern, wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

[0009] In another aspect of the present invention, provided herein is a terminal performing communication using a virtual antenna in a wireless communication system, including: a transmitter; a receiver; and a processor, wherein the processor is configured: to configure one or more virtual antennas according to an antenna virtualization pattern determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and to communicate with a base station using the one or more virtual antennas through one of the transmitter and the receiver, wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

[0010] In another aspect of the present invention, provided herein is a base station supporting communication using a virtual antenna of a terminal in a wireless communication system, including: a transmitter; a receiver; and a processor, wherein the processor is configured: to transmit, to the terminal, control information with respect to an antenna virtualization pattern of the terminal, determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal, through the transmitter; and to communicate with the terminal through one or more virtual antennas of the terminal, configured according to the control information with respect to the antenna virtualization pattern, through one of the transmitter and the receiver, wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

[0011] The following can be commonly applied to the aforementioned embodiments of the present invention.

[0012] The width of a beam formed by the one or more physical antennas mapped to one virtual antenna may be extended in the same direction as the direction of movement of the terminal.

[0013] The one or more physical antennas mapped to one virtual antenna may be one or more physical antennas arranged in the direction of movement of the terminal.

[0014] The antenna virtualization pattern may include at least one of the number of one or more physical antennas mapped to one virtual antenna and information specifying the one or more physical antennas.

[0015] The number of one or more physical antennas mapped to one virtual antenna may be determined on the basis of a moving speed of the terminal.

[0016] The information indicating the movement state may include at least one of information on whether the terminal is

moving, information on the direction of movement of the terminal, information on the moving speed of the terminal and information about an acceleration state or a deceleration state.

[0017] The information indicating the communication state may include at least one of information on a distance between the terminal and the base station, information on relative positions of the terminal and the base station and information on a channel state between the terminal and the base station.

[0018] The antenna virtualization pattern may be adaptively determined according to change of at least one of the information indicating the movement state of the terminal and the information indicating the communication state of the terminal.

[0019] Control information with respect to the antenna virtualization pattern may be received from the base station.

[0020] One or more of the information indicating the movement state of the terminal, position information of the terminal and channel state information may be reported by the terminal to the base station.

[0021] Information indicating the antenna virtualization pattern preferred by the terminal may be reported by the terminal to the base station.

[0022] The configuring of one or more virtual antennas according to the antenna virtualization pattern may be performed when the terminal does not perform data transmission and reception.

[0023] The above description and the following detailed description of the present invention are exemplary and are for additional explanation of the invention disclosed in the claims.

Advantageous Effects

[0024] According to the present invention, it is possible to provide a method and apparatus for virtualizing an antenna to minimize performance deterioration due to channel aging even when channel aging occurs due to precise beamforming and/or high-speed movement.

[0025] The effects of the present invention are not limited to the above-described effects and other effects which are not described herein will become apparent to those skilled in the art from the following description.

DESCRIPTION OF DRAWINGS

[0026] The accompanying drawings, which are included to provide a further understanding of the invention, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention. In the drawings:

[0027] FIG. **1** illustrates a radio frame structure;

[0028] FIG. **2** illustrates a resource grid of a downlink slot;

[0029] FIG. **3** illustrates a downlink subframe structure;

[0030] FIG. **4** illustrates an uplink subframe structure;

[0031] FIG. **5** illustrates a configuration of a wireless communication system having multiple antennas;

[0032] FIG. **6** illustrates exemplary CRS and DRS patterns in one resource block pair;

[0033] FIG. **7** illustrates an exemplary DMRS pattern defined in LTE-A;

[0034] FIG. **8** illustrates exemplary CSI-RS patterns defined in LTE-A;

[0035] FIG. **9** illustrates exemplary beamforming according to a 2-dimensional antenna configuration;

[0036] FIG. **10** illustrates antenna virtualization;

[0037] FIG. **11** illustrates an example of antenna virtualization according to the present invention;

[0038] FIG. **12** illustrates an antenna virtualization method for two-dimensional antenna arrangement according to the present invention;

[0039] FIG. **13** is a flowchart illustrating a communication method using a virtual antenna according to the present invention; and

[0040] FIG. **14** illustrates configurations of a base station and a UE according to the present invention.

BEST MODE

[0041] Embodiments described hereinbelow are combinations of elements and features of the present invention. The elements or features may be considered selective unless otherwise mentioned. Each element or feature may be practiced without being combined with other elements or features. Further, an embodiment of the present invention may be constructed by combining parts of the elements and/or features. Operation orders described in embodiments of the present invention may be rearranged. Some constructions of any one embodiment may be included in another embodiment and may be replaced with corresponding constructions of another embodiment.

[0042] In the embodiments of the present invention, a description is given, centering on a data transmission and reception relationship between a base station (BS) and a user equipment (UE). The BS is a terminal node of a network, which communicates directly with a UE. In some cases, a specific operation described as performed by the BS may be performed by an upper node of the BS.

[0043] Namely, it is apparent that, in a network comprised of a plurality of network nodes including a BS, various operations performed for communication with a UE may be performed by the BS, or network nodes other than the BS. The term "BS" may be replaced with the term "fixed station", "Node B", "evolved Node B (eNode B or eNB)", "Access Point (AP)", etc. The term "UE" may be replaced with the term "terminal", "Mobile Station (MS)", "Mobile Subscriber Station (MSS)", "Subscriber Station (SS)", etc.

[0044] Specific terms used in the embodiments of the present invention are provided to aid in understanding of the present invention. These specific terms may be replaced with other terms within the scope and spirit of the present invention.

[0045] In some cases, to prevent the concept of the present invention from being obscured, structures and apparatuses of the known art will be omitted, or will be shown in the form of a block diagram based on main functions of each structure and apparatus. In addition, wherever possible, the same reference numbers will be used throughout the drawings and the specification to refer to the same or like parts.

[0046] The embodiments of the present invention can be supported by standard documents disclosed for at least one of wireless access systems including Institute of Electrical and Electronics Engineers (IEEE) 802, 3GPP, 3GPP LTE, LTE-A, and 3GPP2. Steps or parts that are not described to clarify the technical features of the present invention can be supported by those documents. Further, all terms as set forth herein can be explained by the standard documents.

[0047] Embodiments of the present invention are applicable to a variety of wireless access technologies such as Code Division Multiple Access (CDMA), Frequency Divi-

sion Multiple Access (FDMA), Time Division Multiple Access (TDMA), Orthogonal Frequency Division Multiple Access (OFDMA), and Single Carrier Frequency Division Multiple Access (SC-FDMA). CDMA can be implemented as a radio technology such as Universal Terrestrial Radio Access (UTRA) or CDMA2000. TDMA can be implemented as a radio technology such as Global System for Mobile communications (GSM)/General Packet Radio Service (GPRS)/Enhanced Data Rates for GSM Evolution (EDGE). OFDMA can be implemented as a radio technology such as Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wireless Fidelity (Wi-Fi)), IEEE 802.16 (Worldwide interoperability for Microwave Access (WiMAX)), IEEE 802.20, and Evolved UTRA (E-UTRA). UTRA is a part of Universal Mobile Telecommunications System (UMTS). 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE) is a part of Evolved UMTS (E-UMTS) using E-UTRA, employing OFDMA for downlink and SC-FDMA for uplink. LTE-Advanced (LTE-A) is an evolution of 3GPP LTE. WiMAX can be described by the IEEE 802.16e standard (Wireless Metropolitan Area Network (WirelessMAN-OFDMA Reference System) and the IEEE 802.16m standard (WirelessMAN-OFDMA Advanced System). For clarity, this application focuses on the 3GPP LTE/LTE-A system. However, the technical features of the present invention are not limited thereto.

[0048] FIG. **1** illustrates a radio frame structure.

[0049] In a cellular OFDM wireless packet communication system, uplink/downlink data packet transmission is performed on a subframe-by-subframe basis. A subframe is defined as a predetermined time interval including a plurality of OFDM symbols. 3GPP LTE supports a type-1 radio frame structure applicable to FDD (Frequency Division Duplex) and a type-2 radio frame structure applicable to TDD (Time Division Duplex).

[0050] FIG. **1**(*a*) illustrates a type-1 radio frame structure. A downlink subframe includes 10 subframes, each of which includes 2 slots in the time domain. A unit time during which one subframe is transmitted is defined as a transmission time interval (TTI). For example, each subframe has a length of 1 ms and each slot has a length of 0.5 ms. A slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in the time domain and includes a plurality of resource blocks (RBs) in the frequency domain. Since 3GPP LTE adopts OFDMA for downlink, an OFDM symbol represents one symbol period. An OFDM symbol may be referred to as an SC-FDMA symbol or symbol period. A resource block (RB) is a resource allocation unit including a plurality of contiguous subcarriers in a slot.

[0051] The number of OFDM symbols included in one slot may depend on cyclic prefix (CP) configuration. CPs include an extended CP and a normal CP. When an OFDM symbol is configured with the normal CP, for example, the number of OFDM symbols included in one slot may be 7. When an OFDM symbol is configured with the extended CP, the duration of one OFDM symbol increases, and thus the number of OFDM symbols included in one slot is smaller than that in case of the normal CP. In case of the extended CP, the number of OFDM symbols allocated to one slot may be 6. When a channel state is unstable, such as a case in which a UE moves at a high speed, the extended CP can be used to reduce inter-symbol interference.

[0052] When the normal CP is used, one subframe includes 14 OFDM symbols since one slot has 7 OFDM symbols. The first two or three OFDM symbols in each subframe can be allocated to a physical downlink control channel (PDCCH) and the remaining OFDM symbols can be allocated to a physical downlink shared channel (PDSCH).

[0053] FIG. **1**(*b*) illustrates a type-2 radio frame structure. The type-2 radio frame includes 2 half frames. Each half frame includes 5 subframes, a downlink pilot time slot (DwPTS), a guard period (GP) and an uplink pilot time slot (UpPTS). One subframe consists of 2 slots. The DwPTS is used for initial cell search, synchronization or channel estimation in a UE. The UpPTS is used for channel estimation in a BS and UL transmission synchronization acquisition in a UE. The GP eliminates UL interference caused by multi-path delay of a DL signal between UL and DL. One subframe includes 2 slots irrespective of radio frame type.

[0054] The radio frame structure is purely exemplary and thus the number of subframes in a radio frame, the number of slots in a subframe, or the number of OFDM symbols in a slot may vary.

[0055] FIG. **2** illustrates a resource grid in a downlink slot.

[0056] While one downlink slot includes 7 OFDM symbols in the time domain and one RB includes 12 subcarriers in the frequency domain in FIG. **2**, the present invention is not limited thereto. For example, one slot includes 7 OFDM symbols in the case of normal CP whereas one slot includes 6 OFDM symbols in the case of extended CP. Each element on the resource grid is referred to as a resource element (RE). One RB includes 12×7 REs. The number NDL of RBs included in the downlink slot depends on a downlink transmit bandwidth. The structure of an uplink slot may be same as that of the downlink slot.

[0057] FIG. **3** illustrates a downlink subframe structure.

[0058] A maximum of three OFDM symbols located in a front portion of a first slot within a subframe correspond to a control region to which a control channel is allocated. The remaining OFDM symbols correspond to a data region to which a physical downlink shared chancel (PDSCH) is allocated.

[0059] Examples of downlink control channels used in 3GPP LTE include a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), a physical hybrid ARQ indicator channel (PHICH), etc. The PCFICH is transmitted at a first OFDM symbol of a subframe and carries information regarding the number of OFDM symbols used for transmission of control channels within the subframe. The PHICH is a response to uplink transmission and carries a HARQ acknowledgment (ACK)/negative-acknowledgment (NACK) signal. Control information transmitted through the PDCCH is referred to as downlink control information (DCI). The DCI includes uplink or downlink scheduling information or uplink Tx power control commands for an arbitrary UE group. The PDCCH may carry a transport format and resource allocation of a downlink shared channel (DL-SCH), resource allocation information of an uplink shared channel (UL-SCH), paging information on a paging channel (PCH), system information on the DL-SCH, information on resource allocation of an upper-layer control message such as a random access response transmitted on the PDSCH, a set of Tx power control commands on individual UEs within an arbitrary UE group, a Tx power control command, information on activation of a voice over IP (VoIP), etc. A plurality of PDCCHs can be transmitted within a control region. The UE can monitor the plurality of PDCCHs.

[0060] The PDCCH is transmitted on an aggregation of one or several consecutive control channel elements (CCEs). The CCE is a logical allocation unit used to provide the PDCCH with a coding rate based on a state of a radio channel. The CCE corresponds to a plurality of resource element groups (REGs). A format of the PDCCH and the number of bits of the available PDCCH are determined by correlation between the number of CCEs and a coding rate provided by the CCEs.

[0061] The BS determines a PDCCH format according to DCI to be transmitted to the UE, and attaches a cyclic redundancy check (CRC) to control information. The CRC is masked with an identifier referred to as a radio network temporary identifier (RNTI) according to an owner or usage of the PDCCH. If the PDCCH is for a specific UE, a cell-RNTI (C-RNTI)) of the UE may be masked to the CRC. Alternatively, when the PDCCH is for a paging message, a paging indicator identifier (P-RNTI) may be masked to the CRC. When the PDCCH is for system information (more specifically, a system information block (SIB)), a system information identifier and system information RNTI (SI-RNTI) may be masked to the CRC. To indicate a random access response corresponding to a response to transmission of a random access preamble of the UE, a random access-RNTI (RA-RNTI) may be masked to the CRC.

[0062] FIG. **4** illustrates an uplink subframe structure.

[0063] An uplink subframe may be divided into a control region and a data region in the frequency domain. The control region is allocated a physical uplink control channel (PUCCH) including uplink control information. The data region is allocated a physical uplink shared channel (PUSCH) including user data. To maintain single carrier property, one UE cannot simultaneously transmit a PUCCH and a PUSCH. A PUCCH for a UE is allocated to an RB pair. RBs belonging to an RB pair occupy different subcarriers in 2 slots. That is, an RB pair allocated to a PUCCH is frequency-hopped at a slot boundary.

[0064] MIMO System Modeling

[0065] FIG. **5** illustrates configurations of wireless communication systems including multiple antennas.

[0066] As shown in FIG. **5**(*a*), when the number of transmit (Tx) antennas increases to N_T, and at the same time the number of receive (Rx) antennas increases to N_R, a theoretical channel transmission capacity of the MIMO communication system increases in proportion to the number of antennas, differently from a case in which only a transmitter or receiver uses several antennas, so that transmission rate and frequency efficiency can be greatly increased. In this case, the transfer rate acquired by the increased channel transmission capacity can theoretically increase by a predetermined amount that corresponds to a product of a maximum transfer rate (R_o) acquired when one antenna is used and a rate of increase (R_i).

$$R_i=\min(N_T, N_R) \quad \text{[Equation 1]}$$

[0067] For example, provided that a MIMO system uses four Tx antennas and four Rx antennas, the MIMO system can theoretically acquire a high transfer rate which is four times higher than that of a single antenna system. After the above-mentioned theoretical capacity increase of the MIMO system was demonstrated in the mid-1990s, many developers began to conduct intensive research into a variety of technologies which can substantially increase data transfer rate using the theoretical capacity increase. Some of the above technologies have been adopted in a variety of wireless communication standards, for example, third-generation mobile communication or next-generation wireless LAN, etc.

[0068] A variety of MIMO-associated technologies have been intensively researched, for example, research into information theory associated with MIMO communication capacity under various channel environments or multiple access environments, research into radio frequency (RF) channel measurement and modeling of the MIMO system, and research into space-time signal processing technology.

[0069] Mathematical modeling of a communication method for use in the above-mentioned MIMO system will hereinafter be described in detail. As can be seen from FIG. **10**(*a*), it is assumed that there are N_T Tx antennas and N_R Rx antennas.

[0070] In the case of a transmission signal, a maximum number of transmission information pieces is N_T under the condition that N_T Tx antennas are used, so that the transmission information can be represented by a specific vector shown in the following equation.

$$s=[s_1, s_2, \ldots, s_{N_T}]^T \quad \text{[Equation 2]}$$

[0071] Individual transmission information pieces s_1, s_2, s_{NT} may have different transmission powers. In this case, if the individual transmission powers are denoted by $P_1, P_2, \ldots, P_{NT}$, then transmission information having an adjusted transmission power can be represented by a specific vector shown in the following equation.

$$\hat{s}=[\hat{s}_1, \hat{s}_2, \ldots, \hat{s}_{N_T}]^T=[P_1 s_1, P_2 s_2, \ldots, P_{N_T} s_{N_T}]^T \quad \text{[Equation 3]}$$

[0072] $\hat{s}$ can be represented by the following equation using a diagonal matrix P of a transmission power.

$$\hat{s} = \begin{bmatrix} P_1 & & 0 \\ & P_2 & \\ & \ddots & \\ 0 & & P_{N_T} \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \\ \vdots \\ s_{N_T} \end{bmatrix} = Ps \quad \text{[Equation 4]}$$

[0073] The information vector $\hat{S}$ having an adjusted transmission power is applied to a weight matrix W, so that N_T transmission signals $x_1, x_2, \ldots, x_{NT}$ to be actually transmitted are configured. In this case, the weight matrix W is adapted to properly distribute transmission information to individual antennas according to transmission channel situations. The above-mentioned transmission signals x_1, x_2, x_{NT} can be represented by the following equation using the vector X.

$$x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_i \\ \vdots \\ x_{N_T} \end{bmatrix} \quad \text{[Equation 5]}$$

-continued

$$= \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1N_T} \\ w_{21} & w_{22} & \cdots & w_{2N_T} \\ \vdots & & \ddots & \\ w_{i1} & w_{i2} & \cdots & w_{iN_T} \\ \vdots & & \ddots & \\ w_{N_T1} & w_{N_T2} & \cdots & w_{N_TN_T} \end{bmatrix} \begin{bmatrix} \hat{s}_1 \\ \hat{s}_2 \\ \vdots \\ \hat{s}_j \\ \vdots \\ \hat{s}_{N_T} \end{bmatrix}$$

$$= W\hat{s}$$

$$= WPs$$

[0074] Here, W_{ij} denotes a weight corresponding to the i-th Tx antenna and j-th information. W represents a weight matrix or precoding matrix.

[0075] When N_R Rx antennas are used, received signals y_1, y_2, . . . , y_{NR} of individual antennas can be represented by a specific vector (y) shown in the following equation.

$$y=[y_1, y_2, \ldots, y_{N_R}]^T \quad \text{[Equation 6]}$$

[0076] When channel modeling is executed in the MIMO communication system, individual channels can be distinguished from each other according to Tx/Rx antenna indexes. A specific channel passing the range from a Tx antenna j to an Rx antenna i is denoted by h_{ij}. In this case, it should be noted that the index order of the channel h_{ij} is located before an Rx antenna index and is located after a Tx antenna index.

[0077] FIG. **5**(*b*) shows channels from N_T Tx antennas to an Rx antenna i. Several channels are tied up, so that they are displayed in the form of a vector or matrix. Referring to FIG. **5**(*b*), the channels passing the range from the N_T Tx antennas to the Rx antenna i can be represented by the following equation.

$$h_i^T=[h_{i1}, h_{i2}, \ldots, h_{iN_T}] \quad \text{[Equation 7]}$$

[0078] Accordingly all channels passing the range from the N_T Tx antennas to N_R Rx antennas can be represented by the following equation.

$$H = \begin{bmatrix} h_1^T \\ h_2^T \\ \vdots \\ h_i^T \\ \vdots \\ h_{N_R}^T \end{bmatrix} \quad \text{[Equation 8]}$$

$$= \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1N_T} \\ h_{21} & h_{22} & \cdots & h_{2N_T} \\ \vdots & & \ddots & \\ h_{i1} & h_{i2} & \cdots & h_{iN_T} \\ \vdots & & \ddots & \\ h_{N_R1} & h_{N_R2} & \cdots & h_{N_RN_T} \end{bmatrix}$$

[0079] Additive white Gaussian noise (AWGN) is added to an actual channel which has passed the channel matrix H. The AWGN n_1, n_2, . . . , n_{NR} added to each of N_R Rx antennas can be represented by a specific vector shown in the following equation.

$$n=[n_1, n_2, \ldots, n_{N_R}]^T \quad \text{[Equation 9]}$$

[0080] A reception signal calculated by the above-mentioned equations can be represented by the following equation.

$$y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_i \\ \vdots \\ y_{N_R} \end{bmatrix} \quad \text{[Equation 10]}$$

$$= \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1N_T} \\ h_{21} & h_{22} & \cdots & h_{2N_T} \\ \vdots & & \ddots & \\ h_{i1} & h_{i2} & \cdots & h_{iN_T} \\ \vdots & & \ddots & \\ h_{N_R1} & h_{N_R2} & \cdots & h_{N_RN_T} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_j \\ \vdots \\ x_{N_T} \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ \vdots \\ n_i \\ \vdots \\ n_{N_R} \end{bmatrix}$$

$$= Hx + n$$

[0081] In the meantime, the number of rows and the number of columns of a channel matrix H indicating a channel condition are determined by the number of Tx/Rx antennas. In the channel matrix H, the number of rows is equal to the number (N_R) of Rx antennas, and the number of columns is equal to the number (N_T) of Tx antennas. Namely, the channel matrix H is denoted by an $N_R \times N_T$ matrix.

[0082] A matrix rank is defined by a smaller number between the number of rows and the number of columns, in which the rows and the columns are independent of each other. Therefore, the matrix rank cannot be higher than the number of rows or columns. The rank rank(H) of the channel matrix H can be represented by the following equation.

$$\text{rank}(H) \leq \min(N_T, N_R) \quad \text{[Equation 11]}$$

[0083] The rank may be defined as the number of non-zero Eigen values when Eigen value decomposition is performed on the matrix. Similarly, the rank may be defined as the number of non-zero singular values when singular value decomposition is performed on the matrix. Accordingly, the rank of the channel matrix refers to a maximum number of information pieces that can be transmitted on a given channel.

[0084] In description of the specification, "rank" with respect to MIMO transmission refers to the number of paths through which signals can be independently transmitted in a specific frequency resource at a specific time, and "the number of layers" refers to the number of signal streams transmitted through each path. Since a transmitter generally transmits as many layers as the number of ranks used for signal transmission, "rank" has the same meaning as "number of layers" unless otherwise mentioned.

[0085] As described above, when the transmitter loads data in Ns data streams (or layers) and simultaneously transmits the data streams, a receiver can decompose received signals into Nx data streams (or layers) and simultaneously receive the data streams. Specifically, when the transmitter precodes the Ns data streams s into a signal x transmitted through a Tx antenna and transmits the signal x, a MIMO receiver can perform a decoding process for decomposing a signal y received through a channel H into Nx received data streams.

That is, a MIMO precoder function is important for the transmitter and an MIMO decoder function is important for the receiver.

[0086] While description of the example of FIG. **5** is based on the narrow-band system, description of the MIMO system can be easily extended to a wideband system. For example, a transmitter performs OFDM modulation and a receiver performs OFDM demodulation in an OFDM system, and thus one wideband system can be modeled as a set of a plurality of narrow-band systems corresponding to a plurality of subcarriers. One narrow-band system can be modeled as the MIMO system as shown in FIG. **5**. Even though the following description is based on modeling of one narrow-band system for clarity, the description can be directly extended and applied to operations in wideband systems.

[0087] Reference Signal (RS)

[0088] Since a packet is transmitted through a radio channel in a wireless communication system, a signal may be distorted during transmission. A receiver needs to correct the distorted signal using channel information in order to correctly receive the distorted signal. To detect channel information, a signal known to both the receiver and a transmitter is transmitted and channel information is detected using a degree of distortion of the signal when the signal is received through a certain channel. This signal is called a pilot signal or a reference signal.

[0089] When multiple antennas are used to transmit and receive data, a correct signal can be received only when channel state between each Tx antenna and each Rx antenna is detected. Accordingly, a reference signal is required for each Tx antenna.

[0090] Reference signals (RSs) can be classified into two types according to purpose in a mobile communication system. One is an RS used for channel information acquisition and the other is an RS used for data demodulation. The former needs to be transmitted in wide band since the RS is used for a UE to acquire downlink channel information. Even a UE that does not receive downlink data in a specific subframe needs to receive and measure the RS for channel information acquisition. This RS is also used for measurement such as handover measurement. The latter is an RS transmitted along with a corresponding resource when a BS performs downlink transmission. A UE can perform channel estimation by receiving the RS and thus can demodulate data. This RS needs to be transmitted in a region in which data is transmitted.

[0091] 3GPP LTE (e.g. 3GPP LTE release-8) defines two types of downlink RSs for unicast service: a common RS (CRS) and a dedicated RS (DRS). The CRS is used for acquisition of information about a channel state and measurement for handover and may be called a cell-specific RS. The DRS is used for data demodulation and may be called a UE-specific RS. In 3GPP LTE, the DRS is used for data demodulation only and the CRS can be used for both channel information acquisition and data demodulation.

[0092] The CRS is transmitted cell-specifically. The CRS is transmitted per subframe in wideband. The CRS can be transmitted for a maximum of four antenna ports according to the number of Tx antennas of a BS. For example, when the number of Tx antennas of the BS is 2, CRSs with respect to antenna ports #**0** and #**1** are transmitted. When the number of Tx antennas of the BS is 4, CRSs with respect to antenna ports #**0**, #**1**, #**2** and #**3** are transmitted.

[0093] FIG. **6** illustrates exemplary CRS and DRS patterns in one resource block pair.

[0094] FIG. **6** shows CRS and DRS patterns in one resource block pair (14 OFDM symbols in the time domain×12 subcarriers in the frequency domain in the case of normal CP) in a system in which a base station supports 4 Tx antennas. In FIG. **6**, REs indicated by "R**0**", "R**1**", "R**2**" and "R**3**" respectively represent CRS positions with respect to antenna port indices **0**, **1**, **2** and **3**. An RE indicated by "D" represents the position of a DRS defined in LTE.

[0095] In LTE-A evolving from LTE, a maximum of 8 Tx antennas can be supported on downlink. Accordingly, reference signals for a maximum of 8 Tx antennas need to be supported. Since only downlink reference signals for a maximum of 4 antenna ports are defined in LTE, reference signals for added antenna ports need to be additionally defined and designed when a BS has 4 to 8 downlink Tx antennas in an LTE-A system. Both the channel measurement reference signal and data demodulation reference signal need to be employed as reference signals for a maximum of 8 Tx antenna ports.

[0096] One important consideration in design of an LTE-A system is backward compatibility. That is, LTE UEs need to operate in LTE-A systems and the LTE-A system needs to support the same. In reference signal transmission, reference signals for a maximum of 8 Tx antenna ports need to be additionally defined in a time-frequency region in which a CRS defined in LTE is transmitted per subframe in the entire bandwidth. In LTE-A, however, when a reference signal pattern for a maximum of 8 transmit antennas is added per subframe to the entire bandwidth as in LTE, reference signal transmission overhead excessively increases.

[0097] Reference signals newly designed in LTE-A are categorized into a channel state information reference signal (CSI-RS) (or channel state information-RS) for channel measurement for selecting a modulation and coding scheme (MCS) and a precoding matrix index (PMI) and a demodulation RS (DMRS) for demodulation of data transmitted through 8 transmit antennas.

[0098] The CSI-RS is designed for the purpose of channel measurement, whereas the CRS is used for measurement, such as channel measurement and handover measurement, and data demodulation in LTE. The CSI-RS may also be used for handover measurement. The CSI-RS need not be transmitted per subframe since the CSI-RS is used to obtain channel state information, differently from the CRS in LTE. Accordingly, the CSI-RS can be designed such that the CSI-RS is intermittently (e.g. periodically) transmitted in the time domain to reduce CSI-RS transmission overhead.

[0099] If data is transmitted in a downlink subframe, a DMRS dedicated to a UE scheduled to transmit data is transmitted to the UE. That is, the DMRS may be called a UE-specific RS. A DMRS dedicated to a specific UE can be designed such that the DMRS is transmitted only in a resource region for which the UE is scheduled, that is, a time-frequency domain in which data with respect to the UE is transmitted.

[0100] FIG. **7** illustrates an exemplary DMRS pattern defined in LTE-A.

[0101] FIG. **7** shows the position of an RE through which a DMRS is transmitted on one RB pair (14 OFDM symbols in the time domain×12 subcarriers in the frequency domain in the case of normal CP) through which downlink data is transmitted. DMRSs can be transmitted for 4 antenna ports (antenna port indices **7**, **8**, **9** and **10**) additionally defined in LTE-A. DMRSs with respect to different antenna ports can be

identified by being located in different frequency resources (subcarriers) and/or different time resources (OFDM symbols) (i.e. multiplexed according to FDM and/or TDM). In addition, DMRSs with respect to different antenna ports, which are located in the same time-frequency resource, can be identified using an orthogonal code (i.e. multiplexed according to CDM). In the example of FIG. **7**, DMRSs with respect to antenna ports **7** and **8** may be located in REs corresponding to DMRS CDM group **1** and multiplexed according to an orthogonal code. Similarly, DMRSs with respect to antenna ports **9** and **10** may be located in REs corresponding to DMRS CDM group **2** and multiplexed according to an orthogonal code.

[0102] When a BS transmits a DMRS, the same precoding as precoding applied to data is applied to the DMRS. Accordingly, channel information estimated by a UE using the DMRS (or UE-specific RS) is precoded channel information. The UE can easily perform data demodulation using the precoded channel information estimated through the DMRS. However, the UE cannot acquire unprecoded channel information from the DMRS since the UE cannot be aware of precoding information applied to the DMRS. The UE can acquire unprecoded channel information using a reference signal other than the DMRS, that is, the aforementioned CSI-RS.

[0103] FIG. **8** illustrates exemplary CSI-RS patterns defined in LTE-A.

[0104] FIG. **8** shows positions of REs on which CSI-RSs are transmitted on one RB pair (14 OFDM symbols in the time domain×12 subcarriers in the frequency domain in the case of normal CP) through which downlink data is transmitted. One of CSI-RS patterns of FIGS. **8**(*a*) to **8**(*e*) can be used in a downlink subframe. CSI-RSs can be transmitted for 8 antenna ports (antenna port indices **15** to **22**) additionally defined in LTE-A. CSI-RSs with respect to different antenna ports can be identified by being located in different frequency resources (subcarriers) and/or different time resources (OFDM symbols) (that is, multiplexed according to FDM and/or TDM). In addition, CSI-RSs with respect to different antenna ports, which are located in the same time-frequency resource, can be identified using an orthogonal code (i.e. multiplexed according to CDM). In FIG. **8**(*a*), CSI-RSs with respect to antenna ports #**15** and #**16** can be located in REs represented as CSI-RS CDM group **1** and can be multiplexed using an orthogonal code. In addition, CSI-RSs with respect to antenna ports #**17** and #**18** can be located in REs represented as CSI-RS CDM group **2** and can be multiplexed using an orthogonal code. CSI-RSs with respect to antenna ports #**19** and #**20** can be located in REs represented as CSI-RS CDM group **3** and can be multiplexed using an orthogonal code. CSI-RSs with respect to antenna ports #**21** and #**22** can be located in REs represented as CSI-RS CDM group **4** and can be multiplexed using an orthogonal code. The principle described with reference to FIG. **8**(*a*) can be equally applied to FIGS. **8**(*b*) to **8**(*e*).

[0105] RS patterns shown in FIGS. **6**, **7** and **8** are exemplary and various embodiments of the present invention are not limited to specific RS patterns. That is, various embodiments of the present invention can be equally applied to a case in which an RS pattern different from those of FIGS. **6**, **7** and **8** is defined and used.

[0106] Channel State Information (CSI)

[0107] MIMO may be classified into open loop and closed loop schemes. Open loop MIMO refers to MIMO transmission performed by a transmitter without CSI feedback of a MIMO receiver. Closed loop MIMO refers to a scheme by which the transmitter receives CSI feedback from the MIMO receiver and performs MIMO transmission. According to closed loop MIMO, the transmitter and receiver can perform beamforming based on CSI to obtain a multiplexing gain of MIMO Tx antennas. The transmitter (e.g. BS) may allocate a UL control channel or UL shared channel to the receiver (e.g. UE) such that the receiver (e.g. UE) can feed back CSI.

[0108] A UE can perform downlink channel estimation and/or measurement using a CRS and/or a CSI-RS. Channel state information (CSI) fed back by the UE to a BS may include a rank indicator (RI), a precoding matrix index (PMI) and a channel quality indicator (CQI).

[0109] The RI is information regarding a channel rank which indicates the number of layers (or streams) capable of transmitting different pieces of information through the same time-frequency resource. Since a rank value is determined according to long term fading of a channel, RI can be fed back in a long period (i.e. less frequently) compared to the PMI and CQI.

[0110] The PMI is information regarding a precoding matrix used for data transmission of a transmitter and reflecting spatial characteristics of a channel. Precoding refers to mapping of a transport layer to a Tx antenna and layer-antenna mapping relationship may be determined by a precoding matrix. PMI corresponds to a precoding matrix index of a preferred BS of a UE on the basis of metrics such as a signal-to-interference plus noise ratio (SINR). To reduce precoding information feedback overhead, the transmitter and receiver may share a codebook including various precoding matrices and only an index indicating a specific precoding matrix in the codebook may be fed back. For example, the PMI can be determined on the basis of a most recently reported RI.

[0111] The CQI is information regarding channel quality or channel intensity. The CQI may be represented by a predetermined MCS combination. That is, a fed back CQI index represents a corresponding modulation scheme and code rate. The CQI can be calculated by setting a specific resource region (e.g. a region specified by valid subframes and/or physical resource blocks) as a CQI reference resource and assuming that PDSCH transmission is present in the CQI reference resource and a PDSCH can be received without exceeding a predetermined error probability (e.g. 0.1). In general, the CQI is a value reflecting reception SINR that can be obtained when a BS configures a spatial channel using the PMI.

[0112] A system (e.g. LTE-A) supporting extended antenna configurations considers acquisition of additional multi-user diversity using multi-user MIMO (MU-MIMO). In MU-MIMO, an interference channel is present between UEs multiplexed in an antenna domain, and thus it is necessary to prevent generation of interference in a UE when a BS performs DL transmission using CSI fed back from another UE from among multiple users. Accordingly, for correct MU-MIMO operation, CSI with higher accuracy needs to be fed back as compared to single user MIMO (SU-MIMO).

[0113] For more accurate CSI measurement and reporting, a method of feeding back new CSI obtained by improving the conventional CSI including RI, PMI and CQI may be applied. For example, precoding information fed back by a receiver can be indicated by a combination of two PMIs (e.g. i**1** and

i2). Accordingly, a more accurate PMI can be fed back and a more accurate CQI can be calculated and reported on the basis of the accurate PMI.

[0114] CSI may be periodically transmitted through a PUCCH or aperiodically transmitted through a PUSCH. In addition, various reporting modes can be defined according to which one of an RI, a first PMI (e.g. W1), a second PMI (e.g. W2) and a CQI is fed back and whether a fed back PMI and/or CQI are for wideband (WB) or subband (SB).

[0115] Deployment of Multiple Antennas

[0116] A beam generated by a conventional one-dimensional antenna configuration is specified only in the azimuth angle (e.g. horizontal domain) direction and cannot be specified in the elevation angle (e.g. vertical domain) direction, and thus only 2-dimensional beamforming is supported therefor. The one-dimensional antenna configuration (e.g. uniform linear array (ULA)) can support adaptive beamforming or spatial multiplexing in the azimuth angle direction, and only MIMO transmission and reception schemes for adaptive beamfoming or spatial multiplexing are designed in conventional wireless communication systems (e.g. systems conforming to 3GPP LTE release-8, 9, 10 and 11).

[0117] When MIMO transmission and reception schemes based on a 2-dimensional antenna configuration (e.g. uniform rectangular array (URA)) for system performance improvement are supported, a beam generated by the 2-dimensional antenna configuration can be specified in the azimuth angle direction and the elevation angle direction and thus 3-dimensional beamforming can be performed therefor.

[0118] FIG. **9** illustrates examples of beamforming according to a 2-dimensional antenna configuration.

[0119] FIG. **9**(*a*) shows examples of sector-specific beamforming, generated by limiting a predetermined range of the azimuth angle and a predetermined range of the elevation angle. FIG. **9**(*b*) shows examples of UE-specific beamforming, generated by varying the elevation angle at the same azimuth angle.

[0120] According to the aforementioned function of generating a beam by specifying the azimuth angle and elevation angle, it is possible to support new beamforming such as sector-specific elevation beamforming (e.g. adaptive control according to a vertical pattern beamwidth and/or downtilt), improved sectorization in the vertical domain and user (or UE)-specific elevation beamforming Vertical sectorization can improve average system performance through a gain of a vertical sector pattern. UE-specific elevation beamforming can increase SINR with respect to a UE by designating a vertical antenna pattern in the direction of the UE.

[0121] Antenna Virtualization

[0122] A transmission antenna and/or a reception antenna, defined to describe operations of a communication system, may be referred to as a virtual antenna or an antenna port. The virtual antenna may or may not be one-to-one mapped to a physical antenna of a transmitter and/or a physical antenna or a receiver.

[0123] FIG. **10** illustrates antenna virtualization.

[0124] When the number of transmission virtual antennas (or transmission antenna ports) is N_{tx}^{V} and the number of transmission physical antennas is N_{tx}^{P}, some physical antennas can be grouped to transmit the same signal all the time if $N_{tx}^{P}>N_{tx}^{V}$. Here, since grouped antennas operate as if the antennas are a single antenna, the grouped antennas can be considered to form one virtual antenna. This can be referred to as transmission antenna virtualization.

[0125] When the number of reception virtual antennas (or reception antenna ports) is N_{rx}^{V}, the number of reception physical antennas is N_{rx}^{P} and $N_{rx}^{P}>N_{rx}^{V}$, the sum of received signals at some grouped physical antennas can be mapped to the input of a MIMO decoder. In this case, the grouped antennas can operate as if the antennas are a single antenna. This can be referred to as reception antenna virtualization.

[0126] Since transmission antenna virtualization and reception antenna virtualization are independent technologies, only one thereof may be applied and different antenna virtualization schemes may be used according to signals even in one system. For example, different antenna virtualization schemes can be respectively applied to transmission of a CSI-RS and a CRS defined in LTE Rel-10 (or LTE-A). LTE Rel-10 supports a maximum of 8 CRS-RS antenna ports (i.e. 8 virtual antennas) and a maximum of 4 CRS antenna ports (or 4 virtual antennas). This means that one system supports up to 8 virtual antennas for a specific pilot (RS) and supports up to 4 virtual antennas for a different type of pilot. Consequently, different antenna virtualization schemes can be applied according to signal type even in the same system. If 16 transmission physical antennas are present, then every two antennas can be grouped to form 8 virtual antennas for CSI-RS transmission or every four antennas can be grouped to form 4 virtual antennas for CRS transmission.

[0127] As described above, antenna virtualization is a technology for mapping a physical antenna to a virtual antenna (or antenna port). Since a virtual antenna-to-physical antenna mapping scheme may depend on a device implementation method, communication standards for defining operations of communication systems define only communication schemes based on the virtual transmission antenna and virtual reception antenna.

[0128] In addition, the purpose of antenna virtualization is to change a channel between a virtual transmission antenna and a virtual reception antenna to a channel more advantageous for communication. The channel between the virtual transmission antenna and the virtual reception antenna is defined as an effective channel $\hat{H}$.

[0129] Channel Aging

[0130] There is a time difference between a time when a UE measures CSI (e.g. an RI, a PMI, a CQI and the like) on a downlink channel and a time when an eNB that has been notified by the UE of the CSI transmits data through the downlink channel. When a channel severely changes with time, the CSI reported to the eNB by the UE may not correctly reflect a channel state at the data transmission time. This phenomenon is called channel aging. Channel aging may cause performance deterioration. Further, channel aging is closely related to temporal variation of the channel, and thus performance deterioration due to channel aging is aggravated as a UE moving speed increases. In addition, since a channel state that a moving UE undergoes may abruptly change as beamforming resolution increases according to 2-dimensional antenna configuration, and thus performance deterioration due to channel aging becomes serious.

[0131] Antenna Virtualization Method for Supporting High-Speed Movement

[0132] The present invention provides an antenna virtualization method for minimizing performance deterioration due to channel aging in a wireless communication system supporting accurate high-speed movement and/or beamforming

Embodiment 1

[0133] According to the present embodiment, antenna virtualization is performed such that channel state variation (or beam pattern variation) due to movement of a UE is minimized. For example, transmission/reception antenna virtualization can be performed in a main movement direction of the UE.

[0134] FIG. **11** illustrates an example of antenna virtualization according to the present invention.

[0135] In the example shown in FIG. **11**, an eNB may have a two-dimensional antenna configuration as in the example of FIG. **9**. Accordingly, resolution of a beam transmitted from the eNB can be increased and the beam can be focused on a specific point.

[0136] FIG. **11**(*a*) is a view for explaining a problem of the conventional method. A channel state, which is measured by a UE on the basis of a virtual antenna (e.g. a virtual antenna composed of a physical antenna a_0) at a position A, is referred to as CSI-A and a channel state, which is measured by the UE on the basis of the virtual antenna (e.g. a virtual antenna composed of the physical antenna a_0) at a position B, is referred to as CSI-B. When a signal transmitted from an eNB is focused on position A, there is a high possibility that CSI-A and CSI-B are inconsistent with each other. For example, the channel state at the position A can be expected to be better than the channel state at position B, and thus channel state can be measured/calculated such that CSI-A can use a higher rank and higher MCS level than CSI-B.

[0137] FIG. **11**(*b*) is a view for explaining the effect obtained when antenna virtualization provided by the present invention is applied. When the UE moves from position A to position B, a plurality of physical antennas located in the moving direction of the UE may be grouped and defined as a virtual antenna. For example, antennas a_0, a_1, a_2, a_3, a_4 and a_5 can be grouped to form one virtual antenna. In this case, it can be expected that a channel state that affects the antennas a_0, a_1, a_2 and a_3 from among the physical antennas constituting the virtual antenna at position A is similar to or substantially the same as a channel state that affects the antennas a_2, a_3, a_4 and a_3 at position B. Accordingly, channel state information CSI-A calculated/measured by the UE at position A can be expected to be very similar to channel state information CSI-B calculated/measured by the UE at position B. Therefore, channel state inconsistency at positions A and B can be remarkably reduced compared to the example of FIG. **11**(*a*) when antenna virtualization is applied as shown in FIG. **11**(*b*).

[0138] That is, antenna virtualization can be performed such that an antenna pattern having a wide beamwidth in the moving direction of the UE. In other words, an antenna virtualization pattern can be determined such that a beamwidth is extended in the same direction as the moving direction of the UE. Otherwise, the antenna virtualization pattern can be determined such that physical antennas arranged in a main movement direction of the UE (or arranged in a direction closest to the main movement direction of the UE) are grouped. For example, virtualization of transmission antennas of the UE can be performed such that the width of a beam transmitted from a virtual antenna of the UE becomes wide so as to reduce inconsistency between states of channels generated according to the transmission antennas when the UE moves at a high speed. In addition, virtualization of reception antennas of the UE can be performed such that inconsistency between channel states that affect the UE moving at a high speed at different positions is reduced when the UE receives a beam transmitted from a specific point (e.g. eNB).

[0139] FIG. **12** illustrates an antenna virtualization method with respect to a two-dimensional antenna configuration according to the present invention.

[0140] In the example of FIG. **12**, it is assumed that a UE has a two-dimensional antenna configuration in which 24 physical antennas are arranged in four columns and 6 rows. The UE may be a vehicle and the physical antennas may be arranged outside the vehicle. If the vehicle moves in the horizontal direction (column direction) in the figure, one virtual antenna can be configured by grouping antennas arranged in a traverse direction from the front to the rear of the vehicle. For example, physical antennas a_{00}, a_{01}, a_{02}, a_{03}, a_{04} and a_{05} can be grouped to configure one virtual antenna #**0**, physical antennas a_{10}, a_{11}, a_{12}, a_{13}, a_{14} and a_{15} can be grouped to configure one virtual antenna #**1**, physical antennas a_{20}, a_{21}, a_{22}, a_{23}, a_{24} and a_{25} can be grouped to configure one virtual antenna #**2**, and physical antennas a_{30}, a_{31}, a_{32}, a_{33}, a_{34} and a_{35} can be grouped to configure one virtual antenna #**3**.

[0141] When the virtual antennas are configured as described above, antenna virtualization is performed such that a wide beamwidth is obtained in the moving direction of the vehicle, and thus inconsistency of channel states that affect the vehicle moving at a high speed can be reduced and antenna gain can be increased.

[0142] In application of embodiments of the present invention, the transmission antenna virtualization method and the reception antenna virtualization method are not limited to the same method. For example, part of a plurality of antennas may be transmission dedicated antennas, the remaining part thereof may be reception dedicated antennas, and a transmission antenna virtualization method and a reception antenna virtualization method may be independently configured. Alternatively, when some or all antennas are used for both transmission and reception, an antenna virtualization method when the antennas operate as transmission antennas and an antenna virtualization method when the antennas operate as reception antennas may be differently applied to one antenna.

[0143] In addition, an antenna virtualization method may be defined per system. Further, different antenna virtualization methods may be respectively defined for frequencies even in the same system.

Embodiment 2

[0144] In the present embodiment, antenna virtualization is adaptively applied according to a movement state and/or a communication state of a UE. Information indicating the movement state of the UE may include parameters indicating whether the UE moves, a movement direction, a moving speed, an acceleration/deceleration state and the like. Information indicating the communication state may include parameters indicating a distance between the UE and a device (e.g. eNB) that transmits/receives signals to/from the UE, relative positions, channel state (e.g. CSI) and the like. Adaptive antenna virtualization refers to variable application of the number of physical antennas included in one virtual antenna, information indicating physical antennas mapped to a virtual antenna (i.e. information indicating/specifying one or more physical antennas (e.g. physical antenna index information)) and the like.

[0145] A description will be given of an antenna virtualization method considering the movement state of the UE.

[0146] Virtual antenna to physical antenna mapping may be determined on the basis of the moving speed of the UE. For example, a large number of physical antennas included in one virtual antenna (or mapped to one virtual antenna) does not always ensure high performance. When channel aging is not severe, such as a case in which the UE moves relatively slowly, higher performance may be expected when the number of physical antennas included in one virtual antenna is not large. For example, when a large number of physical antennas configures one transmission virtual antenna, performance deterioration can occur due to transmission power dispersion. Furthermore, when a large number of physical antennas configures one reception virtual antenna, performance deterioration can occur due to antenna gain dispersion. Accordingly, it is necessary to appropriately control the number of physical antennas mapped to a virtual antenna for concentration of transmission power or antenna gain. The number of physical antennas included in one virtual antenna may be increased such that a virtual antenna pattern robust against channel aging is generated when the UE moves at a high speed (or when the UE moves at a speed higher than a predetermined threshold value). When the UE moves at a low speed (or when the UE moves at a speed higher than the predetermined threshold value), the influence of channel aging is not large and thus the number of physical antennas included in one virtual antenna may be reduced (i.e. the number of virtual antennas may be increased) in order to increase transmission power efficiency/antenna gain. That is, the number of physical antennas included in one virtual antenna can be set to be proportional to the moving speed of the UE. However, this is exemplary and the relationship between the number of physical antennas included in one virtual antenna and the moving speed of the UE is not limited to a proportional relationship. In a specific case, the number of physical antennas included in one virtual antenna may be inversely proportional to the moving speed of the UE. For example, when the number of physical antennas included in a virtual antenna increases and thus the aperture of the virtual antenna increases (when the antenna effective area actually related to signals transmitted and received through the virtual antenna increases, for example) according to configuration of physical antennas, a gain variation of the virtual antenna according to signal transmission/reception directions may increase (i.e. beam pattern fluctuation may increase). In this case, higher performance may be expected when the number of physical antennas included in a virtual antenna decreases as the moving speed of the UE increases. Consequently, the mapping relationship between virtual antennas and physical antennas, such as the number of virtual antennas and the number of physical antennas included in a virtual antenna, can be adaptively applied according to movement state of the UE and the like.

[0147] Antenna virtualization may be applied when the UE moves and may not be applied when the UE does not move. In addition, the number of antennas included in one virtual antenna may be increased when the UE moves and decreased when the UE does not move.

[0148] Physical antennas arranged in the moving direction of the UE (e.g. forward and backward direction or left and right direction when the UE is a vehicle) may be grouped to configure a virtual group according to the moving direction of the UE.

[0149] A description will be given of an antenna virtualization method considering a communication state.

[0150] A method of configuring a virtual antenna by grouping physical antennas arranged in the moving direction of the vehicle (i.e. arranged in a traverse direction from the front to the rear of the vehicle), as shown in FIG. **12**, can obtain higher performance when a device that transmits/receives signals to/from the vehicle is located perpendicularly to the moving direction of the vehicle (e.g. an eNB, a roadside AP or the like is located higher than or far from the vehicle). When the device that transmits/receives signals to/from the vehicle is located in the same direction as the moving direction of the vehicle (e.g. when a plurality of devices is arranged at the center of a road at a height similar to the vehicle), a virtual antenna in a form different from a virtual antenna including physical antennas arranged in the moving direction of the vehicle may be configured or the number of physical antennas included in one virtual antenna may be controlled.

[0151] Even in the antenna virtualization method considering the communication state of the UE, channel state variation (or beam pattern variation) due to a change of the location of the UE needs to be minimized Accordingly, a virtual antenna can be configured such that performance deterioration due to channel aging is minimized

[0152] To adaptively apply an antenna virtualization pattern, as described above, an eNB (or remote radio head (RRH), network node, AP or the like) that transmits/receives signals to/from the UE may signal information on the location thereof to the UE (or cellular phone, vehicle or the like). In addition, the UE may report, to the eNB, information indicating the movement state thereof (e.g. moving speed, moving direction, acceleration/deceleration related information and the like) and/or information indicating the communication thereof (e.g. the location of the UE, channel state information (CSI) and the like). Further, the eNB may determine an antenna virtualization method using the information thereof and/or the information reported by the UE and provide control information about the antenna virtualization method (e.g. the number of physical antennas, pattern, information designating a virtualization mode (e.g. an antenna virtualization mode applied to low-speed movement/antenna virtualization mode applied to high-speed movement) and the like). The UE may transmit information about a preferred antenna virtualization method (e.g. information indicating the number of physical antennas, pattern or virtualization mode, which is recommended by the UE) to the eNB.

[0153] In addition, the number of available antenna virtualization patterns (e.g. information indicating the number of configured transmission virtual antennas, the number of configured reception virtual antennas, the number of physical antennas configuring one virtual antenna, physical antennas mapped to one virtual antenna (i.e. information indicating/specifying one or more physical antennas) and the like) may remarkably increase according to the number of physical antennas of the UE and arrangement of the physical antennas. Accordingly, when control information capable of indicating a large number of cases is defined, overhead of control information transmitted/received between the UE and the eNB considerably increases, which is inefficient. Therefore, the present invention predetermines antenna virtualization pattern candidates between the eNB and the UE and defines control information with respect to an antenna virtualization pattern in the form of information that directly or indirectly indicates a specific pattern from among the antenna virtualization pattern candidates.

[0154] In adaptive application of an antenna virtualization method, changing antenna characteristics (e.g. antenna virtualization pattern) during data transmission and reception between the UE and the eNB may affect transmission and reception performance Accordingly, a virtual antenna configuration scheme may be limited such that a virtual antenna configuration is changed only when the UE does not perform data transmission and reception (e.g. when the UE is idle or turns off a communication function).

[0155] FIG. **13** is a flowchart illustrating a communication method using a virtual antenna according to the present invention.

[0156] An eNB may transmit, to a UE, control information with respect to an antenna virtualization pattern of a UE in step **S1310**. The antenna virtualization pattern may be determined on the basis of information indicating a movement state of the UE and/or information indicating a communication state of the UE. The control information with respect to the antenna virtualization pattern may indicate the number of physical antennas mapped to one virtual antenna, information specifying physical antennas and the like.

[0157] The UE may configure one or more virtual antennas on the basis of the antenna virtualization pattern in step **S1320**. One or more physical antennas mapped to one virtual antenna may be determined on the basis of the moving direction of the UE in the present invention. For example, one or more physical antennas mapped to one virtual antenna can be determined such that the width of a beam formed by the one or more physical antennas is extended in the same direction as the moving direction of the UE or one or more physical antennas arranged in the moving direction of the UE are mapped to one virtual antenna. Accordingly, a virtual antenna robust against channel aging can be configured.

[0158] Communication may be performed between the UE and the eNB through the one or more virtual antennas of the UE in step **S1330**.

[0159] The total number of virtual antennas, determined according to the adaptive antenna virtualization method provided by the present invention (or changed from a previous number), may affect the number of transmitted pilot signals, the number of received pilot signals and/or calculation and configuration of CSI feedback information.

[0160] One of various embodiments of the present invention or combinations of two or more thereof can be applied to the communication method using a virtual antenna according to the present invention, described with reference to FIG. **13**.

[0161] FIG. **14** illustrates a configuration of a UE and an eNB according to a preferred embodiment of the present invention.

[0162] Referring to FIG. **14**, an eNB **10** according to the present invention may include a transmitter **11**, a receiver **12**, a processor **13**, a memory **14** and a plurality of antennas **15**. The transmitter **11** can transmit signals, data and information to an external device (e.g. UE). The receiver **12** can receive signals, data and information from an external device (e.g. UE). The processor **13** can control the overall operation of the eNB **10**. The plurality of antennas **15** can be configured according to a two-dimensional antenna configuration.

[0163] The processor **13** of the eNB **10** according to an embodiment of the present invention can be configured to support communication using a virtual antenna of the UE according to embodiments provided by the present invention. The processor **13** of the eNB **10** can control the eNB **10** to generate control information with respect to an antenna virtualization pattern of the UE, which is determined on the basis of information indicating a movement state of the UE **20** and/or information indicating a communication state of the UE **20**, and transmit the control information to the UE **20** through the transmitter **11**. In addition, the processor **13** of the eNB **10** can control the eNB **10** to perform communication with the UE **20** through one or more virtual antennas, which are configured by the UE **20** according to the control information with respect to the antenna virtualization pattern, using the transmitter **11** and/or the receiver **12**. Here, physical antennas mapped to one virtual antenna of the UE **20** can be determined on the basis of the moving direction of the UE **20**, and thus the eNB **10** can support configuration of a virtual antenna robust against channel aging at the UE **20**.

[0164] In addition, the processor **13** of the eNB **10** can process information received by the eNB **10**, information to be transmitted to the outside and the like, and the memory **14** can store processed information for a predetermined time and may be replaced by a component such as a buffer (not shown).

[0165] Referring to FIG. **14**, the UE **20** according to the present invention may include a transmitter **21**, a receiver **22**, a processor **23**, a memory **24** and a plurality of antennas **25**. The plurality of antennas **25** means that the UE **20** supports MIMO transmission and reception. The transmitter **21** can transmit signals, data and information to an external device (e.g. eNB). The receiver **22** can receive signals, data and information from an external device (e.g. eNB). The processor **23** can control the overall operation of the UE **20**.

[0166] The processor **23** of the UE **20** according to an embodiment of the present invention can be configured to perform communication using a virtual antenna according to the embodiments of the present invention. The processor **12** of the UE **20** can control the UE **20** to configure one or more virtual antennas according to an antenna virtualization pattern determined on the basis of information indicating a movement state of the UE **20** and/or information indicating a communication state of the UE **20**. Further, the processor **23** of the UE **20** can control the UE **20** to perform communication with the eNB **10** using the one or more virtual antennas through the transmitter **21** and/or the receiver **220**. Here, one or more physical antennas mapped to one virtual antenna can be determined on the basis of the moving direction of the UE and thus a virtual antenna robust against channel aging can be configured.

[0167] In addition, the processor **23** of the UE **20** can process information received by the UE **20**, information to be transmitted to the outside and the like, and the memory **24** can store processed information for a predetermined time and may be replaced by a component such as a buffer (not shown).

[0168] Configurations of the eNB **10** and the UE **20** can be implemented such that the above-described various embodiments of the present invention are independently applicable or two or more thereof are simultaneously applicable and redundant description is omitted for clarity.

[0169] While an eNB is exemplarily used as a downlink transmission entity or an uplink reception entity and a UE is exemplarily used as a downlink reception entity or an uplink transmission entity in description of various embodiments of the present invention, the scope or spirit of the present invention is not limited thereto. For example, description of the eNB can be equally applied to a case in which a cell, an antenna port, an antenna port group, an RRH, a transmission point, a reception point, an access point, a relay and the like are downlink transmission entities for downlink transmission

to a UE or uplink reception entities for uplink reception from the UE. In addition, the principle of the present invention, described through various embodiments of the present invention, can be equally applied to a case in which a relay is a downlink transmission entity for downlink transmission to the UE or an uplink reception entity for uplink reception from the UE or a case in which the relay is an uplink transmission entity for uplink transmission to an eNB or a downlink reception entity for downlink reception from the eNB.

[0170] The embodiments of the present invention may be achieved by various means, for example, hardware, firmware, software, or a combination thereof.

[0171] In a hardware configuration, an embodiment of the present invention may be achieved by one or more ASICs (application specific integrated circuits), DSPs (digital signal processors), DSPDs (digital signal processing devices), PLDs (programmable logic devices), FPGAs (field programmable gate arrays), processors, controllers, microcontrollers, microprocessors, etc.

[0172] In a firmware or software configuration, an embodiment of the present invention may be implemented in the form of a module, a procedure, a function, etc. Software code may be stored in a memory unit and executed by a processor. The memory unit is located at the interior or exterior of the processor and may transmit and receive data to and from the processor via various known means.

[0173] The detailed description of the preferred embodiments of the present invention is given to enable those skilled in the art to realize and implement the present invention. While the present invention has been described referring to the preferred embodiments of the present invention, those skilled in the art will appreciate that many modifications and changes can be made to the present invention without departing from the spirit and essential characteristics of the present invention. For example, the structures of the above-described embodiments of the present invention can be used in combination. The above embodiments are therefore to be construed in all aspects as illustrative and not restrictive. Therefore, the present invention is not intended to limit the embodiments disclosed herein but to give a broadest range matching the principles and new features disclosed herein.

[0174] Those skilled in the art will appreciate that the present invention may be carried out in other specific ways than those set forth herein without departing from the spirit and essential characteristics of the present invention. The above embodiments are therefore to be construed in all aspects as illustrative and not restrictive. The scope of the invention should be determined by the appended claims and their legal equivalents, not by the above description, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein. Therefore, the present invention intends not to limit the embodiments disclosed herein but to give a broadest range matching the principles and new features disclosed herein. It is obvious to those skilled in the art that claims that are not explicitly cited in each other in the appended claims may be presented in combination as an embodiment of the present invention or included as a new claim by a subsequent amendment after the application is filed.

INDUSTRIAL APPLICABILITY

[0175] The aforementioned embodiments of the present invention can be applied to various mobile communication systems.

1. A communication method using a virtual antenna of a terminal in a wireless communication system, comprising:

configuring one or more virtual antennas according to an antenna virtualization pattern determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and

communicating with a base station using the one or more virtual antennas,

wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

2. The communication method according to claim **1**, wherein the width of a beam formed by the one or more physical antennas mapped to one virtual antenna is extended in the same direction as the direction of movement of the terminal.

3. The communication method according to claim **1**, wherein the one or more physical antennas mapped to one virtual antenna are one or more physical antennas arranged in the direction of movement of the terminal.

4. The communication method according to claim **1**, wherein the antenna virtualization pattern includes at least one of the number of one or more physical antennas mapped to one virtual antenna and information specifying the one or more physical antennas.

5. The communication method according to claim **4**, wherein the number of one or more physical antennas mapped to one virtual antenna is determined on the basis of a moving speed of the terminal.

6. The communication method according to claim **1**, wherein the information indicating the movement state includes at least one of information on whether the terminal is moving, information on the direction of movement of the terminal, information on the moving speed of the terminal and information about an acceleration state or a deceleration state.

7. The communication method according to claim **1**, wherein the information indicating the communication state includes at least one of information on a distance between the terminal and the base station, information on relative positions of the terminal and the base station and information on a channel state between the terminal and the base station.

8. The communication method according to claim **1**, wherein the antenna virtualization pattern is adaptively determined according to change of at least one of the information indicating the movement state of the terminal and the information indicating the communication state of the terminal.

9. The communication method according to claim **1**, wherein control information with respect to the antenna virtualization pattern is received from the base station.

10. The communication method according to claim **1**, wherein one or more of the information indicating the movement state of the terminal, position information of the terminal and channel state information is reported by the terminal to the base station.

11. The communication method according to claim **1**, wherein information indicating the antenna virtualization pattern preferred by the terminal is reported by the terminal to the base station.

12. The communication method according to claim **1**, wherein the configuring of one or more virtual antennas

according to the antenna virtualization pattern is performed when the terminal does not perform data transmission and reception.

13. A method for supporting, by a base station, communication using a virtual antenna of a terminal in a wireless communication system, comprising:

transmitting, to the terminal, control information with respect to an antenna virtualization pattern of the terminal, determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and

communicating with the terminal through one or more virtual antennas of the terminal, configured according to the control information with respect to the antenna virtualization pattern,

wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

14. A terminal performing communication using a virtual antenna in a wireless communication system, comprising:

a transmitter;

a receiver; and

a processor,

wherein the processor is configured: to configure one or more virtual antennas according to an antenna virtualization pattern determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal; and to communicate with a base station using the one or more virtual antennas through one of the transmitter and the receiver,

wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

15. A base station supporting communication using a virtual antenna of a terminal in a wireless communication system, comprising:

a transmitter;

a receiver; and

a processor,

wherein the processor is configured: to transmit, to the terminal, control information with respect to an antenna virtualization pattern of the terminal, determined on the basis of at least one of information indicating a movement state of the terminal and information indicating a communication state of the terminal, through the transmitter; and to communicate with the terminal through one or more virtual antennas of the terminal, configured according to the control information with respect to the antenna virtualization pattern, through one of the transmitter and the receiver,

wherein one or more physical antennas mapped to one virtual antenna are determined on the basis of a direction of movement of the terminal.

* * * * *

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Wong et al.

(54) **SIGNALING AND FRAME STRUCTURE FOR MASSIVE MIMO CELLULAR TELECOMMUNICATION SYSTEMS**

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(21) Appl. No.: **14/703,293**

(22) Filed: **May 4, 2015**

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Publication Classification

(51) **Int. Cl.**

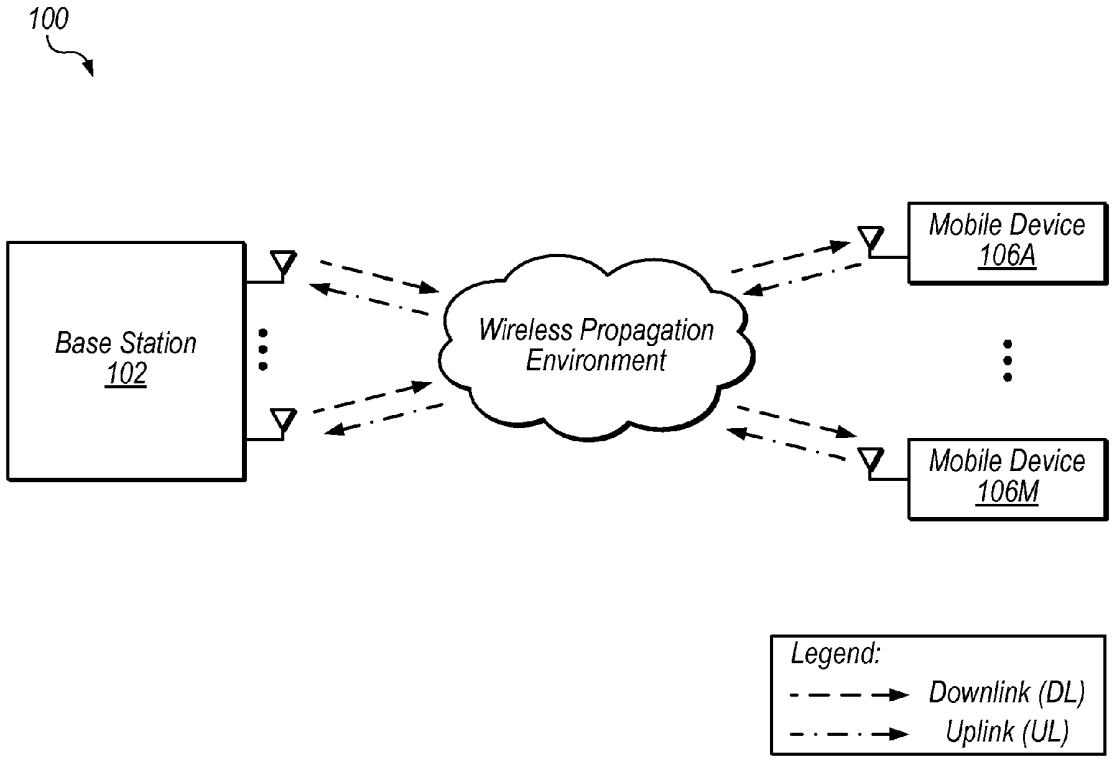
H04B 7/04	(2006.01)
H04L 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***H04B 7/0456*** (2013.01); ***H04B 7/0452*** (2013.01); ***H04L 5/0048*** (2013.01)

(57) **ABSTRACT**

Techniques are disclosed relating to signaling and frame structure for massive MIMO communication systems. In some embodiments, an apparatus is configured to receive an uplink pilot symbol from a mobile device over a first channel and receive uplink data from the mobile device over the first channel, where the uplink data is included in one or more orthogonal frequency division multiplexing (OFDM) symbols at a symbol rate. In these embodiments, the apparatus is configured to, determine channel information based on the pilot symbol, precode downlink data based on the channel information, and transmit the precoded downlink data to the mobile device. In these embodiments, a transition interval between receiving the uplink pilot symbol and beginning to transmit the precoded downlink data corresponds to less than five OFDM symbols at the symbol rate. This may facilitate reciprocity-based precoding for fast-moving mobile devices, in some embodiments.



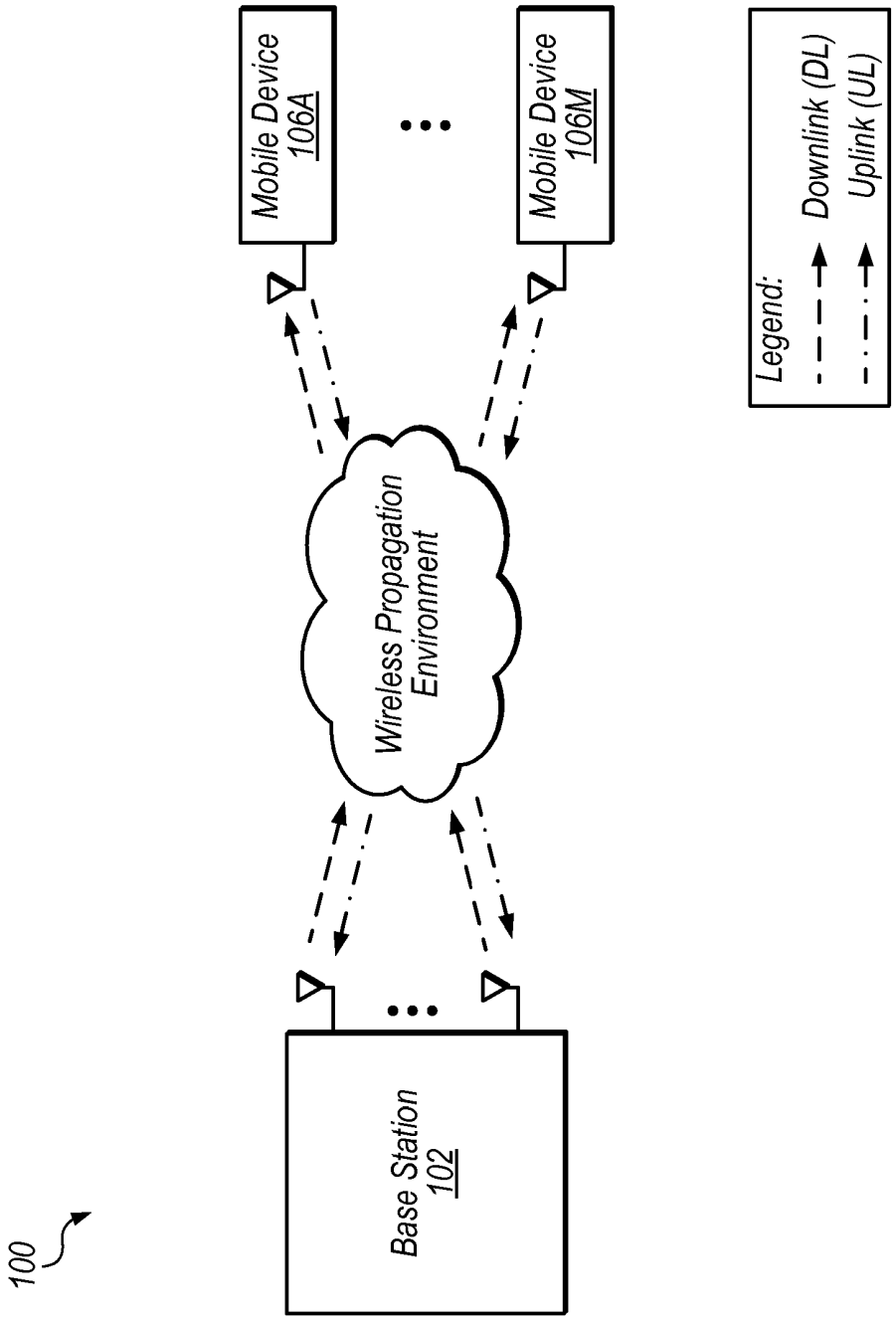

Mobile Device 106A
Mobile Device 106M
Legend:
Downlink (DL)
Uplink (UL)
Wireless Propagation Environment
Base Station 102
100

FIG. 1

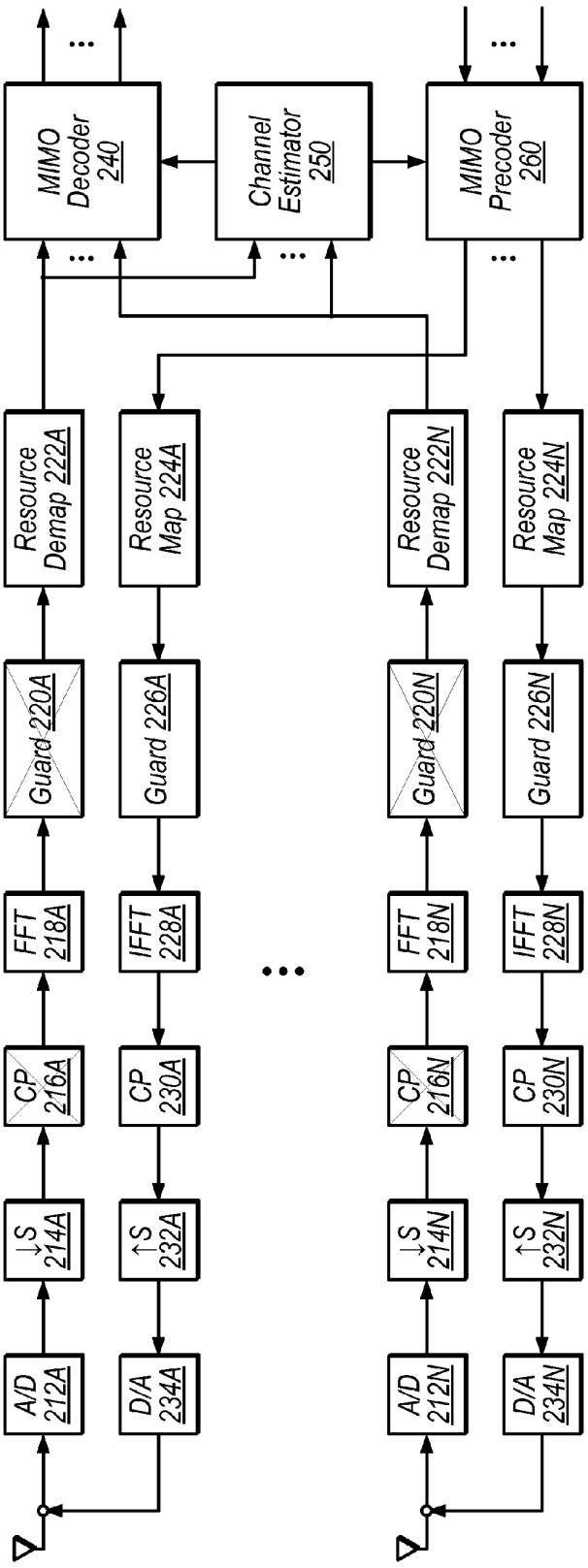

MIMO Decoder 240
Channel Estimator 250
MIMO Precoder 260
Resource Demap 222A
Resource Map 224A
Resource Demap 222N
Resource Map 224N
Guard 220A
Guard 226A
Guard 220N
Guard 226N
FFT 218A
IFFT 228A
FFT 218N
IFFT 228N
CP 216A
CP 230A
CP 216N
CP 230N
↓S 214A
↑S 232A
↓S 214N
↑S 232N
A/D 212A
D/A 234A
A/D 212N
D/A 234N

FIG. 2

446

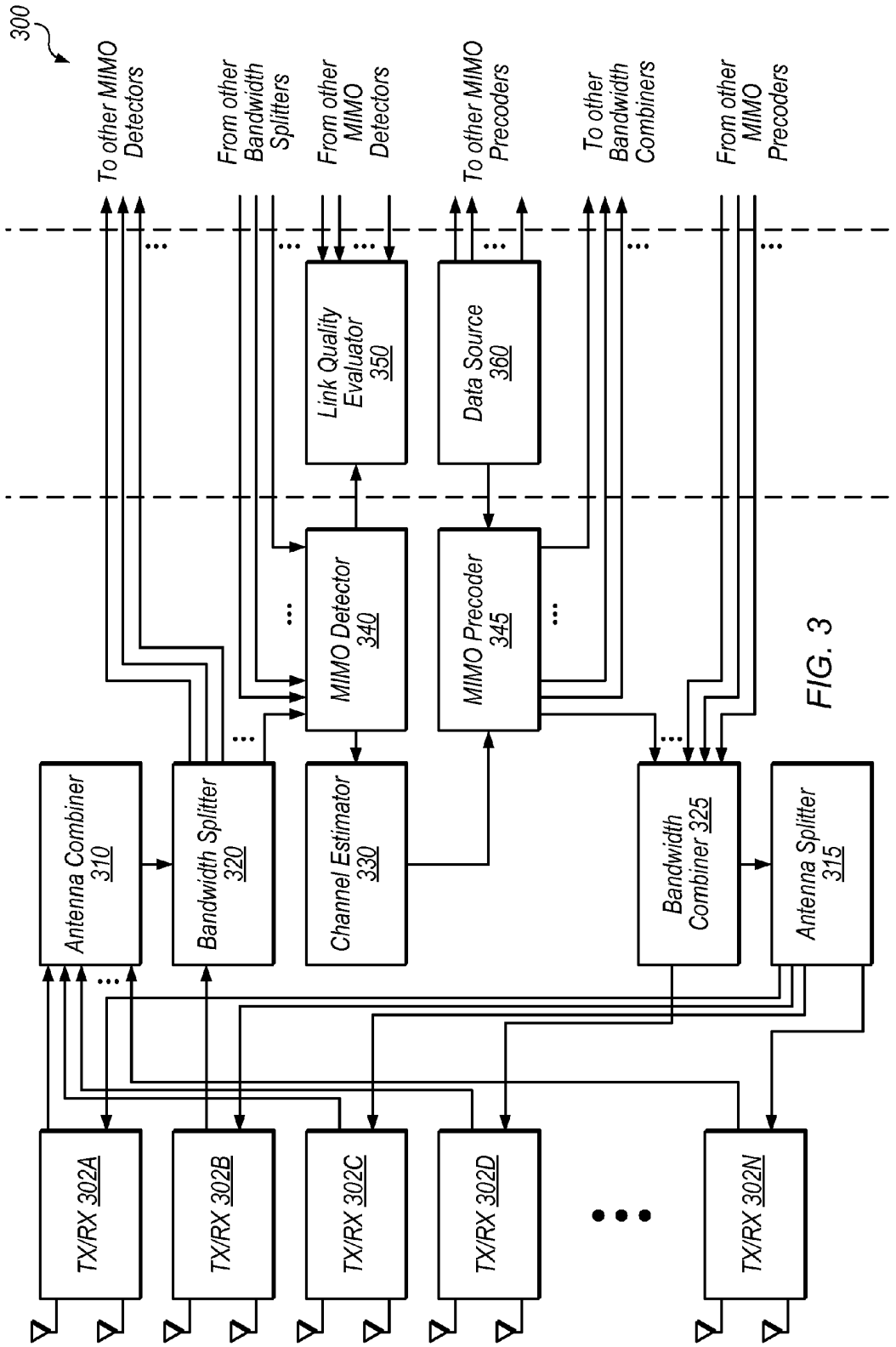

300
To other MIMO Detectors
From other Bandwidth Splitters
From other MIMO Detectors
To other MIMO Precoders
To other Bandwidth Combiners
From other MIMO Precoders
Link Quality Evaluator 350
Data Source 360
MIMO Detector 340
MIMO Precoder 345
Antenna Combiner 310
Bandwidth Splitter 320
Channel Estimator 330
Bandwidth Combiner 325
Antenna Splitter 315
TX/RX 302A
TX/RX 302B
TX/RX 302C
TX/RX 302D
TX/RX 302N

FIG. 3

447

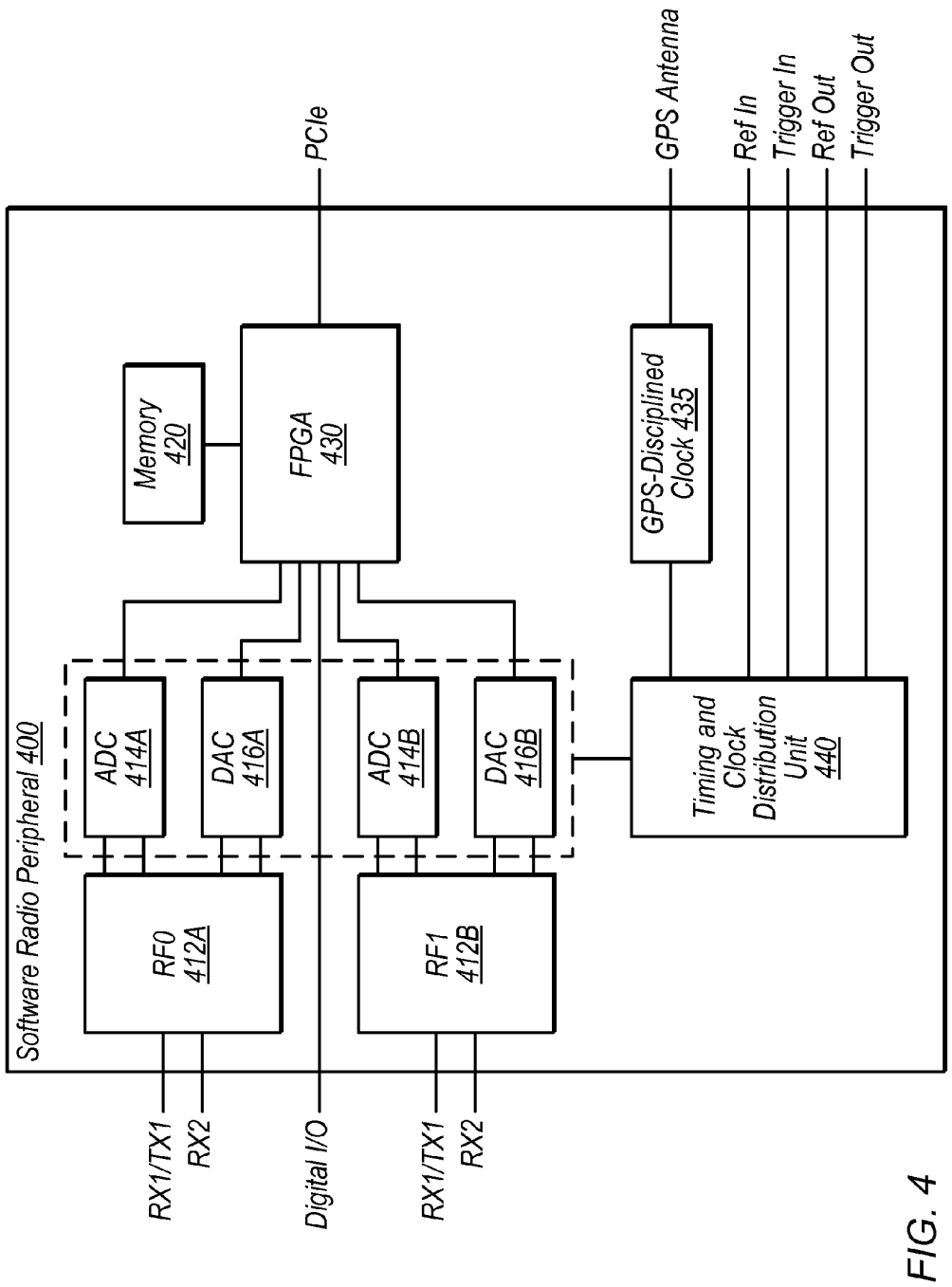

Software Radio Peripheral 400
PCIe
GPS Antenna
Ref In
Trigger In
Ref Out
Trigger Out
Memory 420
FPGA 430
GPS-Disciplined Clock 435
ADC 414A
DAC 416A
ADC 414B
DAC 416B
Timing and Clock Distribution Unit 440
RF0 412A
RF1 412B
RX1/TX1
RX2
Digital I/O
RX1/TX1
RX2
448

FIG. 4

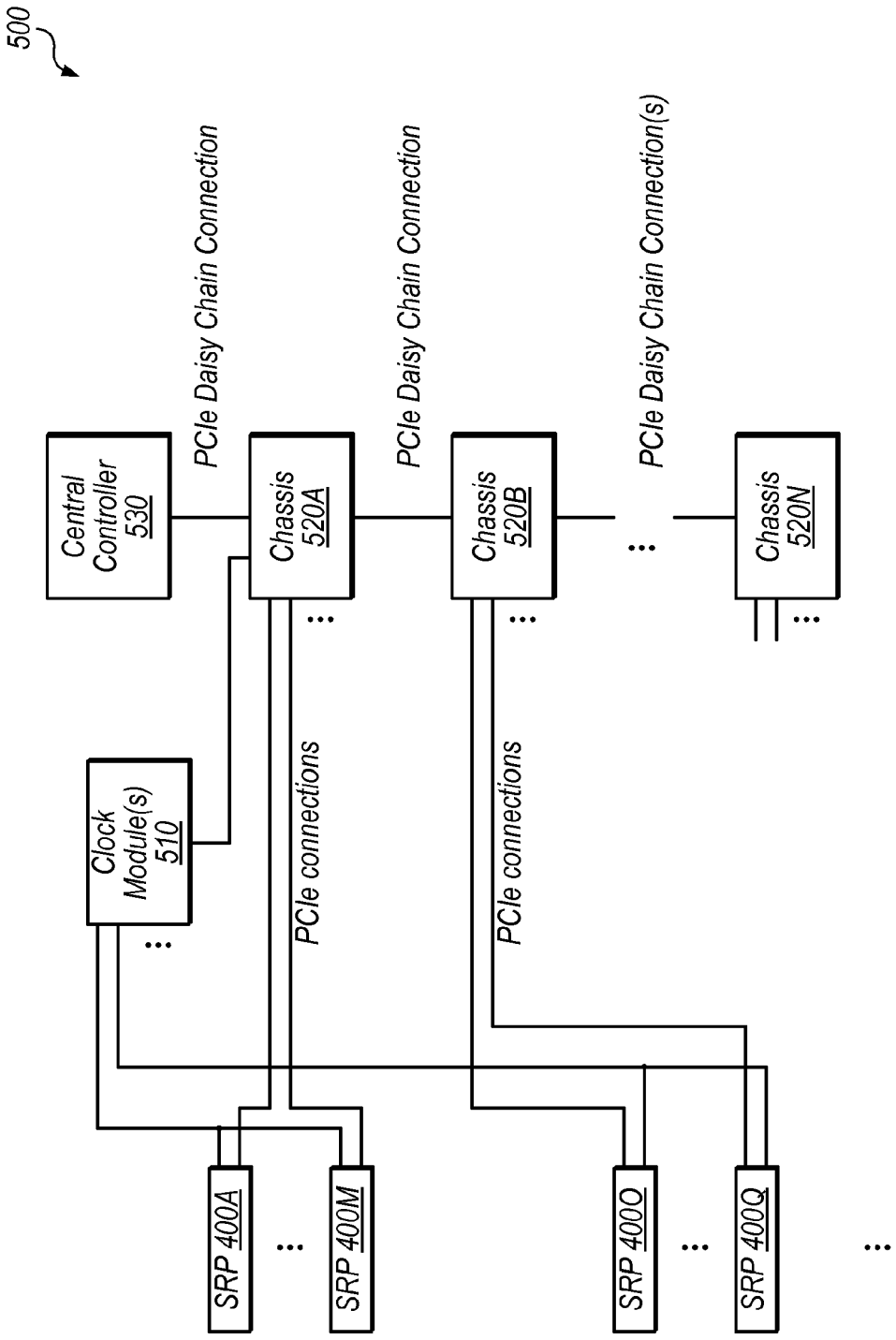

500
Central Controller 530
PCIe Daisy Chain Connection
Chassis 520A
PCIe Daisy Chain Connection
Chassis 520B
PCIe Daisy Chain Connection(s)
Chassis 520N
Clock Module(s) 510
PCIe connections
PCIe connections
SRP 400A
SRP 400M
SRP 400O
SRP 400Q
449

FIG. 5

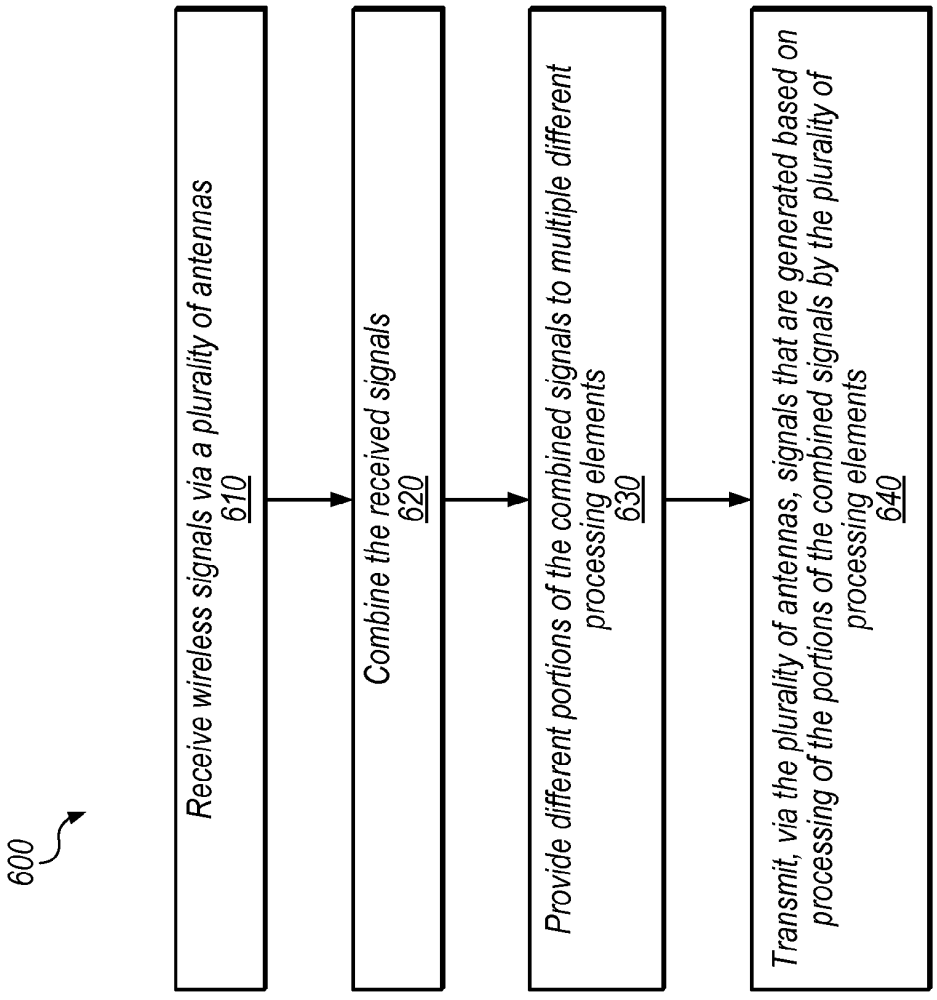

600
Receive wireless signals via a plurality of antennas
610
Combine the received signals
620
Provide different portions of the combined signals to multiple different processing elements
630
Transmit, via the plurality of antennas, signals that are generated based on processing of the portions of the combined signals by the plurality of processing elements
640
450

FIG. 6

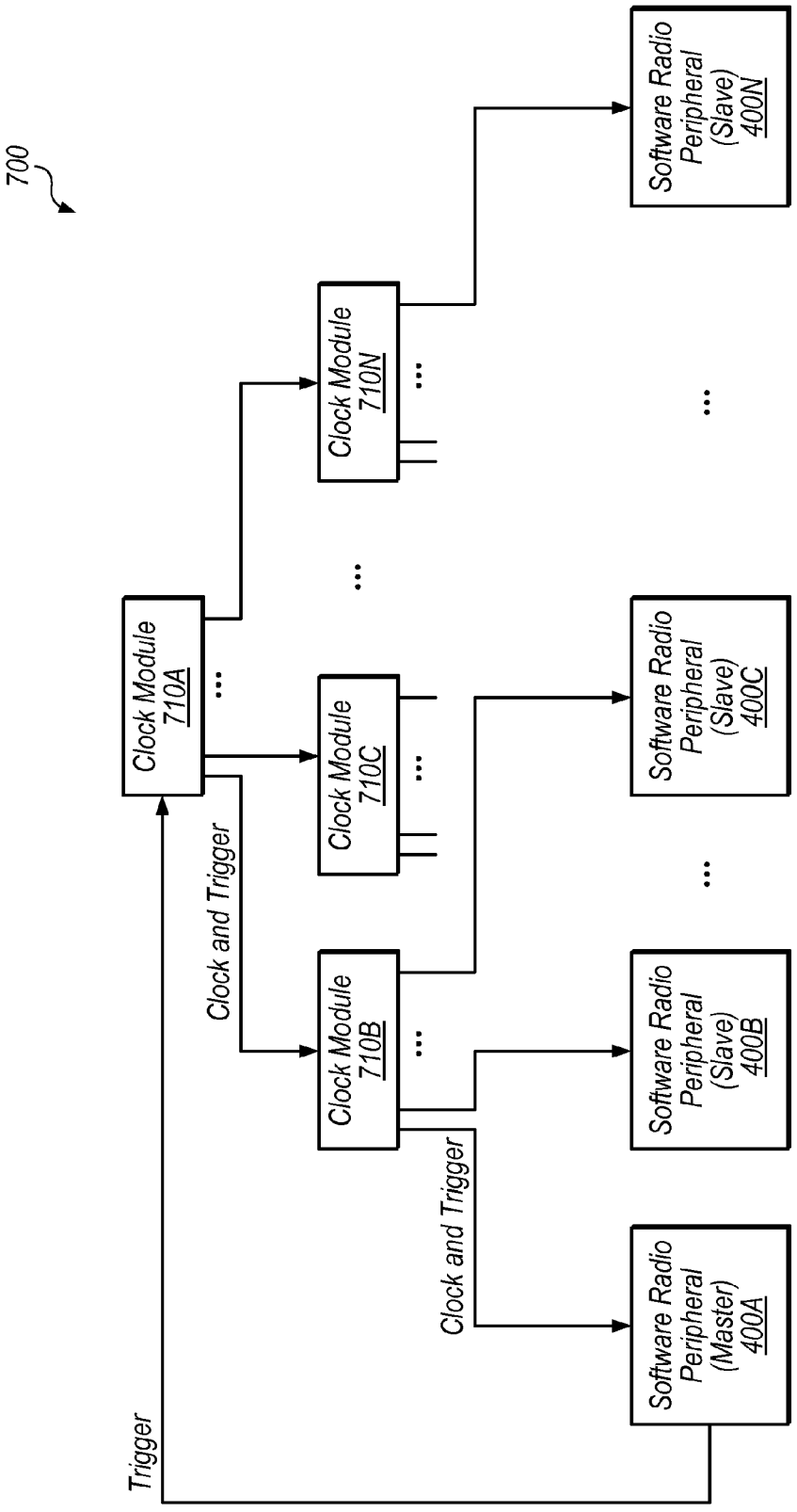

700
Clock Module 710A
Clock Module 710B
Clock Module 710C
Clock Module 710N
Clock and Trigger
Clock and Trigger
Trigger
Software Radio Peripheral (Master) 400A
Software Radio Peripheral (Slave) 400B
Software Radio Peripheral (Slave) 400C
Software Radio Peripheral (Slave) 400N
451

FIG. 7

FIG. 8A

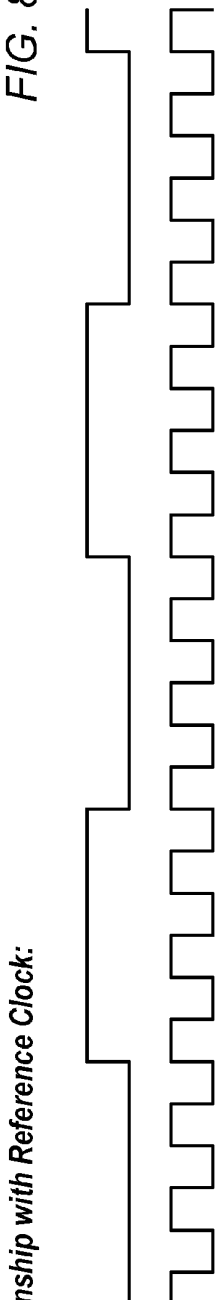


FIG. 8B

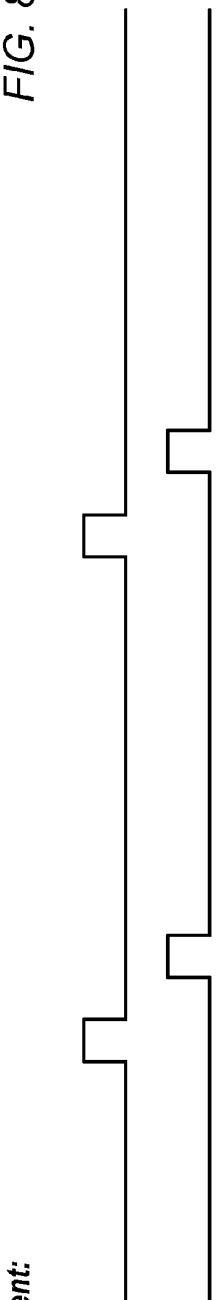
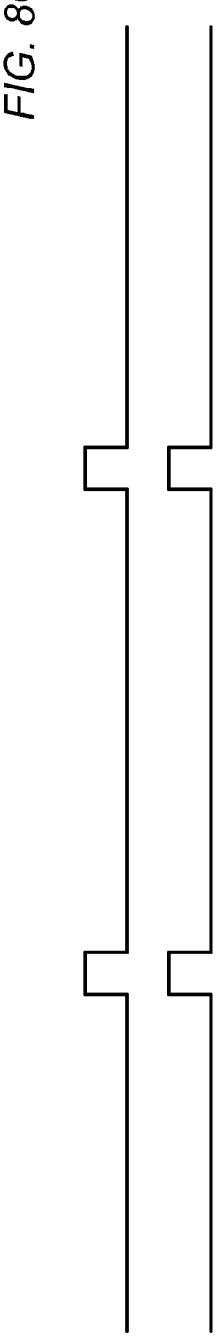


FIG. 8C



452

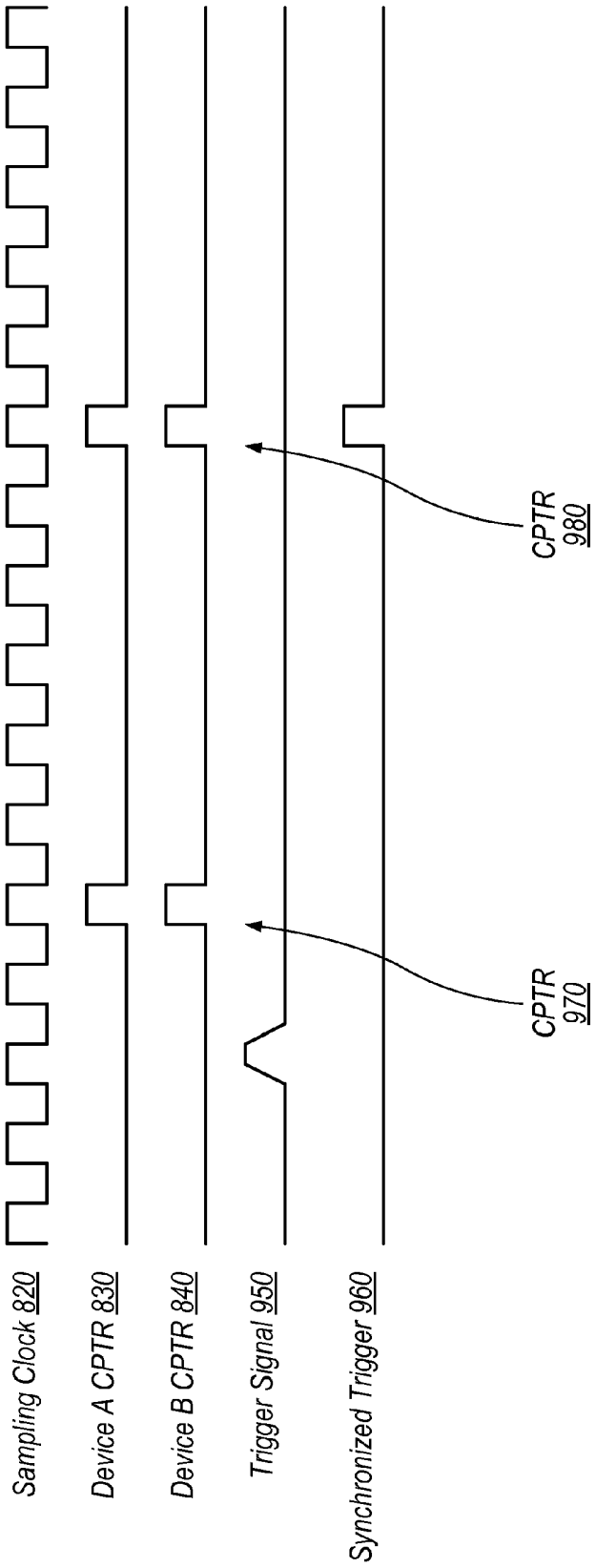

Sampling Clock 820
Device A CPTR 830
Device B CPTR 840
Trigger Signal 950
Synchronized Trigger 960
CPTR 970
CPTR 980

FIG. 9A

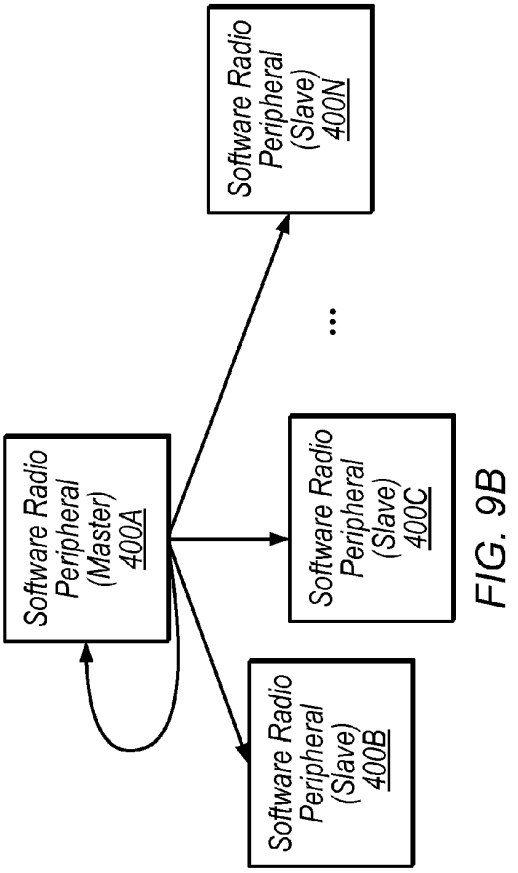


FIG. 9B

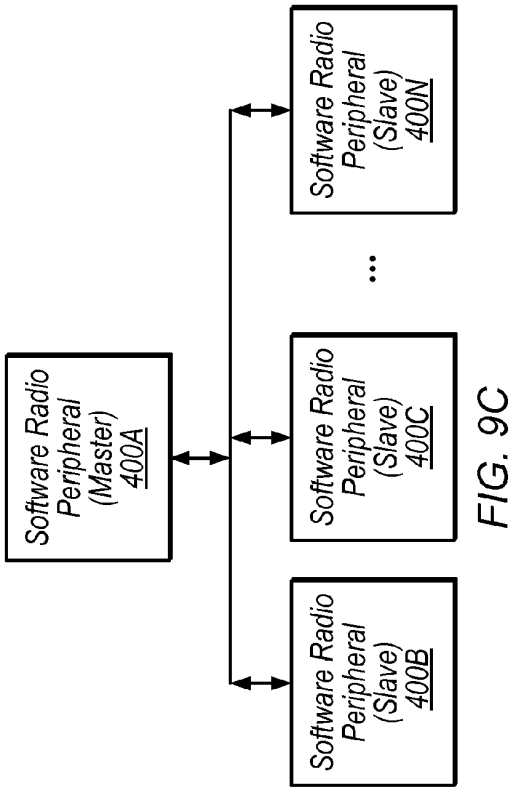


FIG. 9C

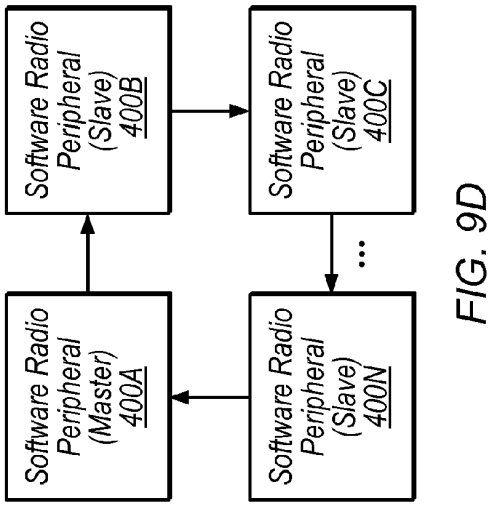


FIG. 9D

454

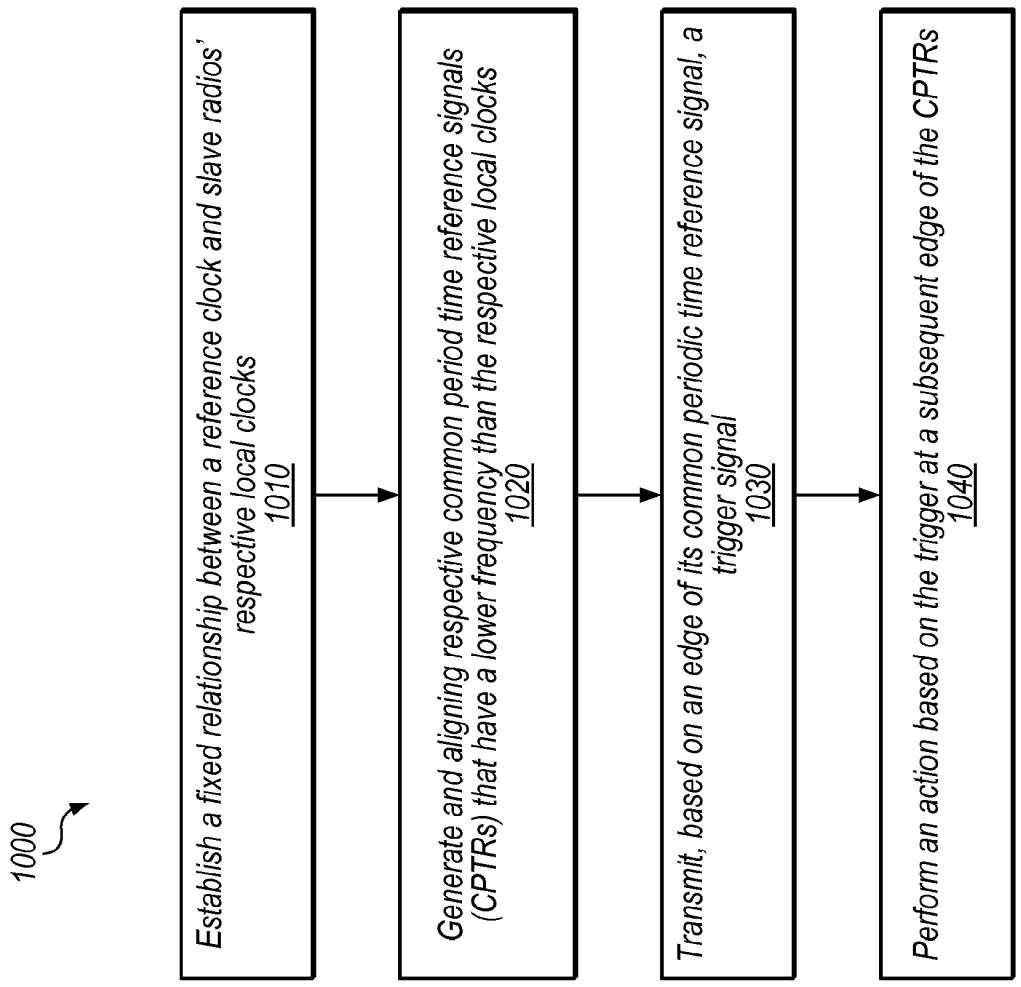

1000
Establish a fixed relationship between a reference clock and slave radios' respective local clocks
1010
Generate and aligning respective common period time reference signals (CPTRs) that have a lower frequency than the respective local clocks
1020
Transmit, based on an edge of its common periodic time reference signal, a trigger signal
1030
Perform an action based on the trigger at a subsequent edge of the CPTRs
1040

FIG. 10

455

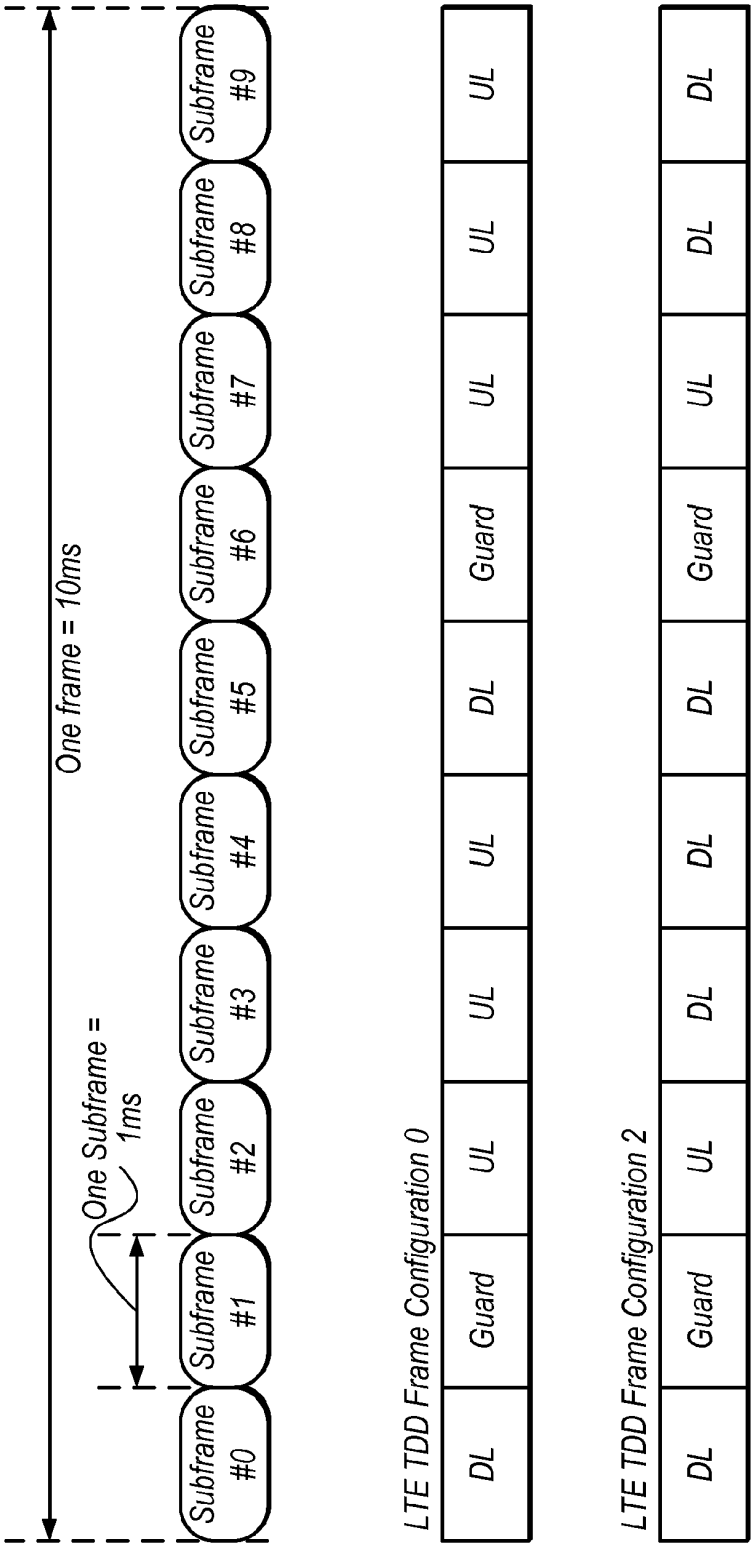

One frame = 10ms
One Subframe = 1ms
Subframe #0
Subframe #1
Subframe #2
Subframe #3
Subframe #4
Subframe #5
Subframe #6
Subframe #7
Subframe #8
Subframe #9
LTE TDD Frame Configuration 0
DL
Guard
UL
UL
UL
DL
Guard
UL
UL
UL
LTE TDD Frame Configuration 2
DL
Guard
UL
DL
DL
DL
Guard
UL
DL
DL

FIG. 11

456

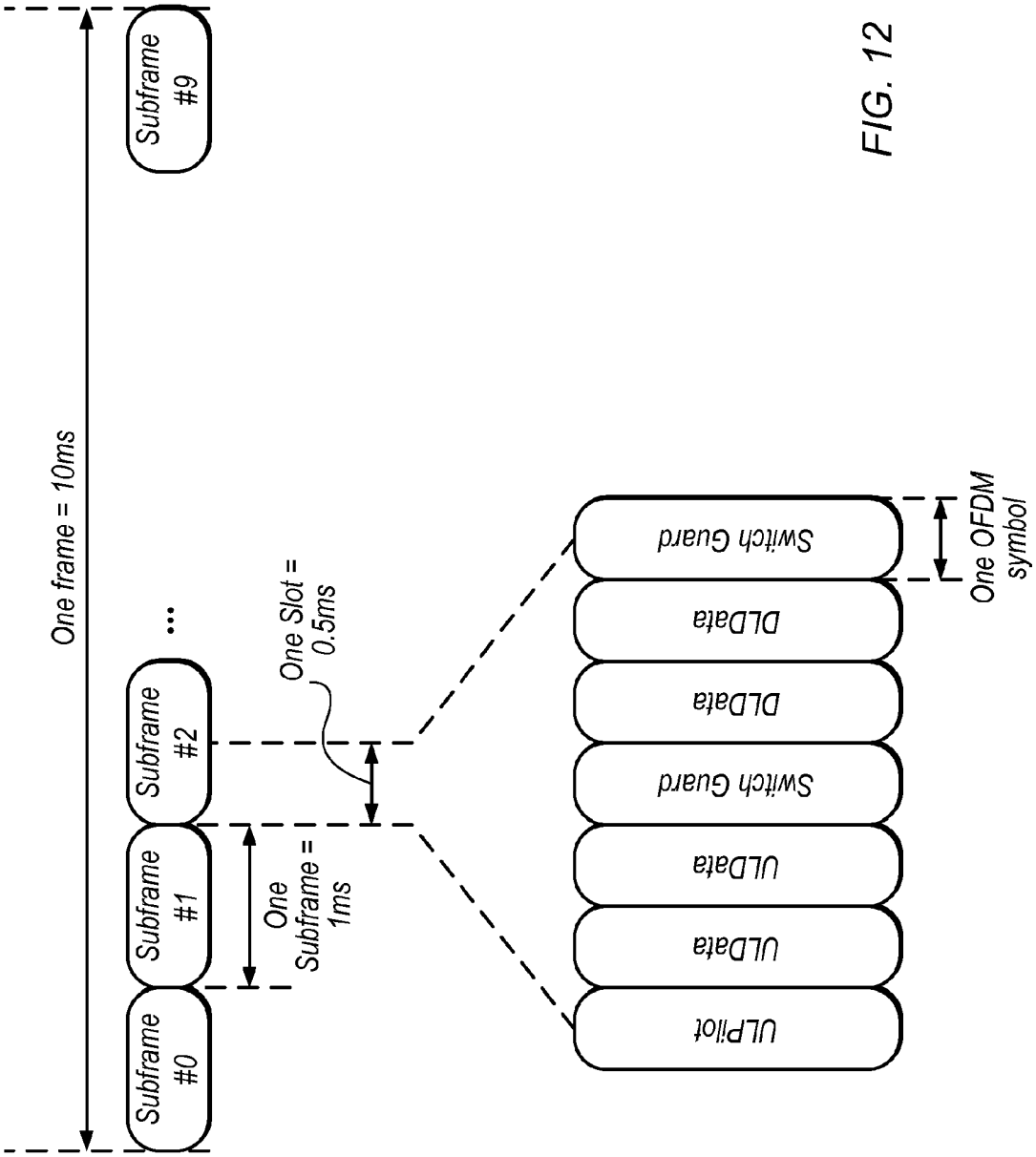

One frame = 10ms
Subframe #0
Subframe #1
Subframe #2
...
Subframe #9
One Subframe = 1ms
One Slot = 0.5ms
ULPilot
ULData
ULData
Switch Guard
DLData
DLData
Switch Guard
One OFDM symbol

FIG. 12

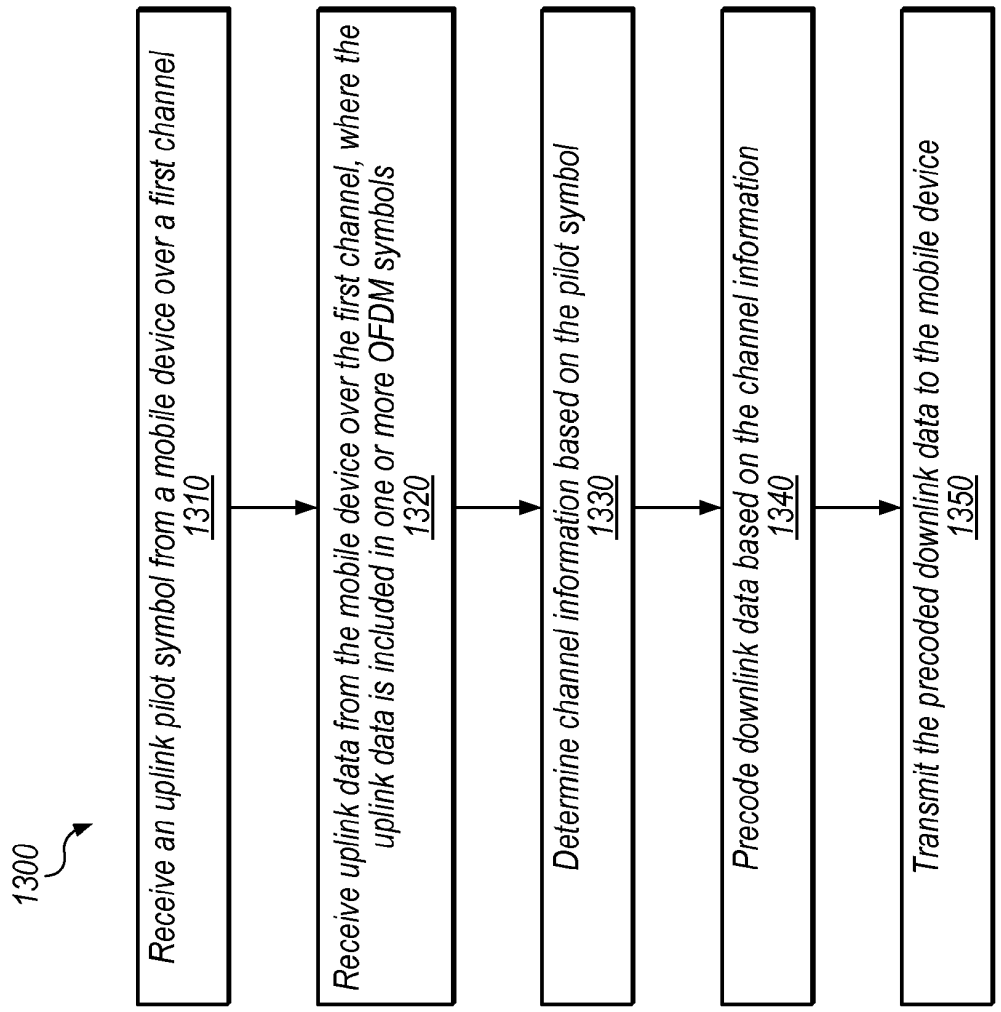

1300
Receive an uplink pilot symbol from a mobile device over a first channel
1310
Receive uplink data from the mobile device over the first channel, where the uplink data is included in one or more OFDM symbols
1320
Determine channel information based on the pilot symbol
1330
Precode downlink data based on the channel information
1340
Transmit the precoded downlink data to the mobile device
1350

FIG. 13

458

SIGNALING AND FRAME STRUCTURE FOR MASSIVE MIMO CELLULAR TELECOMMUNICATION SYSTEMS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/989,784, filed on May 7, 2014, U.S. Provisional Application No. 62/024,872, filed on Jul. 15, 2014, U.S. Provisional Application No. 62/024,885, filed on Jul. 15, 2014, and U.S. Provisional Application No. 62/024,896, filed on Jul. 15, 2014, which are herein incorporated by reference in their entirety as though fully and completely set forth herein.

BACKGROUND

[0002] 1. Technical Field

[0003] This disclosure relates to wireless communication systems and more particularly to multiple input, multiple output (MIMO) communications.

[0004] 2. Description of the Related Art

[0005] Modern communication systems rely upon multiple antennas at the transmitter and/or receiver to enhance link performance. This class of techniques, known as multiple input, multiple output (MIMO) exploits the spatial dimension by employing spatial encoding and/or decoding. Massive MIMO is an exciting theoretical area of 5G wireless that promises significant gains that offer the ability to accommodate more users, at higher data rates, with better reliability, while consuming less power. Conventional MIMO base stations typically use six or eight antennas in a sectorized topology, but massive MIMO base stations utilize more than eight antennas (and sometimes as many as 128, 256, or more) while massive MIMO user equipment devices (UEs) may typically utilize around eight antennas. Using the larger number of antenna elements, massive MIMO reduces power in a given channel by focusing the energy to targeted mobile users using precoding techniques. By directing the wireless energy to specific users, the power in channel is reduced and, at the same time, interference to other users is decreased.

[0006] The introduction of so many antenna elements, however, introduces several system challenges not encountered in conventional networks. For example, conventional data networks may use LTE or LTE-Advanced, which in turn use the pilot tones in an orthogonal frequency division multiplexing (OFDM) waveform to estimate the channel condition. With many antennas and transmitters, a massive MIMO system, may essentially run out of unique pilot tones for a receiver to effectively detect and resolve channel conditions. Further, processing and synchronization requirements for massive MIMO may be difficult to meet using conventional systems.

[0007] Therefore both test systems for prototyping different MIMO techniques and approaches and production MIMO systems configured to utilize these techniques are desired.

SUMMARY

[0008] Techniques are disclosed relating to massive MIMO communications.

[0009] In some embodiments, a base station includes a plurality of antennas, a plurality of processing elements coupled to the plurality of antennas and configured to perform processing for wireless communications via the plurality of antennas, and an interconnect configured to couple the plurality of processing elements. In these embodiments, the base station is configured to combine signals received by multiple antennas. In these embodiments, for at least a subset of the processing elements, each processing element is configured to operate on a different portion of the combined signals, where each portion includes signals from multiple antennas.

[0010] In some embodiments, a large antenna count system includes a master device, a plurality of slave radios communicatively coupled to the master device and to respective antennas in the large antenna clock system, and a clock and trigger distribution system, coupled to the master device and the plurality of slave radios. In these embodiments, each slave includes a local clock and the clock and trigger distribution system comprises a hierarchy of clock and trigger distribution modules. In these embodiments, the plurality of slave radios are configured to establish and maintain a fixed relationship between a reference clock and their respective local clocks, where the reference clock is distributed via the clock and trigger distribution system. In these embodiments, the master device and the plurality of slave radios are configured to generate and align respective common periodic time reference signals that have a lower frequency than the respective local clocks. In these embodiments, the master device is configured to transmit, based on an edge of its common periodic time reference signal, a trigger signal via the clock and trigger distribution system to the plurality of slave radios. In these embodiments, the plurality of slave radios are configured to perform an action based on the trigger at a subsequent edge of their common periodic time reference signals. In some embodiments the master device is configured similarly to the slave devices, at least in the sense that it also includes a local clock, is configured to establish and maintain a fixed relationship between a reference clock and its local clock, and is configured to perform an action based on the trigger at the subsequent edge of its common period time reference signal.

[0011] In some embodiments, an apparatus includes a plurality of antennas, a plurality of radios configured to perform wireless communication with one or more mobile devices, and one or more processing elements coupled to the plurality of radios. In these embodiments, the apparatus is configured to receive an uplink pilot symbol from a mobile device over a first channel, receive uplink data from the mobile device over the first channel, where the uplink data is included in one or more orthogonal frequency division multiplexing (OFDM) symbols at a symbol rate, determine channel information based on the pilot symbol, precode downlink data based on the channel information, and transmit, via one or more of the plurality of antennas, the precoded downlink data to the mobile device. In these embodiments, a transition interval between receiving the uplink pilot symbol and beginning to transmit the precoded downlink data corresponds to less than five OFDM symbols at the symbol rate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is a block diagram illustrating MIMO communications in a wireless propagation environment, according to some embodiments.

[0013] FIG. **2** is a block diagram illustrating exemplary send and receive processing chains for reciprocity-based MIMO, according to some embodiments.

[0014] FIG. **3** is a block diagram illustrating a portion of an exemplary massive MIMO system configured to distribute processing, according to some embodiments.

[0015] FIG. **4** is a block diagram illustrating an exemplary software radio peripheral, according to some embodiments.

[0016] FIG. **5** is a block diagram illustrating a hardware system configured to implement a massive MIMO base station, according to some embodiments.

[0017] FIG. **6** is a flow diagram illustrating a method for MIMO processing according to some embodiments.

[0018] FIG. **7** is a block diagram illustrating one embodiment of a clock and trigger distribution network for synchronization, according to some embodiments.

[0019] FIGS. **8**A-**9**A are timing diagrams illustrating exemplary synchronization techniques according to some embodiments.

[0020] FIGS. **9**B-**9**D are block diagrams illustrating exemplary synchronization topologies, according to some embodiments.

[0021] FIG. **10** is a flow diagram illustrating a method for synchronization of radio circuitry, according to some embodiments.

[0022] FIG. **11** is a diagram illustrating exemplary LTE TDD frame configurations, according to some embodiments.

[0023] FIG. **12** is a diagram illustrating an exemplary frame structure for reciprocity-based massive MIMO communications, according to some embodiments.

[0024] FIG. **13** is a flow diagram illustrating a method for using disclosed frame structures, according to some embodiments.

[0025] This specification includes references to "one embodiment" or "an embodiment." The appearances of the phrases "in one embodiment" or "in an embodiment" do not necessarily refer to the same embodiment. Particular features, structures, or characteristics may be combined in any suitable manner consistent with this disclosure.

[0026] Various units, circuits, or other components may be described or claimed as "configured to" perform a task or tasks. In such contexts, "configured to" is used to connote structure by indicating that the units/circuits/components include structure (e.g., circuitry) that performs the task or tasks during operation. As such, the unit/circuit/component can be said to be configured to perform the task even when the specified unit/circuit/component is not currently operational (e.g., is not on). The units/circuits/components used with the "configured to" language include hardware—for example, circuits, memory storing program instructions executable to implement the operation, etc. Reciting that a unit/circuit/component is "configured to" perform one or more tasks is expressly intended not to invoke 35 U.S.C. §112(f) for that unit/circuit/component.

DETAILED DESCRIPTION

[0027] This disclosure initially describes, with reference to FIGS. **1-2**, an overview of exemplary multiple-input multiple-output (MIMO) communications and processing. Generally, MIMO technology may exploit multipath propagation to increase radio capacity, performance, and/or range using multiple transmit and receive antennas. Exemplary massive MIMO systems are then discussed with reference to FIGS. **3-6**. Exemplary synchronization techniques for MIMO systems are discussed with reference to FIGS. **7-10**. Exemplary frame structures to facilitate utilization of channel reciprocity are discussed with reference to FIGS. **11-13**. In some embodiments, a massive MIMO system is configured as a versatile, flexible, and scalable massive MIMO platform for real-time, two-way communication. The disclosed systems and techniques may be used in a production environment and/or in test environments.

Acronyms

[0028] The following acronyms are used in the present disclosure.

[0029] 3GPP: Third Generation Partnership Project

[0030] 3GPP2: Third Generation Partnership Project 2

[0031] BER: Bit Error Rate

[0032] CDMA: Code Division Multiple Access

[0033] CPTR: Common Periodic Time Reference

[0034] DDR: Double Data Rate

[0035] DL: Downlink

[0036] EVM: Error Vector Magnitude

[0037] FFT: Fast Fourier Transform

[0038] FPGA: Field Programmable Gate Array

[0039] GSM: Global System for Mobile Communications

[0040] LTE: Long Term Evolution

[0041] MIMO: Multiple Input Multiple Output

[0042] MRT: Maximum Radio Transmission

[0043] OFDM: Orthogonal Frequency-Division Multiplexing

[0044] PER: Packet Error Rate

[0045] PCIe: Peripheral Component Interconnect Express

[0046] PLMN: Public Land Mobile Network

[0047] PXIe: PCI eXtensions for Instrumentation Express

[0048] RAT: Radio Access Technology

[0049] RF: Radio Frequency

[0050] RX: Receive

[0051] SDR: Software Defined Radio

[0052] SRP: Software Radio Peripheral

[0053] TX: Transmit

[0054] UE: User Equipment

[0055] UL: Uplink

[0056] UMTS: Universal Mobile Telecommunications System

[0057] WCDMA: Wideband Code Division Multiple Access

[0058] ZF: Zero Forcing

Terms

[0059] The following is a glossary of terms used in the present application:

[0060] Memory Medium—Any of various types of memory devices or storage devices. The term "memory medium" is intended to include an installation medium, e.g., a CD-ROM, floppy disks, or tape device; a computer system memory or random access memory such as DRAM, DDR RAM, SRAM, EDO RAM, Rambus RAM, etc.; a non-volatile memory such as a Flash, magnetic media, e.g., a hard drive, or optical storage; registers, or other similar types of memory elements, etc. The memory medium may include other types of memory as well or combinations thereof. In addition, the memory medium may be located in a first computer system in which the programs are executed, or may be located in a second different computer system which connects to the first computer system over a network, such as the Internet. In the latter instance, the second computer system may provide program instructions to the first computer for execution. The term "memory medium" may include two or more memory mediums which may reside in different locations, e.g., in different computer systems that are connected over a network. The memory medium may store program instructions (e.g., embodied as computer programs) that may be executed by one or more processors.

[0061] Carrier Medium—a memory medium as described above, as well as a physical transmission medium, such as a bus, network, and/or other physical transmission medium that conveys signals such as electrical, electromagnetic, or digital signals.

[0062] Computer System—any of various types of computing or processing systems, including a personal computer system (PC), mainframe computer system, workstation, network appliance, Internet appliance, personal digital assistant (PDA), personal communication device, smart phone, television system, grid computing system, or other device or combinations of devices. In general, the term "computer system" can be broadly defined to encompass any device (or combination of devices) having at least one processor that executes instructions from a memory medium.

[0063] User Equipment (UE) (or "UE Device")—any of various types of computer systems devices which are mobile or portable and which performs wireless communications. Examples of UE devices include mobile telephones or smart phones (e.g., iPhone™, Android™-based phones), portable gaming devices (e.g., Nintendo DS™, PlayStation Portable™, Gameboy Advance™, iPhone™), laptops, PDAs, portable Internet devices, music players, data storage devices, other handheld devices, as well as wearable devices such as wrist-watches, headphones, pendants, earpieces, etc. In general, the term "UE" or "UE device" can be broadly defined to encompass any electronic, computing, and/or telecommunications device (or combination of devices) which is easily transported by a user and capable of wireless communication.

[0064] Base Station—The term "Base Station" has the full breadth of its ordinary meaning, and at least includes a wireless communication station installed at a fixed location and used to communicate as part of a wireless telephone system or radio system.

[0065] Processing Element—refers to various elements or combinations of elements. Processing elements include, for example, circuits such as an ASIC (Application Specific Integrated Circuit), portions or circuits of individual processor cores, entire processor cores, individual processors, programmable hardware devices such as a field programmable gate array (FPGA), and/or larger portions of systems that include multiple processors.

[0066] Automatically—refers to an action or operation performed by a computer system (e.g., software executed by the computer system) or device (e.g., circuitry, programmable hardware elements, ASICs, etc.), without user input directly specifying or performing the action or operation. Thus the term "automatically" is in contrast to an operation being manually performed or specified by the user, where the user provides input to directly perform the operation. An automatic procedure may be initiated by input provided by the user, but the subsequent actions that are performed "automatically" are not specified by the user, i.e., are not performed "manually", where the user specifies each action to perform. For example, a user filling out an electronic form by selecting each field and providing input specifying information (e.g., by typing information, selecting check boxes, radio selections, etc.) is filling out the form manually, even though the computer system must update the form in response to the user actions. The form may be automatically filled out by the computer system where the computer system (e.g., software executing on the computer system) analyzes the fields of the form and fills in the form without any user input specifying the answers to the fields. As indicated above, the user may invoke the automatic filling of the form, but is not involved in the actual filling of the form (e.g., the user is not manually specifying answers to fields but rather they are being automatically completed). The present specification provides various examples of operations being automatically performed in response to actions the user has taken.

MIMO Example and Theory

[0067] FIG. **1** shows an exemplary MIMO system **100** that includes base station **102** and M mobile devices **106**A-M (which may also be referred to as user equipment devices or UEs **106**A-M). In the illustrated embodiment, base station **102** includes N antennas configured to transmit and receive data with mobile devices **106** using time-division duplexing (TDD). In other embodiments, other transmission techniques may be used including frequency-division duplexing (FDD), for example.

[0068] In system **100**, mobile devices **106** may concurrently communicate with base station **102** via wireless propagation environment. The paths taken by different signals may vary among the mobile devices, e.g., based on their location in the environment. Therefore, using MIMO techniques to precode signals transmitted by the base station, for example, may greatly improve overall radio capacity, performance, and/or range. Thus, base station **102** may allocate multiple antennas (e.g., as many as ten or more in some massive MIMO systems) to a given mobile device **10**. To configure allocation, in some embodiments, mobile devices may concurrently transmit a known pattern to the base station in a particular time or frequency slot. Base station **102** may compare the pattern across a number of antennas to determine the unique channel characteristics to each spatially diverse path for the different UEs. Subsequently, the base station may apply the inverse of channel characteristic parameters as a form of precoding, such that each mobile device **106** receives its intended messages.

[0069] In some embodiments, base station **102** is configured to exploit the reciprocity of the channel between base station **102** and a given mobile device **106** by using uplink channel conditions (for communications from one or more of the mobile devices **106** to the base station **102**) to configure downlink transmissions (from the base station **102** to at least one of the mobile devices **106**). Received downlink and uplink signals, y and z, may be modeled as:

$$y=Hd+w \quad (1)$$

$$z=Gu+v \quad (2)$$

where d and u represent transmitted downlink and uplink signals respectively, H represents a complex-valued downlink channel matrix of M×N dimensions, G represents a complex-valued uplink channel matrix of N×M dimensions, and x and v represent additive noise that is independent on each signal path.

[0070] If the transition from uplink to downlink is sufficiently fast (e.g., within the channel coherence time), G approaches the conjugate transpose of H, H*. This concept is referred to as channel reciprocity. Techniques for facilitating performance of the transition from uplink to downlink within the coherence time are discussed below with reference to FIGS. **11-13**.

[0071] Various options are available for precoding the downlink signal (d). For example, linear precoding may generate d as:

$d=Fx$

Where F is a downlink precoder applied to signals x_N intended for each of N users of mobile devices **106**. Typically, the precoder is formed using channel estimates. Common precoders include zero forcing (ZF) and minimum mean squared error (MMSE). In some massive MIMO embodiments with a large number of antennas, the columns of H may become nearly orthogonal and maximum ratio transmission (MRT) precoding may be applied. This may simplify precoding while maintaining a maximum sum rate relative to other precoding methods. In various embodiments, however, any of various appropriate precoding techniques may be implemented.

[0072] Speaking generally, MIMO techniques may increase capacity, performance, and/or range of wireless communications. Although various embodiments are discussed herein in the context of cellular communications, these embodiments are not intended to limit the scope of the present disclosure. Rather, the disclosed techniques may be used in various wireless communication contexts, such as WIFI, for example.

[0073] FIG. **2** shows exemplary send and receive chains for reciprocity-based MIMO for two antennas, which may be included in MIMO base station **102**, for example. In the illustrated embodiment, analog-to-digital (A/D) converters **212**A-N demodulate and digitize received uplink signals from RF. Down-samplers **214**A-N down-sample the digital samples to a desired sampling rate, e.g., that is some fraction of the A/D sampling rate. Subsequently, units **216**A-N, **218**A-N, **220**A-N, and **222**A-N perform OFDM signal processing, including removing the cyclic prefix (CP), performing a Fast Fourier Transform (FFT) after serial-to-parallel conversion, removing guard subcarriers, and de-allocating uplink data and pilots to the resource map. Base station **102** may then pass pilot and data symbols for all N receive chains to channel estimator **250**.

[0074] Channel estimates generated by channel estimator **250**, in the illustrated embodiment, are used by MIMO decoder **240** to decode M uplink data streams and by MIMO precoder **260** to precode M downlink data streams.

[0075] The precoded downlink data streams, in the illustrated embodiment, are then processed by units **224**A-N, **226**A-N, **228**A-N, and **230**A-N, including resource mapping, adding guard symbols, serial-to parallel conversion, performing an inverse FFT, and adding the cyclic prefix. Subsequently, units **232**A-N up-convert the data from the baseband rate and digital to analog converters (D/As) **234**A-N convert the result for transmission via the antennas.

[0076] Various disclosed techniques address challenges when adding a large number of receive and transmit chains to a system, as in massive MIMO. In some embodiments, software defined radios are used to implement a massive MIMO system that is configurable, modular, meets I/O requirements for distributed processing, and supports real-time processing for large numbers of antennas.

Exemplary Massive MIMO System

[0077] FIG. **3** is a block diagram illustrating a subsystem of one embodiment of a massive MIMO system **300**. System **300** may be included in base station **102**, for example. In some embodiments, system **300** is configured to perform at least a portion of the processing described above with reference to FIG. **2** in a distributed manner. In the illustrated embodiment, the subsystem includes front-end TX/RX units **302**A-N, antenna combiner **310**, antenna splitter **315**, bandwidth splitter **320**, bandwidth combiner **325**, channel estimator **330**, MIMO detector **340**, and MIMO precoder **345**. In the illustrated embodiment, link quality evaluator **350** and data source **360** are included in a central control unit that is shared among multiple subsystems (as indicated by the vertical dashed lines, delineating units included in the central controller, according to this embodiment).

[0078] Other subsystems of system **300** (not shown), in the illustrated embodiment, include additional MIMO detectors, MIMO precoders, bandwidth splitters, and bandwidth combiners. For example, in an embodiment in which the subsystem of FIG. **3** includes eight TX/RXs **302** and the system includes six subsystems, **96** antennas may be used. MIMO processing, in the illustrated embodiment, is distributed among various processing elements. This may allow baseband processing to be partitioned across multiple FPGAs, for example. This may facilitate scaling of massive MIMO systems far beyond what a single centralized processing unit could achieve for real-time baseband processing.

[0079] TX/RX units **302**A-N, in some embodiments, are included in software defined radio modules, which may also include processing elements configured or configurable to perform the functionality of various other units shown in FIG. **3**. For example, TX/RX **302**A and antenna combiner **310** may be implemented by the same SDR element. An exemplary embodiment of a peripheral configured to implement an SDR is discussed in further detail below with reference to FIG. **4**.

[0080] For uplink symbols, as previously discussed with reference to FIG. **2**, each TX/RX **302** may be configured to digitize the received RF signals, perform analog front-end calibration and time/frequency synchronization, remove the cyclic prefix (CP), and perform FFT OFDM demodulation and guard-band removal. This may result in frequency domain pilot and unequalized data symbol vectors, which is provided to antenna combiner **310** in the illustrated embodiment. Note that, at this point, the OFDM symbols may contain the superposition of transmitted signals by all users. For downlink symbols, each TX/RX **302** may be configured to perform ODFM processing as described above with reference to FIG. **2** for signals received from antenna splitter **315**.

[0081] In one embodiment, antenna combiner **310**, bandwidth, splitter **320**, MIMO precoder **345**, bandwidth combiner **325**, and antenna splitter **315** are each located on a different SDR element that also implements one of TX/RXs **302**. In one embodiment, channel estimator **330** and MIMO detector **340** are located on another SDR element that also implements one of TX/RXs **302**. In various embodiments, the various elements of FIG. **3** may be partitioned among various hardware elements configured to perform the disclosed functionality. The hardware elements may be programmable and/or include dedicated circuitry.

[0082] Antenna combiner **310**, in the illustrated embodiment, is configured to receive the yet unequalized OFDM symbols from each TX/RX **302** and combines them into a signal sent to bandwidth splitter **320**. This combines the signals from up to N antennas in the subsystem. Combining this information before further processing may allow the system to stay within throughput constraints and may reduce the number of peer-to-peer connections between SDRs, for example. In some embodiments, the number of antennas for which signals are combined by each antenna combiner **310** is dynamically configurable.

[0083] Bandwidth splitter **320**, in the illustrated embodiment, is configured to split the received signals into separate bandwidth portions and send the portions to MIMO detectors in different subsystems. Thus, in the illustrated embodiment, processing is distributed across different processing elements that each process data for a different frequency band. Each bandwidth portion may include one or more subcarriers and the portions may or may not be non-overlapping. In some embodiments, the number of bandwidth portions and the size of each portion is configurable, e.g., based on the number of antennas, current number of users in communication, etc. In other embodiments, processing may be distributed among processing elements across different time slices in addition to and/or in place of splitting by frequency. In some embodiments, bandwidth splitter **320** is replaced with a time-slice splitter. Post-FTT subcarrier processing in OFDM may be inherently independent, allowing subsequent processing to be performed in parallel by different processing elements.

[0084] In the illustrated embodiment, the output of TX/RX **302**B is provided directly to bandwidth splitter **320** and an output of bandwidth combiner **325** is provided directly to TX/RX **302**D. In other embodiments, these outputs may be provided to antenna combiner **310** and antenna splitter **315** similarly to the other signals. In embodiments in which TX/RX **302**B and bandwidth splitter **320** share the same SDR element and TX/RX **302**D and bandwidth combiner **325** share the same SDR element, however, the illustrated coupling may conserve I/O resources.

[0085] MIMO detector **340**, in the illustrated embodiment, is configured to use an estimated channel matrix (e.g., based on uplink pilot symbols) to cancel interference and detect frequency-domain symbols from each mobile device **106**. As shown, in some embodiments MIMO detector **340** is configured to process signals in a given bandwidth from multiple subsystems of system **300**. In the illustrated embodiment, MIMO detector **340** is configured to send the detected signals to channel estimator **330** and to link quality evaluator **350** (included in a central controller in some embodiments) for further processing.

[0086] Channel estimator **330**, in the illustrated embodiment, is configured to perform channel estimation for its frequency portion for a number of mobile devices, e.g., to produce soft-bits (also referred to as log-likelihood ratios (LLRs)) and provide them to link quality evaluator **350** (coupling not shown). In some embodiments, multiple decoders are implemented, including a turbo decoder, for example.

[0087] For downlink symbols, data source **360**, in test system embodiments, is configured to generate test data, which may be pseudo-random or may be explicitly specified for a particular test. In these embodiments, data source **360** may be located in a central control unit. In production systems, data source **360** may provide data from various networks to be transmitted to mobile devices **106**.

[0088] MIMO precoder **345**, in the illustrated embodiment, is configured to receive downlink data from data source **360** and precode the data based on channel estimates (e.g., estimated reciprocity calibration weights) from channel estimator **330**. In some embodiments, the MIMO precoders in system **300** are configured to perform precoding on different frequency portions of the downlink data. In some embodiments (not shown), the MIMO precoders in system **300** are configured to perform precoding on different time portions of the downlink data.

[0089] Exemplary precoders, according to some embodiments, include maximum radio transmission (MRT) and zero forcing (ZF) precoders. In other embodiments, any of various appropriate precoding techniques may be implemented. Depending on the precoding technique implemented, varying amounts of processing for the precoding may be performed by at a central controller or distributed among MIMO precoders **345**.

[0090] Bandwidth combiner **325**, in the illustrated embodiment, is configured to combine signals at different bandwidths from multiple MIMO precoders and send the data to antenna splitter **315**. This may result in a complete set of precoded data for transmission from the separately processed bandwidth portions. In other embodiments, bandwidth combiner **325** is configured to combine data corresponding to separately-processed time slices in place of or in addition to combining separately-processed frequency portions.

[0091] Antenna splitter **315**, in the illustrated embodiment, is configured to split the received signal and provide the split signal to TX/RXs **302** for OFDM processing and transmission to mobile devices **106**. The set of antennas to which antenna splitter **315** is configured to provide signals is dynamically configurable, in some embodiments (e.g., the number of antennas and/or the particular antennas in the set). Thus, in some embodiments, the set of processing elements configured to perform distributed processing for particular antennas and/or users is dynamically configurable.

[0092] Link quality evaluator **350**, in the illustrated embodiment, is included in a central control unit and is configured to measure link quality using one or more of various metrics such as bit error rate (BER), error vector magnitude (EVM), and/or packet-error rate (PER).

[0093] In various embodiments, system **300** is highly configurable, e.g., based on user input and/or current operating conditions. In some embodiments, various disclosed configuration operations are performed automatically. In some embodiments, the number of processing elements used at a given time to perform distributed processing for a set of users or a set of antennas is configurable. In some embodiments, the number of antennas used to communicate with each UE is configurable and/or dynamically determined. In some embodiments, the processing elements configured to perform different functionality described above is configurable. For example, the antenna combiner function may be moved from one FPGA to another FPGA or performed by multiple FPGAs. In some embodiments, the routing of data between processing elements is configurable, e.g., to avoid malfunctioning antennas and/or processing elements. In various embodiments, system **300** is configured to adjust these configurable aspects dynamically based on current operating conditions. In some embodiments, system **300** includes a large number of antennas, e.g., more than 8. In some embodiments, for example, system **300** includes 16, 32, 64, 100, 128, 256, or more antennas. In some embodiments, components of system **300** are modular such that the number of antennas may be increased by adding additional components.

[0094] In some embodiments, a software library is provided with system **300** and is configured with example test scenarios for configuring system **300**. In some embodiments, a graphical programming language such as LabVIEW is used to configure programmable hardware devices in system **300**. Thus, various functionality described herein may be configured using a graphical programming interface.

[0095] Exemplary high-level system parameters, according to some embodiments, include a system bandwidth of 20 MHz, a carrier frequency of 3.7 GHz, a sampling rate of 30.72 MS/s, and FFT size of 2048, 1200 used subcarriers, a 0.5 ms slot time, a 1 ms subframe time, a 10 ms frame time, and 100 antennas. These parameters are exemplary only and are not intended to limit the scope of the present disclosure. In some embodiments, the parameters are user configurable and/or are dynamically configurable by the system itself.

[0096] In the illustrated embodiment, bandwidth splitter **320** is configured to separate and provide bandwidth portions of the incoming signals from multiple antennas in order to distribute processing load. In other embodiments, the incoming signals maybe split in other dimensions in addition to and/or in place of the frequency dimension. Processing for downlink signals may be similarly distributed. Thus, in various embodiments, the disclosed system is highly configurable and provides high-performance distributed processing to meet real-time performance requirements for massive MIMO systems.

Exemplary Software Defined Radios

[0097] FIG. **4** shows one embodiment of a software radio peripheral **400**. The National Instruments® Universal Software Radio Peripheral (USRP) is one exemplary embodiment of a software radio peripheral **400**. In some embodiments, a software radio peripheral **400** is configured to implement one or more of TX/RXs **302** and one or more of antenna combiner **310**, bandwidth splitter **320**, channel estimator **330**, MIMO detector **340**, MIMO precoder **345**, bandwidth combiner **325**, and antenna splitter **315** of FIG. **3**. In some embodiments, multiple software radio peripherals **400** are coupled via one or more interconnects to implement a massive MIMO base station.

[0098] Software radio peripheral **400**, in the illustrated embodiment, includes radio frequency transceivers RF0 **412**A and RF1 **412**B, ADCs **414**A-B, DACs **416**A-B, memory **420**, field-programmable gate array (FPGA) **430**, timing and clock distribution unit **440**, and GPS-disciplined clock **435**.

[0099] RF transceivers RF0 **412**A and RF1 **412**B, in the illustrated embodiment, are configured to send and receive transmissions to one or more mobile devices **106** via one or more antennas. In one embodiment, each transceiver is configured to utilize up to 40 MHz of radio frequency bandwidth at center frequencies of 1.2-6 GHz and is configured to transmit with up to 15 decibel-milliwatts (dBm).

[0100] ADCs **414**A-B and DACs **416**A-B may be configured similarly to A/D **212**A-N and D/A **234**A-N as described above with reference to FIG. **2**. In some embodiments, these elements are respectively configured to convert received analog data to digital form and received digital information to analog form for wireless transmission.

[0101] FPGA **430**, in some embodiments, is a programmable hardware element configured to and/or configurable to perform various radio processing functionality. In some embodiments, FPGA **430** is configured to perform various MIMO processing described above with reference to FIG. **3**. For example, FPGA **430** may be configured to perform one or more of OFDM front-end processing (e.g., as discussed with reference to units **214**, **216**, **218**, **220**, **222**, **224**, **226**, **228**, **230**, and **232** of FIG. **2**), antenna combining, bandwidth splitting, MIMO detection, channel estimation, MIMO precoding, bandwidth combining, antenna splitting, etc. In the illustrated embodiment, FPGA **430** is coupled to ADCs **414**A-B and DACs **416**A-B, a digital I/O port, and a Peripheral Component Interconnect Express (PCIe) connection. In some embodiments, software radio peripheral **400** is coupled to other software radio peripherals and/or a central control unit via PCIe (or any of various other appropriate couplings).

[0102] With reference to various operations disclosed herein, a program may described as capable of causing or configuring a computing system to perform various operations. This encompasses both instructions that are executable by the computing system to cause the system to perform the operation(s) and instructions that are usable to configure the computing system (e.g., by configuring FPGA **430**) such that it is capable of performing the operation(s) (note that the latter type of instructions may not be executed, but may be used to configure programmable circuitry, for example, which is then configured to perform the operation(s)).

[0103] In other embodiments, FPGA **430** may be replaced or supplemented with any of various appropriate processing elements. Inclusion of a programmable hardware element in software radio peripheral **400** in some embodiments, however, may increase configurability and flexibility of the system. In test systems, for example, test engineers may modify the configuration of FPGA **430** to develop and test different MIMO software radio processing techniques. In production systems, programmable hardware elements may facilitate system reconfiguration and/or updates in various contexts.

[0104] Memory **420**, in some embodiments, is configured to facilitate programming of FPGA **430** and/or storing of values (e.g., sampled and processed uplink signals) during processing operations by FPGA **430**. Memory **420** may include multiple different storage elements or a single storage element and may be implemented using various different memory technologies as appropriate.

[0105] Timing and clock distribution unit **440**, in the illustrated embodiment, is configured to receive information from GPS-disciplined clock **435**, a reference signal input "ref in," and/or a trigger input signal. In the illustrated embodiment, unit **440** is also configured to provide a reference output signal "ref out" and a trigger output signal. In some embodiments, described in further detail below with reference to FIGS. **7-10**, one or more of these signals may be used to synchronize sampling and/or other operations by multiple software radio peripherals.

[0106] GPS-disciplined clock **435**, in the illustrated embodiment, is configured to receive global positioning system (GPS) signals and generate a clock signal for timing and clock distribution unit **440** that is disciplined to a GPS time. GPS is provided as one example of a reference clock, but in other embodiments, any of various appropriate reference clocks may be used, including clocks generated by satellite navigation systems other than GPS, etc. In some embodiments, the reference signal input may be configured to receive a reference clock signal and the GPS-disciplined clock **435** is omitted, disabled, or ignored.

[0107] Software radio peripheral **400** is provided as one example of a hardware module configured or configurable to implement a portion of the functionality of system **300**. In other embodiments, other processing elements such as a central processing unit or a non-FPGA programmable hardware element in addition to or in place of an FPGA may be used to perform similar operations. Further, although unit **400** is referred to as a "software" radio peripheral **400** in disclosed embodiments, it may also be a hardwired radio peripheral

configured to perform similar functionality. In some embodiments, software radio peripheral **400** is a plug-in module or card configured to be inserted into a chassis (such as a PCIe chassis for example) for communication with other modules. In other embodiments, processing elements configured to perform similar functionality may be integrated or coupled into a massive MIMO system using other techniques.

[0108] Software radio peripheral **400** is provided as one example of a hardware module configured to implement functionality of system **300**. In other embodiments, other processing elements such as processors or other programmable hardware elements in addition to or in place of an FPGA may be used to perform similar operations. Further, although unit **400** is referred to as a "software" radio peripheral **400** in disclosed embodiments, it may also be a hardwired radio peripheral configured to perform similar functionality. In some embodiments, software radio peripheral **400** is a plug-in module or card configured to be inserted into a chassis (such as a PCIe chassis for example) for communication with other modules. In other embodiments, processing elements configured to perform similar functionality may be integrated or coupled into a massive MIMO system using other techniques.

Exemplary System Interfaces

[0109] In some embodiments, the disclosed massive MIMO system performs within practical hardware I/O limits while providing a low-latency path for time-critical processing. In some embodiments, the critical signal path is from receipt of OFDM symbols through channel estimation, MIMO precoding, and OFDM transmission. This path may be especially important for reciprocity-based MIMO. In some embodiments, this path includes RX front-end delay, CP removal, FFT, guard subcarrier removal, channel estimation, precoder calculation, guard subcarrier interleave, IFFT, CP addition, and TX front-end delay. Additional sources of latency may include overhead in data routing, packing, unpacking, and hops across the PCIe backplane. In disclosed embodiments this latency is reduced by using efficient routing mechanisms over a high speed communication bus (such as PCIe, for example). Further, a high degree of pipelining (which may be enabled by packing data antennas-first) and the disclosed combining data from multiple antennas and then splitting it based on bandwidth before distributing the data for processing, as shown in FIG. **3**, allows the number of antennas and the overall system bandwidth to be scaled upwards almost indefinitely. Pipelining, in various embodiments, may allow different sets of data (e.g., data sampled from the antennas at different times) to reside in different processing stages. For example, one FPGA may perform bandwidth splitting, then pass the data on to another FPGA for MIMO detection before splitting a subsequent set of data, in a pipelined fashion. Referring back to FIG. **3**, various units may be configured to operate in a pipelined and distributed manner.

[0110] FIG. **5** shows one embodiment of a system **500** that includes hardware configured to implement a massive MIMO base station. In the illustrated embodiment, system **500** includes clock module(s) **510**, chassis **520**A-N, SRPs **400**A-Q, and central controller **530**.

[0111] Clock module(s) **510** are configured to distribute clock and/or trigger signals, in some embodiments, e.g., to the reference and/or trigger terminals of each SRP. An exemplary clock/trigger distribution system is described below with reference to FIG. **7**.

[0112] In one embodiment, each SRP **400** is included in or coupled to a chassis **520** and is configured to handle up to 800 MB/s bidirectional via a PCI eXtensions for Instrumentation Express (PXIe) backplane. In other embodiments, any of various appropriate backplane protocols may be implemented.

[0113] Chassis **520**, in the illustrated embodiment, are configured to include or couple to multiple SRPs **400** via PCIe connections. In some embodiments, each chassis **520** includes one or more switches configured to route communications. In one embodiment, each chassis **520** includes two switches. Each switch may be configured to stream up to 3.2 GB/s of bidirectional traffic for each slot in the chassis, with a total of 12 GB/s shared between devices on the switch, for example. In the illustrated embodiment, the chassis **520** are coupled via a PCIe daisy chain connection. In some embodiments, daisy chain connections in a star configurations may be used to build higher channel-count systems. In one embodiment, the daisy-chain cables between chassis are configured to stream up to 5.6 GB/s unidirectional or 2.8 GB/s bidirectional. In other embodiments, any of various appropriate communications protocols may be implemented. The bandwidths discussed above are exemplary only, and are not intended to limit the scope of the present disclosure. They illustrate, however, that the disclosed distributed processing results in a scalable system configured to operate within bandwidth constraints of various components.

[0114] Central controller **530**, in some embodiments, is configured to implement the functionality of link quality evaluator **350** and data source **360**. In some embodiments, central controller **530** provides a user interface for radio configuration, deployment of FPGA configuration code, system visualization etc. In some embodiments, central controller **530** is configured to source and sink user data, e.g., with other networks with as the Internet. In some embodiments, central controller **350** is configured to measure link quality using metrics such as bit error rate (BER), packet error rate (PER), and/or error vector magnitude (EVM), for example.

[0115] In one embodiment, five types of FPGA images are used to configure the SRPs **400** of system **500**. In this embodiment, the first type is OFDM TX/RX only, used to implement one or more front-end TX/RXs **302**. In some embodiments, this type may be allocated among available processing elements after allocation of the four other types. In this embodiment, the second type is OFDM TX/RX with antenna combiner and bandwidth splitter. In some embodiments, this type is spread evenly across chassis segments, e.g., with one per PXI switch segment. In one embodiments, each FPGA of this type is associated, at least initially, with sixteen antennas. In these embodiments, the third type is OFDM TX/RX with MIMO detector. In some embodiments, the MIMO detector may output channel estimates and/or LLR outputs. In these embodiments, the fourth type is OFDM TX/RX with MIMO precoder, which may output precoded data bits. In these embodiments, the fifth type is OFDM TX/RX with bandwidth combiner and antenna splitter, which may distributed similarly to the second type, as discussed above. In other embodiments, processing may be distributed among various types of processing elements (e.g., in addition to and/or in place of FPGAs) using any of various appropriate distributions.

[0116] FIG. **6** shows a flow diagram illustrating one exemplary embodiment of a method **600** for massive MIMO processing. The method shown in FIG. **6** may be used in conjunction with any of the computer systems, devices, elements,

or components disclosed herein, among other devices. In various embodiments, some of the method elements shown may be performed concurrently, in a different order than shown, or may be omitted. Additional method elements may also be performed as desired. Flow begins at **610**.

[0117] At **610**, wireless signals are received via a plurality of antennas. For example, the illustrated subsystem of FIG. **3** may receive wireless signals via the 2N antennas coupled to TX/RXs **302**A-N. In some embodiments the signals are OFDM signals, but in other embodiments, other modulation schemes may be implemented.

[0118] At **620**, the received signals are combined. In some embodiments, antenna combiner **310** is configured to combine the signals. The signals combined may be from all antennas in a given massive MIMO system or for a portion of the antennas in a massive MIMO system (e.g., for the subsystem shown in FIG. **3** or for a portion thereof). The combined signals may include information from multiple different users.

[0119] At **630**, different portions of the combined signals are provided to different processing elements. In some embodiments, the different portions are mutually exclusive (e.g., the information provided to a given processing element is not provided to other processing elements). In other embodiments, there may be some overlap between the information provided to the different processing elements. In some embodiments, bandwidth splitter **320** is configured to provide frequency portions of the combined signals to different software radio peripherals **400**. In some embodiments, one or more processing elements are configured to split the combined signals into different time slices and provide the time slices to different software radio peripherals **400**. In some embodiments, the combined signals are split in both the time and frequency dimension to further distribute processing.

[0120] At **640**, signals are transmitted via the plurality of antennas. In the illustrated embodiment, the signals are generated based on processing of the portions of the combined signals by the plurality of processing elements. For example, the processing may generate channel information used to precode the transmitted signals for massive MIMO communications. The distributed nature of the processing may allow system **300** to operate in real time and provide reciprocity-based precoding before the channel changes significantly.

[0121] In some embodiments, each processing element is configured to operate on a different frequency portion of signals received by multiple antennas. In some embodiments, each processing element is configured to operate on a different time portions of signal received by multiple antennas. In some embodiments, the number of processing elements in the subset is dynamically configurable based on current communication conditions. In some embodiments, the operating includes detecting one or more uplink pilot symbols and generated channel information based on the pilot symbols. In some embodiments, similar techniques are used for distributed processing for precoding downlink data then combining the different portions for transmission via multiple antennas.

[0122] Further, the disclosed techniques may facilitate dynamic configurability of the massive MIMO base station. For example, if elements of system **300** are malfunctioning or otherwise unavailable, system **300** is configured, in some embodiments, to alter the set of software radio peripherals assigned to a given set of antennas to route around the unavailable elements. In some embodiments, the number of processing elements assigned to a given set of antennas at a given time is also configurable. For example, the size of the bandwidth and/or time portions processed by each processing element is also configurable, in some embodiments. Further, the number of antennas used for a given user device may also be dynamically configurable. Various dynamic configuration may be performed by system **300** in response to current operations conditions, e.g., power conditions, the state of the wireless communication environment, number of user devices in communication, etc.

Exemplary Synchronization System

[0123] FIG. **7** shows a block diagram illustrating one embodiment of a clock and trigger distribution system **700**. In the illustrated embodiment, system **700** includes clock modules **710**A-N which are configured to provide clock and trigger signals to SRPs **400**A-N. In the illustrated embodiment the SRPs **400** include a master SRP **400**A and multiple slave SRPs **400**B-N. In some embodiments, low skew buffering circuitry and matched-length transmission cables are used to reduce skew between the reference clock inputs and trigger inputs at each SRP. In some embodiments of system **700**, reference clock skew is less than 100 picoseconds and trigger skew is less than 1.5 nanoseconds.

[0124] Clock modules **710**, in the illustrated embodiment, are arranged in a hierarchical tree structure with clock module **710**A at the root. Each clock module **710**, in the illustrated embodiment, is configured to receive or generate a clock signal and a trigger signal and provide the clock signal and the trigger signal to multiple other elements. This configuration may allow the system **700** to be scaled to synchronize massive MIMO systems with various numbers of SRPs **400**. Although two levels are shown in the illustrated embodiments, in other embodiments, the hierarchical structure may include greater or smaller numbers of levels of clock modules (e.g., 1, 3, 4, etc.).

[0125] Master SRP **400**A, in the illustrated embodiment, may trigger a sample (e.g., of uplink data) by asserting the trigger line to clock module **710**A. The trigger may propagate through clock modules **710**A to each SRP **400**, which may perform various operations such as sampling based on the trigger. In the illustrated embodiment, the master device also receives the trigger. In the illustrated embodiment, the master device is an SRP, but in other embodiments the master device may be any appropriate processing element such as the central controller **530**, etc.

[0126] FIGS. **8**A-**9** illustrate exemplary timing diagrams for synchronizing an event across multiple devices according to some embodiments. FIG. **8**A shows the reference clock **810** and a sampling clock **820** of one of the SRPs. In the illustrated example, a fixed relationship has been established with a reference clock **810**. In the illustrated example, sampling clock **820** has been phase locked to the reference clock **810**. As shown, the reference clock has a lower frequency than the sampling clock. In the illustrated embodiment, sampling clock **820** is also disciplined to a particular frequency (a particular number of edges per reference clock edge). In some embodiments, timing and clock distribution unit **440** includes a phase-locked loop and/or other circuitry configured to discipline an internal sampling clock to a reference clock. In some embodiments, reference clock **810** is provided to the "ref in" input of each SRP **400**.

[0127] FIG. **8**B-**8**C show alignment of common periodic time reference (CPTR) signals across multiple devices. In some embodiments, each SRP **400** is configured to generate

an internal CPTR and slave SRPs **400**B-**400**N are configured to align their CPTRs (e.g., to the CPTR of master SRP **400**A or to some other point). Assuming that each device has locked its sampling clock to the same reference clock, alignment of the CPTRs may ensure that the CPTRs occur at the same sampling clock edge across all devices. In some embodiments, the CPTR is a 10 MHz signal. In the illustrated embodiment, the CPTR is high for one sample clock cycle and then low for the remainder of its period. In other embodiments, any of various appropriate waveforms may be used for CPTRs. In some embodiments, the CPTR period is configurable. In various embodiments, the CPTR period is configured to be longer than propagation delay in a synchronization system such as system **700**.

[0128] In some embodiments, to synchronize the CPTRs to the same sampling clock edge, a finer granularity clock is needed than the sampling clock **820**. In some embodiments, one or more of SRPs **400** are configured to utilize a clock signal at twice the frequency of sampling clock **820** and double data rate (DDR) flip flop circuitry to determine how many edges of sampling clock **820** to move each device's CPTR in order to align the CPTRs to the same sampling clock edge. In some embodiments, a start pulse is sent to each device and each device is configured to measure the difference between receipt of the start pulse and its CPTR. In some embodiments, this information is sent to central controller **530** or one of the SRPs **400**, which is configured to determine how far each CPTR should be moved for alignment. This information is then sent back to the respective SRPs and used to move their respective CPTRs. As shown in FIGS. **8**B-**8**C, two devices A and B with CPTRs **830** and **840** occurring at different times are aligned in FIG. **8**C, in this example by moving the CPTR of device A two sampling clock edges.

[0129] FIG. **9**A shows an exemplary use of CPTRs to synchronize an event. In the illustrated embodiment, devices A and B have disciplined their sampling clocks based on a reference clock and aligned their CPTRs. A trigger signal **950** is received (e.g., at the master device) and transmitted to the synchronization system (e.g., to clock module **710**A and throughout the tree) on the next CPTR edge (CPTR **970**). Based on the trigger, each device is configured to perform an operation (e.g., a sampling operation) on the subsequent CPTR **980** (illustrated by the synchronized trigger **960**). In some embodiments, the triggering device is configured to record the delay between receiving the trigger and transmitting the trigger signal and/or the delay between receiving the trigger and the synchronized trigger. In some embodiments, the latter delay is between one and two CPTR periods. In embodiments in which the CPTR is longer than the propagation delay, this may ensure that all the synchronized devices can perform the event on the same sampling clock edge, even in systems in which the devices would not have received the trigger signal **950** on the same sampling clock edge. Said another way, slowing down the rate at which triggers are evaluated (using the CPTR, which is slower than the sampling clocks), repeatability is improved at the expense of some trigger latency. The illustrated synchronization may be performed across multiple processing elements, e.g., multiple SRPs or FPGAs.

[0130] Although FIG. **7** shows a hierarchical structure, the disclosed techniques may be implemented in various different synchronization network topologies. FIG. **9**B shows an exemplary star network in which the master SRP **400**A is configured to transmit trigger signals to each slave (and to itself in some embodiments). Speaking generally, system **700** is one example of a star network with a hierarchical set of clock modules **710** used to transmit the triggers to the slave SRPs **400**B-N. FIG. **9**C shows an exemplary bus topology in which the master SRP **400**A is configured to transmit trigger signals to each slave (and to itself in some embodiments) via a bus. FIG. **9**D shows an exemplary ring topology in which a trigger from the master SRP **400**A is forwarded along a ring of slave SRPs **400**B-N (e.g., via the trigger out ports shown in FIG. **4**). In some embodiments, the reference clock signal is also distributed via the ring topology. In still other embodiments, various other network topologies such as daisy chain couplings may be implemented.

[0131] In some embodiments, similar techniques are used for time-based synchronization. For example, each SRP **400** may be configured to maintain a local time and to reset or update the local time based on a trigger signal from a master device. In some embodiments, a pulse-per-second (PPS) signal is transmitted to each SRP **400** and a command is issued to each radio to set a common time on the next edge of the PPS signal, to establish a common time. The shared time may be set to an arbitrary time or a reference time, e.g., a coordinated universal time (UTC) queried from a GPS. Using time-based synchronization, commands may be issued to the SRPs **400** to perform future actions at a particular time. In some applications, trigger-based synchronization may be preferable to time-based synchronization, e.g., because of greater calibration time for time-based synchronization and latency in loading a future event, which may render immediate triggering events difficult to accomplish.

[0132] FIG. **10** shows a flow diagram illustrating one exemplary embodiment of a method **1000** for synchronization of radio circuitry. The method shown in FIG. **10** may be used in conjunction with any of the computer systems, devices, elements, or components disclosed herein, among other devices. In various embodiments, some of the method elements shown may be performed concurrently, in a different order than shown, or may be omitted. Additional method elements may also be performed as desired. Flow begins at **1010**.

[0133] At **1010**, a fixed relationship is established between a reference clock and slave radios' respective local clocks. The fixed relationship may be a frequency and/or phase relationship. In some embodiments, the reference clock is at a lower frequency than the local clocks. In some embodiments the reference clock is transmitted via a clock and trigger distribution network. In some embodiments the clock and trigger distribution network is a hierarchical tree.

[0134] At **1020**, a master device and the slave radios generate and align respective common periodic time reference signals (CPTRs) that have a lower frequency than the respective local clocks. In some embodiments, the master device is also a radio and is configured or specified as a master device rather than a slave device. In some embodiments, assignment of one of the radios to be the master device is configurable by a user and/or by the system (e.g., based on current operating conditions). In some embodiments, each device is configured to measure a number of local clock edges (or a number of edges of a derivation of the local clock, e.g., a 2× or greater clock) from a start signal and provide the measured information to central controller **530** and/or to the master device. In some embodiments, the master device is configured to instruct each device how many clock cycles to move its respective CPTR to achieve alignment.

[0135] At **1030** the master device transmits, based on an edge of its common periodic time reference signal, a trigger signal. In this embodiment, rather than immediately forwarding a received or determined trigger, the master device is configured to wait until its next CPTR edge to send the trigger. This may ensure that all devices can trigger on the same CPTR edge, e.g., by giving a full CPTR period for the trigger signal from the master to propagate. Otherwise, if the master were to send a trigger signal just before a CPTR edge, different slave devices might receive the signal in different CPTR periods, e.g., based on slightly different propagation delays, etc. In some embodiments, the master device transmits the trigger signal via the clock and trigger distribution network.

[0136] At **1040**, the slave radios perform an action based on the trigger at a subsequent edge (subsequent to the edge on which the master device sends the trigger signal) of their respective CPTRs. In this embodiment, because the CPTRs are aligned, the action is synchronized. In some embodiments, the action is a sampling action for signals in a massive MIMO base station.

[0137] In some embodiments, the master device is configured to receive or generate a trigger indication and wait until the edge of its CPTR to transmit the trigger signal. In some embodiments, the action is a sampling action. In some embodiments, the fixed relationship includes discipline to a particular frequency and/or a phase lock. In some embodiments, the reference clock has a lower frequency than the local clocks. In some embodiments, a period of the CPTRs is configured to be greater than a propagation delay of the clock and trigger distribution system.

Exemplary Frame Structures

[0138] In some embodiments, the disclosed system is configured to utilize conventional signaling (e.g., 3GPP LTE signaling). In other embodiments, the LTE frame structure is modified or a different frame structure is used to improve massive MIMO processing, especially in the reciprocity-based systems.

[0139] FIG. **11** shows an exemplary LTE time division duplexing (TDD) frame. In the illustrated embodiment, the frame covers ten milliseconds (ms) in the time dimension and includes ten subframes, each covering one ms. In the illustrated embodiment, each subframe is used either for downlink (DL) data, as a guard subframe, or for uplink (UL) data. LTE TDD defines several frame configurations, two of which are shown in FIG. **11**. The guard frames may include pilot time slots such as DwPTS and UpPTS.

[0140] In some embodiments, the LTE frame structure is problematic for reciprocity-based MIMO. Generally, to allow for reciprocity-based MIMO the following events must occur within the coherence time of the channel: process received samples, measure uplink channels, and precode downlink samples. In some embodiments, the turnaround time between receiving an uplink pilot symbol to transmitting a downlink symbol is specified to be less than 0.5 ms to ensure that it is less than the coherence-time, even for UEs that are moving relatively quickly. As shown in FIG. **11**, this is not typically achieved using a typical LTE TDD frame, because a full 1 ms subframe is dedicated to UL or DL data.

[0141] FIG. **12** shows an exemplary data frame according to some embodiments. In the illustrated embodiment, each frame covers ten ms and includes ten subframes which each cover one ms in the time dimension. In contrast to the LTE frame of FIG. **10**, however, in the illustrated embodiment each subframe (and each slot) includes both uplink and downlink data, as well as a switch guard symbol. In the illustrated embodiment, each slot (corresponding to half of a subframe) includes 7 OFDM symbols, one of which is used for an uplink pilot symbol, two of which are used for uplink data, two of which are used for downlink data, and two of which are used as guard symbols for switching between uplink and downlink. In the illustrated embodiment, the uplink pilot symbol and switch guard periods each consist of a single OFDM symbol.

[0142] In some embodiments, uplink pilot symbols are sequentially interleaved in the frequency dimension for users in the system. For example, each user's pilot data may be distributed across multiple separate subcarrier chunks. In some embodiments, pre-coded pilot information is also inserted into DL OFDM symbols to allow for compensation of RF chain responses.

[0143] In some embodiments, each frame starts with a down-link broadcasting subframe to set up initial network synchronization (e.g., for mobile devices **106** to synchronize carrier and/or sampling frequency with the base station). In some embodiments, the remaining nine subframes are used for UL and DL data transmission.

[0144] In various embodiments, different frame sizes, subframe sizes, number of OFDM symbols per slot, etc. may be implemented. In various embodiments, the turnaround time between receiving an uplink pilot symbol and transmitting the last downlink data that is encoded based on the uplink pilot symbol is less than 0.5 ms. In some embodiments, the turnaround time between receiving an uplink pilot symbol and transmitting the last downlink data that is encoded based on the uplink pilot symbol is less than the coherence time of the channel, which may vary over time, e.g., based on movement of source or receiver.

[0145] As used herein, the "coherence time" of a channel quantifies the similarity of the channel response at different times and refers to a time interval over which the impulse response to the channel is considered to be not varying. Coherence time is inversely proportional to doppler spread and is often estimated using the equation 0.423 times the maximum doppler frequency (e.g., as determined based on movement of the source and/or receiver). For example, the maximum doppler frequency of a transmitter moving directly towards a receiver is the frequency of the carrier wave times the velocity of movement divided by the speed of light.

[0146] Thus, in some embodiments, frame structures with short turnaround between uplink pilot receipt and downlink data transmission allow reciprocity to be used reliably even for fast-moving mobile devices **106**. As discussed above, the distributed processing techniques disclosed herein may provide a short critical path for signals and processing needed to meet such a short turnaround time.

[0147] Further, the disclosed time dimension duplexing (TDD) techniques may be advantageous relative to frequency division duplexing (FDD) techniques because FDD systems may run out of unique pilot tones for a receiver to effectively resolve channel conditions, given the large number of antennas.

[0148] FIG. **13** shows a flow diagram illustrating one exemplary embodiment of a method **1300** for synchronization of radio circuitry. The method shown in FIG. **13** may be used in conjunction with any of the computer systems, devices, elements, or components disclosed herein, among other devices. In various embodiments, some of the method elements shown

may be performed concurrently, in a different order than shown, or may be omitted. Additional method elements may also be performed as desired. Flow begins at **1310**.

[0149] At **1310** an uplink pilot symbol is received from a mobile device over a first channel. In some embodiments pilot symbols are allocated to users in an interleaved manner. In some embodiments the first channel is a wireless channel.

[0150] At **1320** uplink data is received from the mobile device over the first channel. In this embodiment, the uplink data is included in one or more orthogonal frequency-division multiplexing (OFDM) symbols.

[0151] At **1330** channel information is determined based on the pilot symbol. In some embodiments, MIMO detector **340**, channel estimator **330**, and/or link quality evaluator **350** are configured to determine this information within a single OFDM symbol, allowing greater time to performing downlink processing. In some embodiments, pilot information in a given OFDM symbol is processed by multiple MIMO detectors and/or channel estimators **330** in system **340**. Thus, in some embodiments, pilot information for a given user is processed by multiple different processing elements.

[0152] At **1340** downlink data is precoded based on the channel information. In some embodiments, multiple MIMO precoders **345** are configured to perform this encoding and transmit their frequency portions to a bandwidth combiner **325**.

[0153] At **1350** the precoded downlink data is transmitted to the mobile device. This transmission may be performed within the coherence time for a receiving device, allowing reciprocity-based precoding even for fast-moving devices. Further, it may allow precoding to be performed in the massive MIMO context with large numbers of antennas and user devices.

[0154] In some embodiments, a guard period between reception of the uplink data and transmission of the downlink data is only one OFDM symbol. In some embodiments, the transition time is less than one millisecond, which may be advantageous relative to the slower turnaround time for LTE TDD frames. In some embodiments, an interval between receiving the uplink pilot symbol and transmitting a final symbol of the precoded downlink data (the last symbol precoded based on the particular uplink pilot symbol), is less than a coherence time of the first channel. In some embodiments, the short turnaround time is achieved by separately decoding and/or precoding different time and/or frequency portions of uplink and/or downlink data and/or pilots (e.g., as discussed above with reference to FIG. **3**). In some embodiments, base station **102** is configured to transmit a signaling schedule that specifies transmission intervals for the uplink pilot symbol, the uplink data, and the downlink data. User device may then communicate with base station **102** based on the signaling schedule. In some embodiments, base station **102** is configured to determine the channel information based on the pilot symbol within a time interval corresponding to a single OFDM symbol at the symbol rate.

[0155] In various embodiments, the disclosed massive MIMO system may have the following attributes: flexible software defined radios (SDRs) for acquiring and transmitting radio frequency (RF) signals, accurate time and frequency synchronization across the radio heads, high-throughput deterministic bus for moving and aggregating large amounts of data, and high-performance processing to meet real-time performance requirements. The system may also be quickly customized for a wide variety of operating conditions and/or research needs.

[0156] Although specific embodiments have been described above, these embodiments are not intended to limit the scope of the present disclosure, even where only a single embodiment is described with respect to a particular feature. Examples of features provided in the disclosure are intended to be illustrative rather than restrictive unless stated otherwise. The above description is intended to cover such alternatives, modifications, and equivalents as would be apparent to a person skilled in the art having the benefit of this disclosure.

[0157] The scope of the present disclosure includes any feature or combination of features disclosed herein (either explicitly or implicitly), or any generalization thereof, whether or not it mitigates any or all of the problems addressed herein. Accordingly, new claims may be formulated during prosecution of this application (or an application claiming priority thereto) to any such combination of features. In particular, with reference to the appended claims, features from dependent claims may be combined with those of the independent claims and features from respective independent claims may be combined in any appropriate manner and not merely in the specific combinations enumerated in the appended claims.

What is claimed is:

1. An apparatus, comprising:

a plurality of antennas;

a plurality of radios configured to perform wireless communication with one or more mobile devices; and

one or more processing elements coupled to the plurality of radios;

wherein the apparatus is configured to:

receive an uplink pilot symbol from a mobile device over a first channel;

receive uplink data from the mobile device over the first channel, wherein the uplink data is included in one or more orthogonal frequency division multiplexing (OFDM) symbols at a symbol rate;

determine channel information based on the pilot symbol;

precode downlink data based on the channel information; and

transmit, via one or more of the plurality of antennas, the precoded downlink data to the mobile device;

wherein a transition interval between receiving the uplink pilot symbol and beginning to transmit the precoded downlink data corresponds to less than five OFDM symbols at the symbol rate.

2. The apparatus of claim **1**, wherein a guard period between reception of the uplink data and transmission of the downlink data is one OFDM symbol.

3. The apparatus of claim **1**, wherein the transition time interval is less than 1 millisecond.

4. The apparatus of claim **1**, wherein an interval between receiving the uplink pilot symbol and transmitting a final symbol of the precoded downlink data is less than a coherence time of the first channel.

5. The apparatus of claim **1**, wherein the base station is configured to separately precode different frequency portions of the downlink data using different processing elements.

6. The apparatus of claim 1, wherein the base station is configured to separately determine channel information for different frequency portions of the pilot symbol, using different processing elements.

7. The apparatus of claim 1, wherein the base station is configured to transmit a signaling schedule to the mobile device that specifies scheduled transmission intervals for the uplink pilot symbol, the uplink data, and the downlink data.

8. The apparatus of claim 1, wherein the apparatus is configured to determine the channel information based on the pilot symbol within a time interval corresponding to a single OFDM symbol at the symbol rate.

9. A method, comprising:

receiving an uplink pilot symbol from a mobile device over a first channel;

receiving uplink data from the mobile device over the first channel, wherein the uplink data is included in one or more orthogonal frequency division multiplexing (OFDM) symbols at a symbol rate;

determining channel information based on the pilot symbol;

precoding downlink data based on the channel information; and

transmitting, via one or more of the plurality of antennas, the precoded downlink data to the mobile device;

wherein a transition interval between receiving the uplink pilot symbol and beginning to transmit the precoded downlink data corresponds to less than five OFDM symbols at the symbol rate.

10. The method of claim 9, wherein a guard period between receiving the uplink data and transmitting the downlink data is one OFDM symbol.

11. The method of claim 9, wherein the transition time interval is less than 1 millisecond.

12. The method of claim 9, further comprising:

transmitting a signaling schedule to the mobile device that specifies scheduled transmission intervals for the uplink pilot symbol, the uplink data, and the downlink data.

13. The method of claim 9, wherein the determining is performed within a time interval corresponding to a single OFDM symbol at the symbol rate.

14. The method of claim 9, wherein the pilot symbol includes interleaved pilot information for multiple mobile devices.

15. A user equipment device (UE), comprising:

a plurality of antennas;

one or more radios configured to perform wireless communications using the plurality of antennas; and

one or more processing elements coupled to the one or more radios;

wherein the UE is configured to:

transmit an uplink pilot symbol to a base station over a first channel, wherein the uplink pilot symbol is usable by the base station to determine channel quality information for subsequent downlink transmissions to the mobile device;

transmit uplink data to the base station over the first channel using one or more orthogonal frequency division multiplexing (OFDM) symbols at a particular symbol rate; and

receive subsequent downlink transmissions from the base station over the first channel, wherein the downlink transmission are precoded based on channel quality information determined based on the uplink pilot symbol;

wherein a transition time interval between transmitting the uplink pilot symbol and beginning to receive the downlink transmissions corresponds to less than five OFDM symbols at the symbol rate.

16. The UE of claim 15, wherein a time interval from transmission of the uplink pilot symbol to reception of the downlink data is less than a half millisecond.

17. The UE of claim 15, wherein a time interval between transmission of the uplink pilot symbol over the first channel and reception of a last portion of the subsequent downlink data that is precoded based on the uplink pilot symbol is less than a coherence time of the first channel.

18. The UE of claim 15, wherein the UE is configured to transmit the uplink pilot symbol, transmit the uplink data, and receive the downlink transmission based on a signaling schedule received from the base station.

19. The UE of claim 15, wherein the UE is configured to transmit at least five uplink pilot symbols per ten millisecond interval during communication with the base station.

20. The UE of claim 15, wherein a guard interval between transmitting the uplink data and beginning to receive the downlink transmissions corresponds to at most one OFDM symbol.

* * * * *

PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	18/089,999	Filing Date	2022-12-28	Docket Number (if applicable)	ZL0205-0005-US-CON2	Art Unit	2472
First Named Inventor	Xiaobo ZHANG			Examiner Name	DEEPA BELUR		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the orde in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

☐ Other _____

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☒ Amendment/Reply

☒ Information Disclosure Statement (IDS)

☐ Affidavit(s)/ Declaration(s)

☐ Other _____

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☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____
(Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

☒ The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 602313

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

☐ Applicant Signature

PTO/SB/30EFS (07-09)
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Signature	/Jialin Zhong/	Date (YYYY-MM-DD)	2024-09-25
Name	Jialin Zhong	Registration Number	62937

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is t file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Tim will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions fo reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

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

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

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

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

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

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

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

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(Not for submission under 37 CFR 1.99)

Application Number	18089999
Filing Date	2022-12-28
First Named Inventor	Xiaobo ZHANG
Art Unit	2472
Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

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	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

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CERTIFICATION STATEMENT

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

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

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☐ See attached certification statement.

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

☐ A certification statement is not submitted herewith.

SIGNATURE

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

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2024-09-25
Name/Print	JIALIN ZHONG	Registration Number	62937

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Examiner Name	DEEPA BELUR
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	18089999
	Filing Date	2022-12-28
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2472
	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	1	3GPP TS 36.304 version 14.0.0 release 14, 3rd Generation Partnership Project (3GPP), dated October 3, 2016	☒
	2	3GPP TS 36.304 version 9.1.0 Release 9, 3rd Generation Partnership Project (3GPP), dated February 9, 2010	☒
	3	3GPP TS 36.306 version 14.2.0 release 14, 3rd Generation Partnership Project (3GPP), dated April 11, 2017	☒
	4	3GPP TS 36.321 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated October 28, 2014	☒
	5	3GPP TS 36.321 version 12.6.0 release 12, 3rd Generation Partnership Project (3GPP), dated June 30, 2015	☒
	6	3GPP TS 36.321 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 4, 2016	☒
	7	3GPP TS 36.321 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	8	3GPP TS 36.321 version 14.3.0 release 14, Project (3GPP) ETSI publication of 3rd Generation, dated July 27, 2017	☒
	9	3GPP TS 36.331 version 12.3.0 release 12, 3rd Generation Partnership Project (3GPP), dated September 29, 2014	☒
	10	3GPP TS 36.331 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 18, 2016	☒
	11	3GPP TS 36.331 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated January 6, 2016	☒

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	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	12	3GPP TS 36.331 version 13.3.0 release 13, 3rd Generation Partnership Project (3GPP), dated October 3, 2016	☒
	13	3GPP TS 36.331 version 13.5.0 release 13, 3rd Generation Partnership Project (3GPP), dated April 11, 2017	☒
	14	3GPP TS 38.212 version 15.2.0 release 15, 3rd Generation Partnership Project (3GPP), dated June 29, 2018	☒
	15	3GPP TS 38.214 version 15.2.0 release 15, 3rd Generation Partnership Project (3GPP), dated June 29, 2018	☒
	16	3GPP TS 38.306 version 15.5.0 release 15, 3rd Generation Partnership Project (3GPP), dated April 11, 2019	☒
	17	3GPP TS 36.304 version 13.0.0 release 13, 3rd Generation Partnership Project (3GPP), dated February 2, 2016	☒
	18	3GPP TS 36.331 version 12.8.0 release 12, 3rd Generation Partnership Project (3GPP), dated January 4, 2016	☒
	19	4G LTE/LTE Advanced for Mobile Broadband, Erik Dahlman, dated 2011	☒
	20	4G LTE/LTE Advanced for Mobile Broadband, Erik Dahlman, dated 2014	☒
	21	1st 5G Algorithm Innovation Competition - Filtered-OFDM, Terasic Inc., dated 2015	☒
	22	A Comparison of Symbol-wise and Self-contained Frame Structure for 5G Services, Mohamed Ibrahim, dated 2016	☒

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	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	23	Accurate Determination of Transport Block Size for 5G New Radio, Hao Wu, dated April 30, 2020	☒
	24	An Enhanced Multiantenna Solution through Beamforming to 3G Long-term Evolution, Ken Long, dated 2009	☒
	25	Antenna Grouping based Feedback Compression for FDD-based Massive MIMO Systems, Byungju Lee, dated July 21, 2015	☒
	26	Antenna Grouping Techniques for MIMO Beamforming Systems, Kyungchul Kim, dated 2008	☒
	27	Beam Selection Strategies for Orthogonal Random Beamforming in Sparse Networks, Jose Lopez Vicario, dated September 2008	☒
	28	Comparison Between Bit Error Rate And Signal To Noise Ratio in OFDM Using LSE Algorithm, Raghav Pandey, dated 2013	☒
	29	Delay-Prioritized Scheduling (DPS) for Real Time Traffic in 3GPP LTE System, 2010 Kumbesan Sandrasegaran, dated April 2010	☒
	30	Dynamic TDD in LTE Small Cells, Jussi Kerttula, dated 2016	☒
	31	Enabling Massive IoT in 5G and Beyond Systems: PHY Radio Frame Design Considerations, Ayesha Ijaz, dated June 24, 2016	☒
	32	Enhanced Beam Selection for Multiuser MM-Wave massissive MIMO Systems, Jiaxuan Chen, dated July 7, 2016	☒
	33	Filtered-OFDM: Foundational Waveform for Selfadaptive Air Interface, Terasic Inc., dated 2015	☒

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	Art Unit	2472
	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	34	Joint Transmitter- Receiver Beamforming Over Space-Time Fading Channels, T. Zhang, A. Manikas, dated 2007	☒
	35	LTE – The UMTS Long Term Evolution from Theory to Practice, Second Edition, Stefania Sesia, dated 2011	☒
	36	Millimeter Wave Communications for Future Mobile Networks, Ming Xiao, dated May 17, 2017	☒
	37	MIMO Beamforming for High-Bit-Rate Transmission over Frequency-Selective Fading Channels, Huy Hoang Pham, dated 2004	☒
	38	Multibeam Selection for Indoor MIMO Systems: Two Cases of Study, Luis Gurrieri, dated April 2007	☒
	39	Overview of Full- Dimension MIMO in LTE-Advanced Pro, Hyoungju Ji, dated August 10, 2016	☒
	40	Overview of Narrowband IoT in LTE Rel-13, Rapeepat Ratasuk, dated 2016	☒
	41	Novel OFDM transmission scheme to overcome caused by multipath delay longer than cyclic prefix, Chiwoo Lim, dated 2005	☒
	42	R1-130140, ZTE, dated January 28-February 1, 2013 (Meeting dates) January 19, 2013 (Publication)	☒
	43	R1-130269, LG Electronics, dated January 28-February 1, 2013 (Meeting dates) January 18, 2013 (Publication)	☒
	44	R1-144047, LG Electronics, dated October 6-10, 2014 (Meeting dates) September 27, 2014 (Publication)	☒

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	Art Unit	2472
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	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	45	R1-150779, LG Electronics, ETRI, InterDigital, Qualcomm, Sony Coorperation, dated February 9-13, 2015 (Meeting dates) February 19, 2015 (Publication)	☒
	46	R1-151365, CATT, dated April 20-24, 2015 (Meeting dates) April 11, 2015 (Publication)	☒
	47	R1-151535, LG Electronics, dated April 20-24, 2015 (Meeting date) April 11, 2015 (Publication)	☒
	48	R1-153175, Ericsson, dated May 25-29, 2015 (Meeting date) May 16, 2015 (Publication)	☒
	49	R1-154127, Samsung, dated August 24-28, 2015 (Meeting date) August 14, 2015 (Publication)	☒
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Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

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OR

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

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

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

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2024-09-25
Name/Print	JIALIN ZHONG	Registration Number	62937

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US 20130182594A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2013/0182594 A1

(43) Pub. Date: Jul. 18, 2013

KIM et al.

(54) METHOD AND APPARATUS FOR TRANSMITTING AND RECEIVING REFERENCE SIGNAL

(71) Applicant: **Samsung Electronics Co. Ltd.**, Suwon-si (KR)

(72) Inventors: **Youn-Sun KIM**, Seongnam-si (KR); **Ki-Il KIM**, Yongin-si (KR); **Ju-Ho LEE**, Suwon-si (KR); **Hyo-Jin LEE**, Suwon-si (KR); **Joon-Young CHO**, Suwon-si (KR)

(73) Assignee: **Samsung Electronics Co. Ltd.**, Suwon-si (KR)

(21) Appl. No.: **13/742,757**

(22) Filed: **Jan. 16, 2013**

(30) **Foreign Application Priority Data**

Jan. 16, 2012 (KR) 10-2012-0004666

Publication Classification

(51) **Int. Cl.**

H04W 72/04 (2006.01)

H04W 24/10 (2006.01)

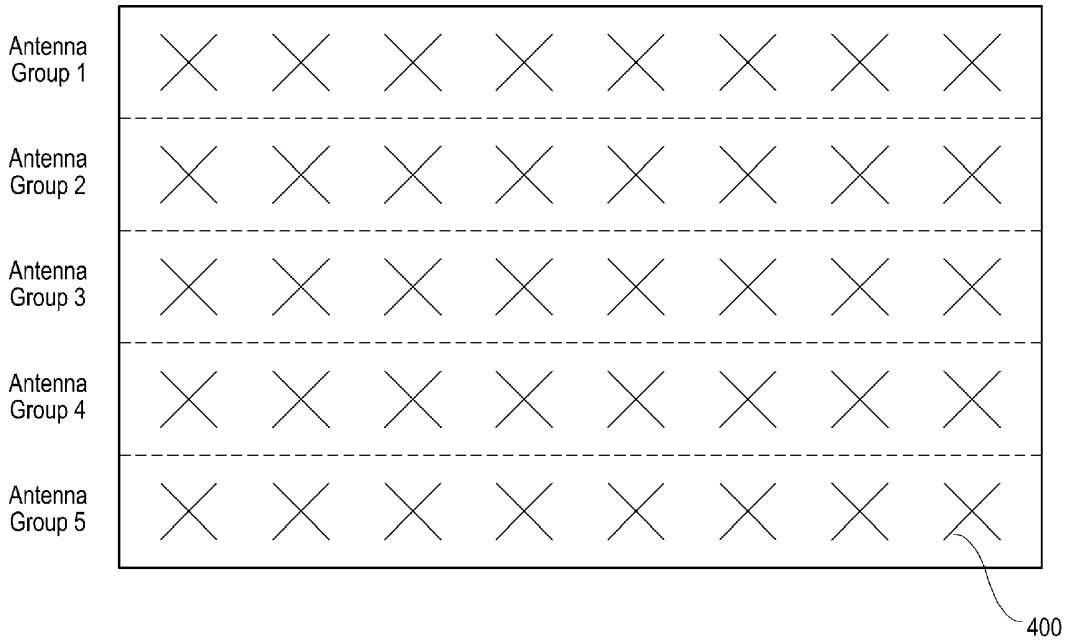
(52) **U.S. Cl.**

CPC ***H04W 72/042*** (2013.01); ***H04W 24/10*** (2013.01)

USPC **370/252**; 370/329; 370/330

(57) **ABSTRACT**

An apparatus and a method for generation of channel state information in a wireless communication system are provided. The method includes transmitting, by an evolved Node B (eNB), a first reference signal to a plurality of User Equipments (UEs), receiving channel state information generated based on the first reference signal from the plurality of UEs, selecting candidate UEs to which wireless resources are to be allocated and transmitting second reference signals to the selected candidate UEs, receiving channel state information generated based on the second reference signals from the candidate UEs, and selecting final UEs, to which wireless resources are to be allocated, from the candidate UEs based on the channel state information generated based on the second reference signals, and transmitting control information for data reception to the selected final UEs.



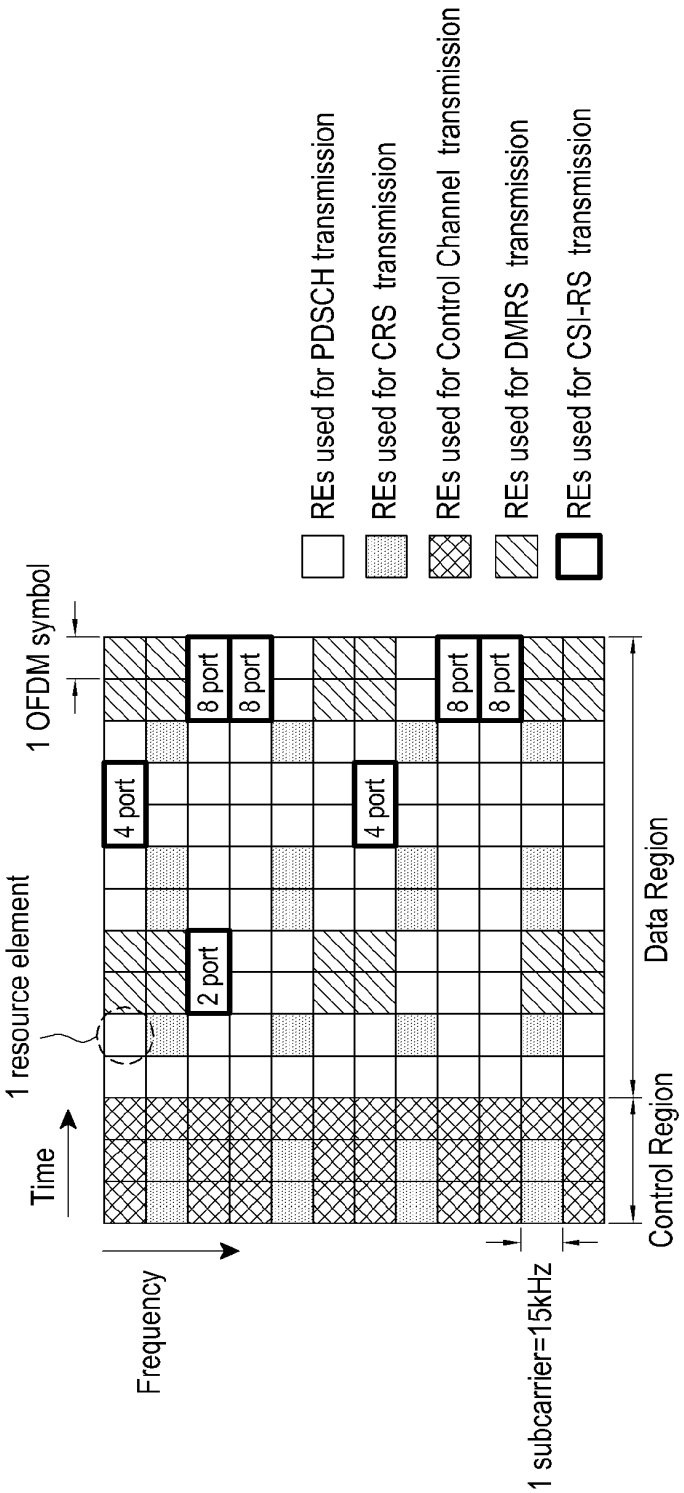


FIG.1
(RELATED ART)

520

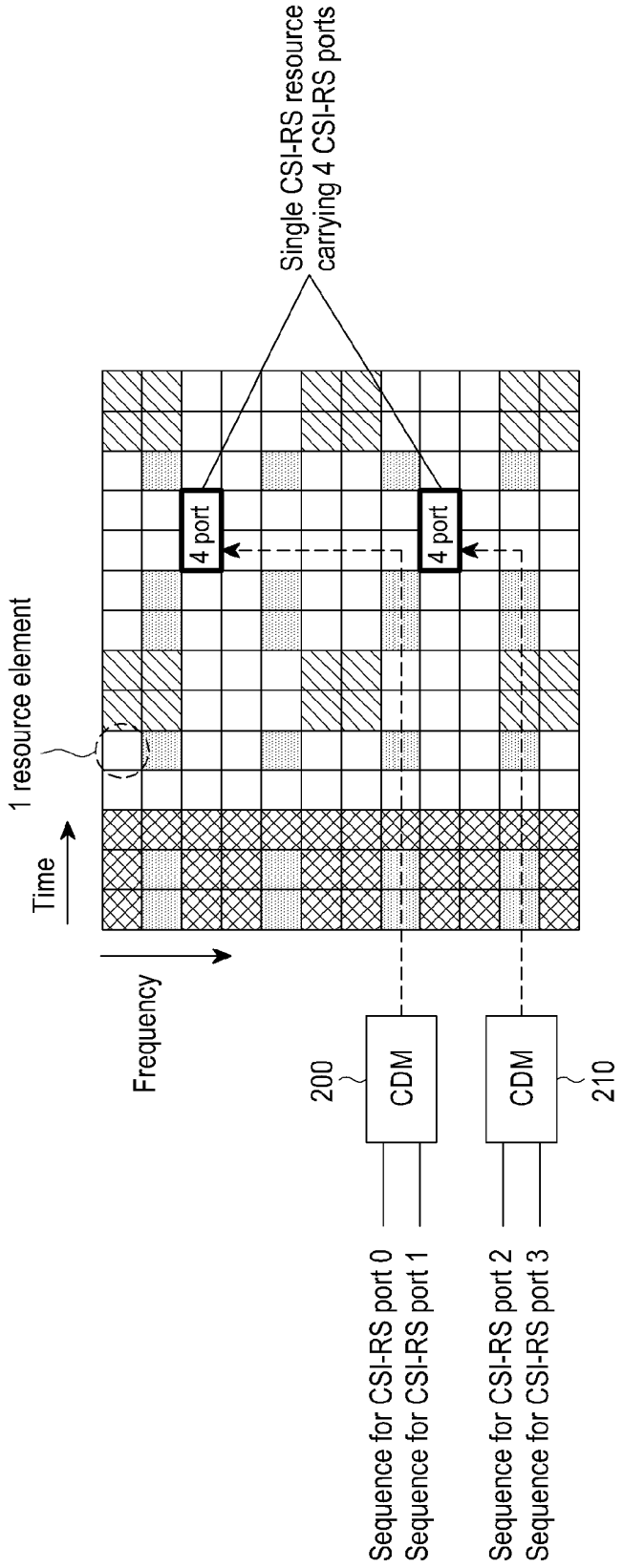


FIG.2
(RELATED ART)

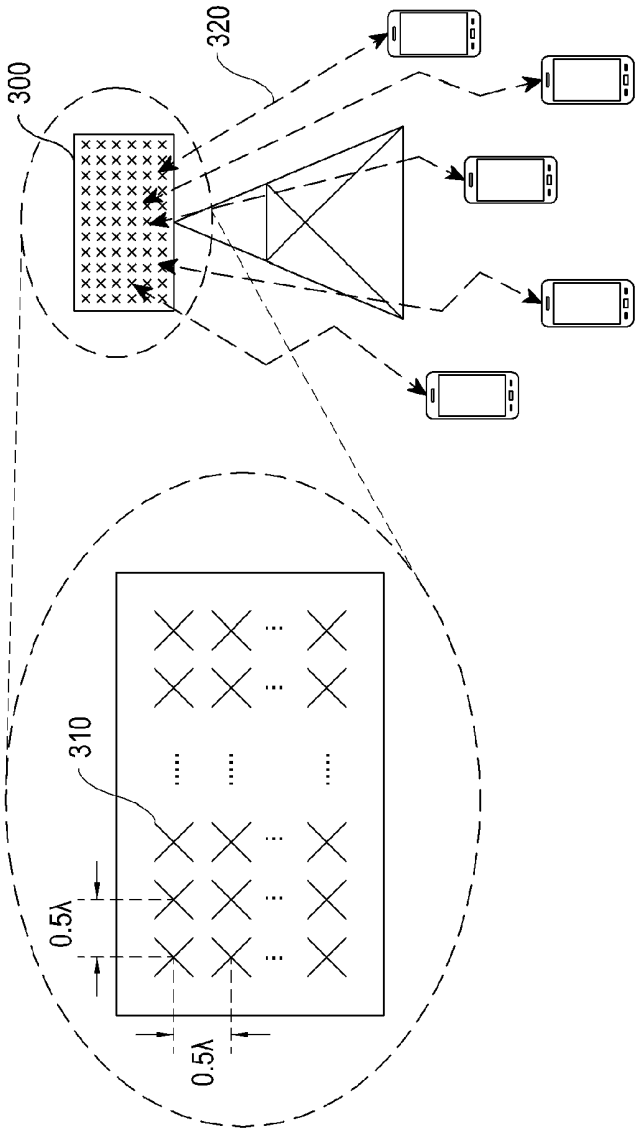


FIG.3

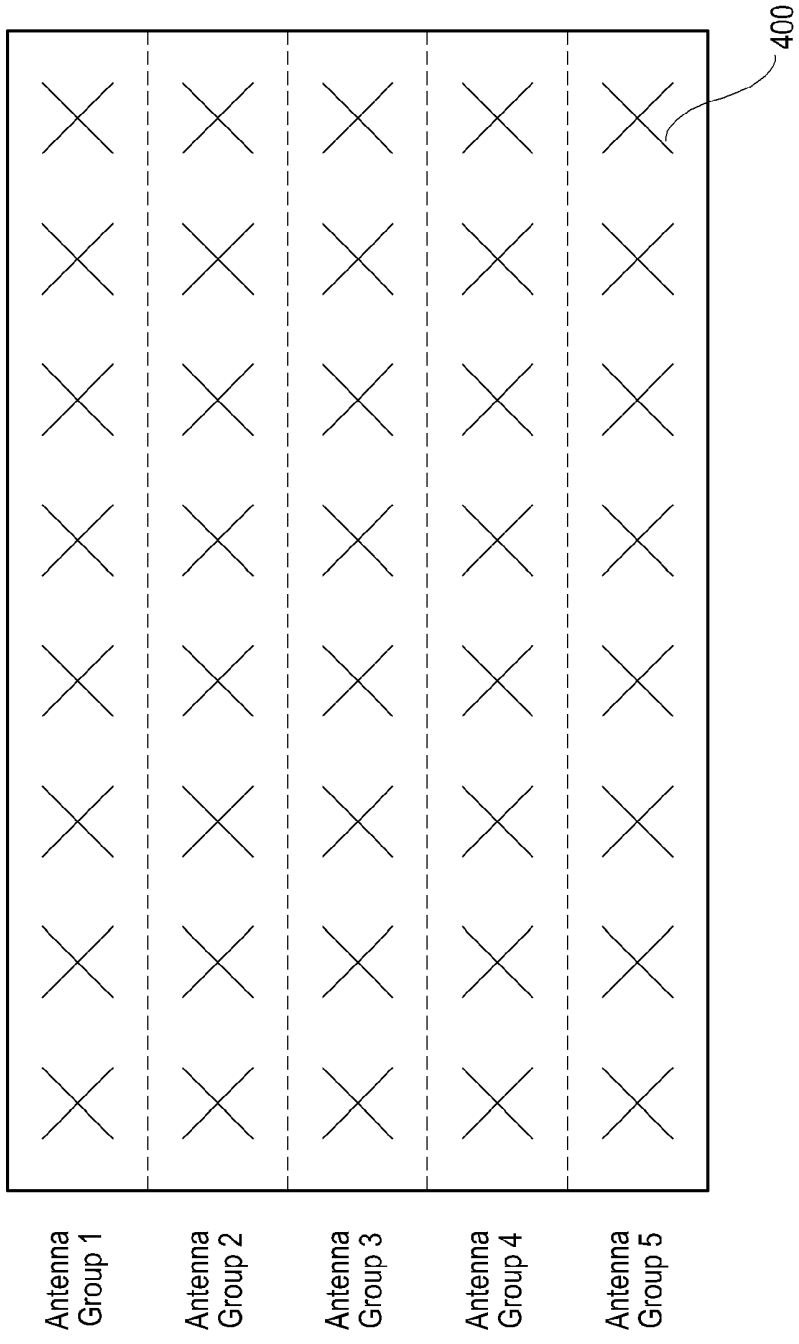

400
Antenna Group 1
Antenna Group 2
Antenna Group 3
Antenna Group 4
Antenna Group 5

FIG.4

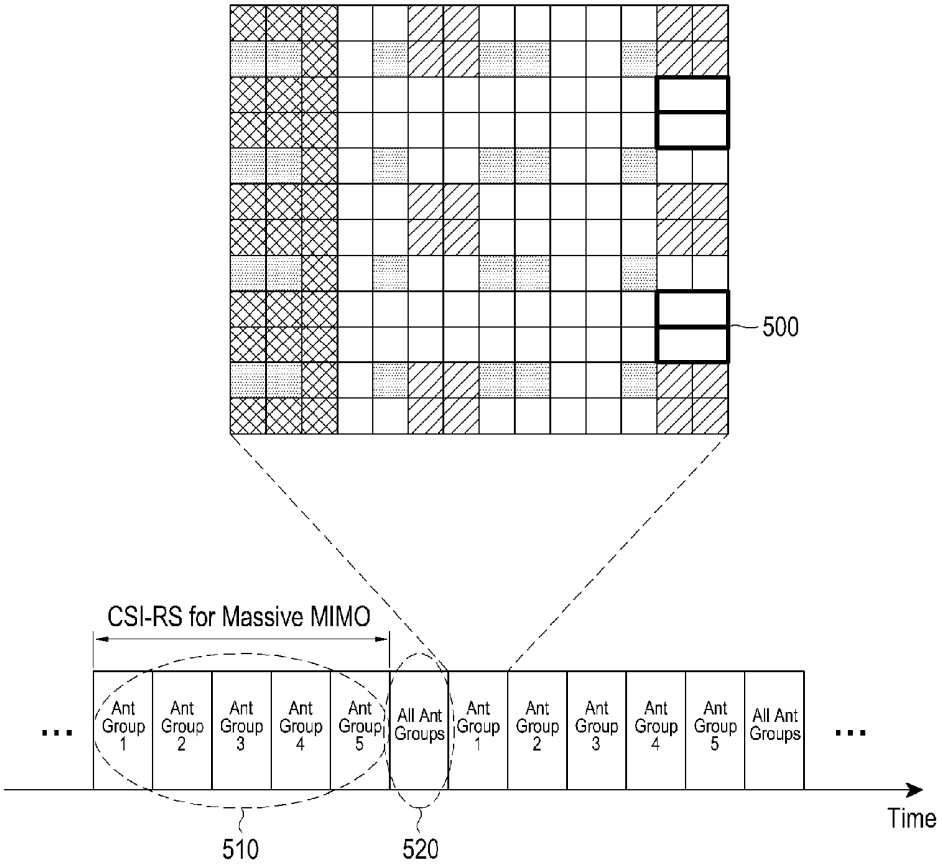

500
CSI-RS for Massive MIMO
Ant Group 1
Ant Group 2
Ant Group 3
Ant Group 4
Ant Group 5
All Ant Groups
Ant Group 1
Ant Group 2
Ant Group 3
Ant Group 4
Ant Group 5
All Ant Groups
Time
510
520

FIG.5

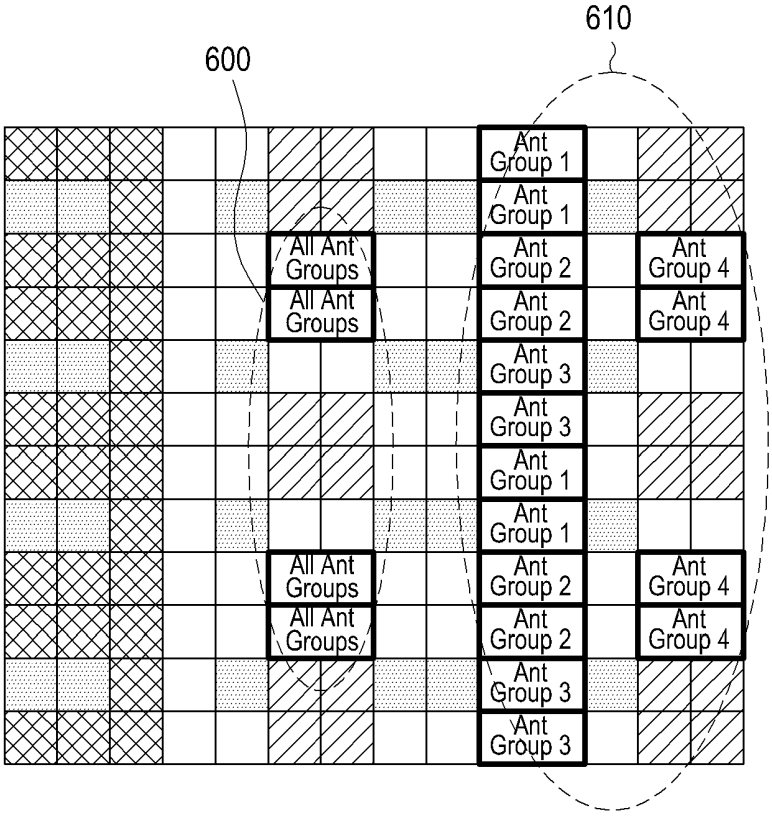

610
600
Ant Group 1
Ant Group 1
All Ant Groups
Ant Group 2
Ant Group 4
All Ant Groups
Ant Group 2
Ant Group 4
Ant Group 3
Ant Group 3
Ant Group 1
Ant Group 1
All Ant Groups
Ant Group 2
Ant Group 4
All Ant Groups
Ant Group 2
Ant Group 4
Ant Group 3
Ant Group 3

FIG.6

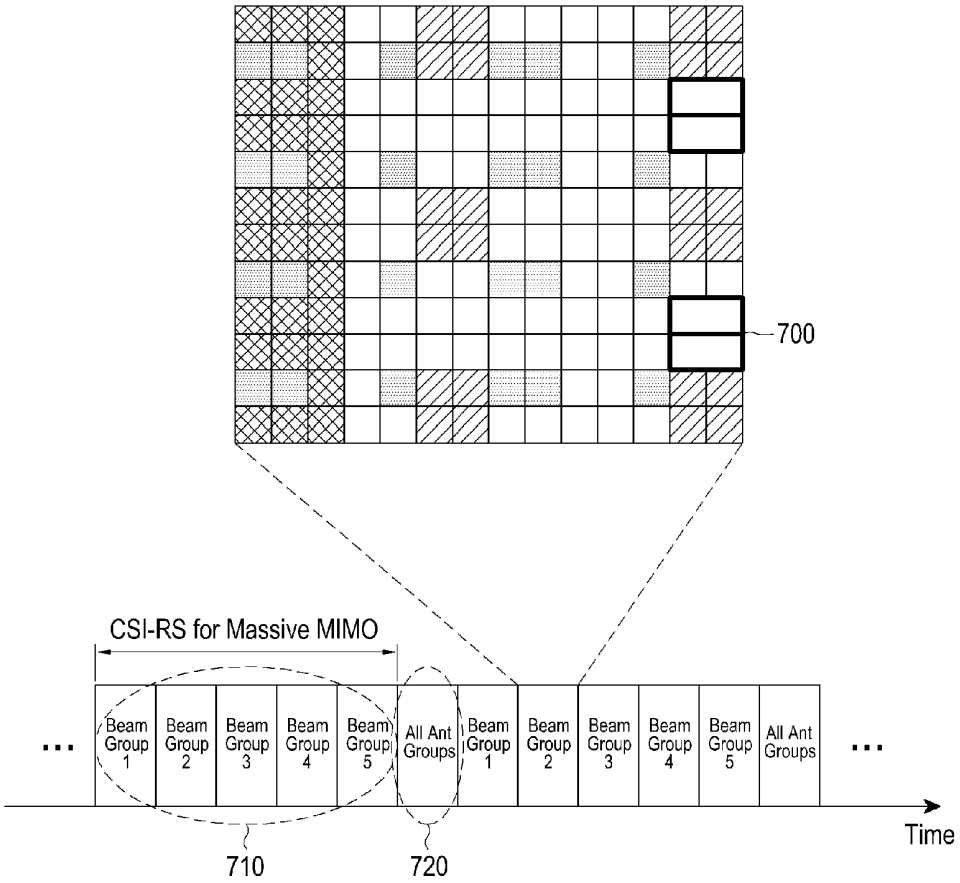

700
CSI-RS for Massive MIMO
Beam Group 1
Beam Group 2
Beam Group 3
Beam Group 4
Beam Group 5
All Ant Groups
Beam Group 1
Beam Group 2
Beam Group 3
Beam Group 4
Beam Group 5
All Ant Groups
Time
710
720

FIG.7

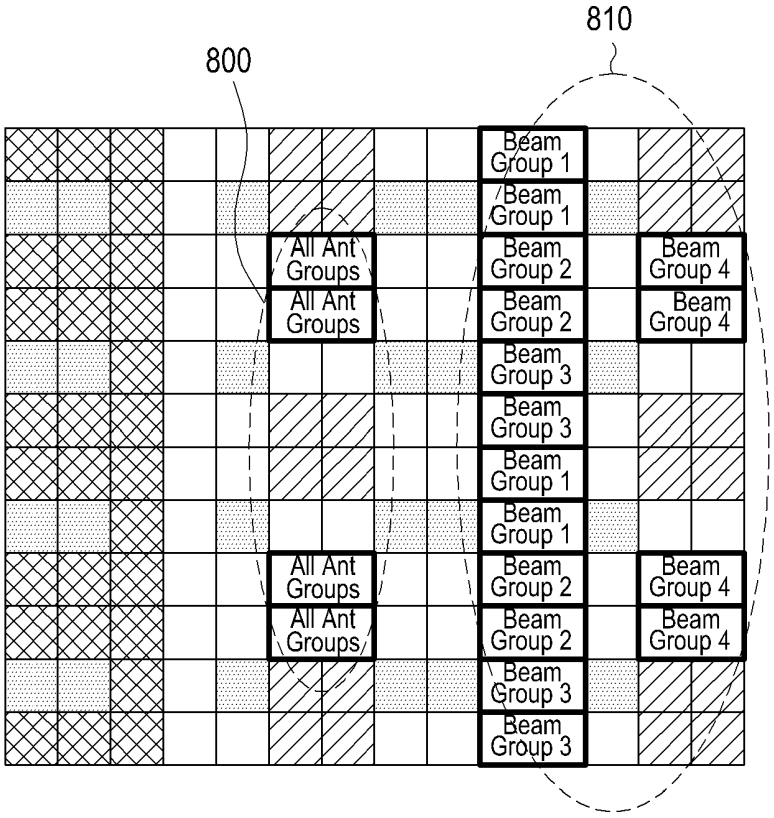

800
810
All Ant Groups
All Ant Groups
All Ant Groups
All Ant Groups
Beam Group 1
Beam Group 1
Beam Group 2
Beam Group 2
Beam Group 3
Beam Group 3
Beam Group 1
Beam Group 1
Beam Group 2
Beam Group 2
Beam Group 3
Beam Group 3
Beam Group 4
Beam Group 4
Beam Group 4
Beam Group 4

FIG.8

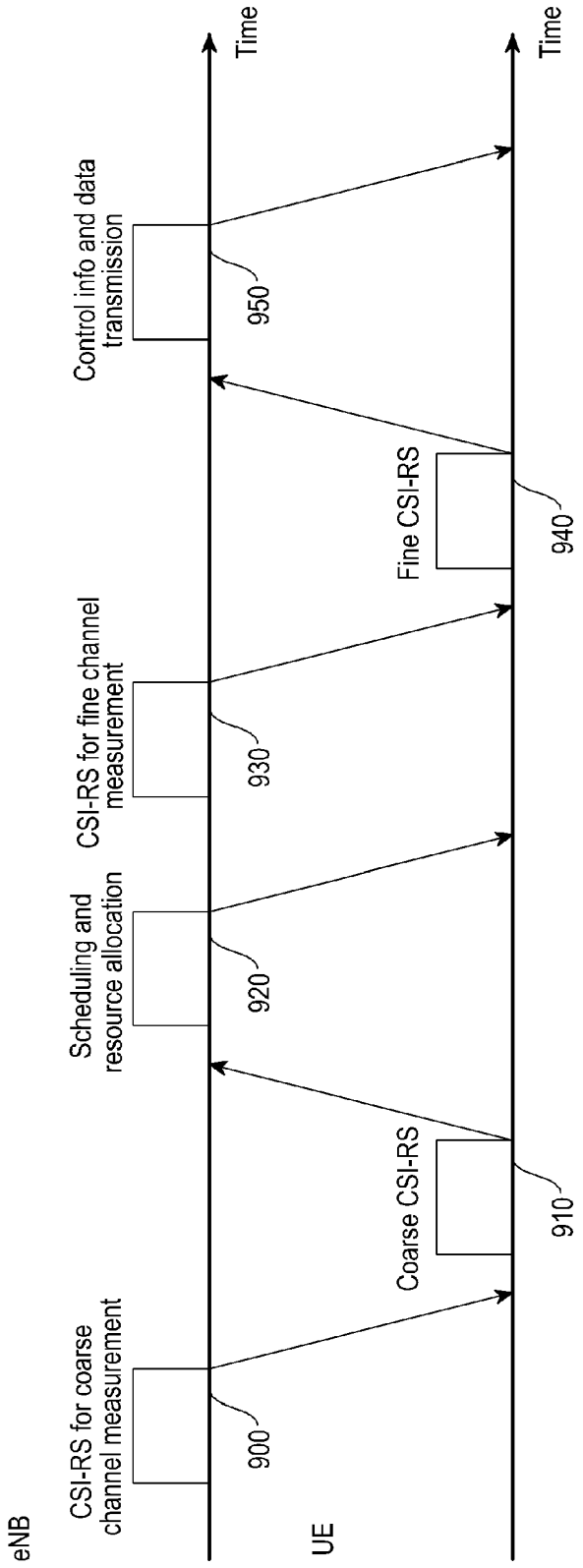

eNB
UE
Time
Time
CSI-RS for coarse channel measurement
900
Coarse CSI-RS
910
Scheduling and resource allocation
920
CSI-RS for fine channel measurement
930
Fine CSI-RS
940
Control info and data transmission
950

FIG.9

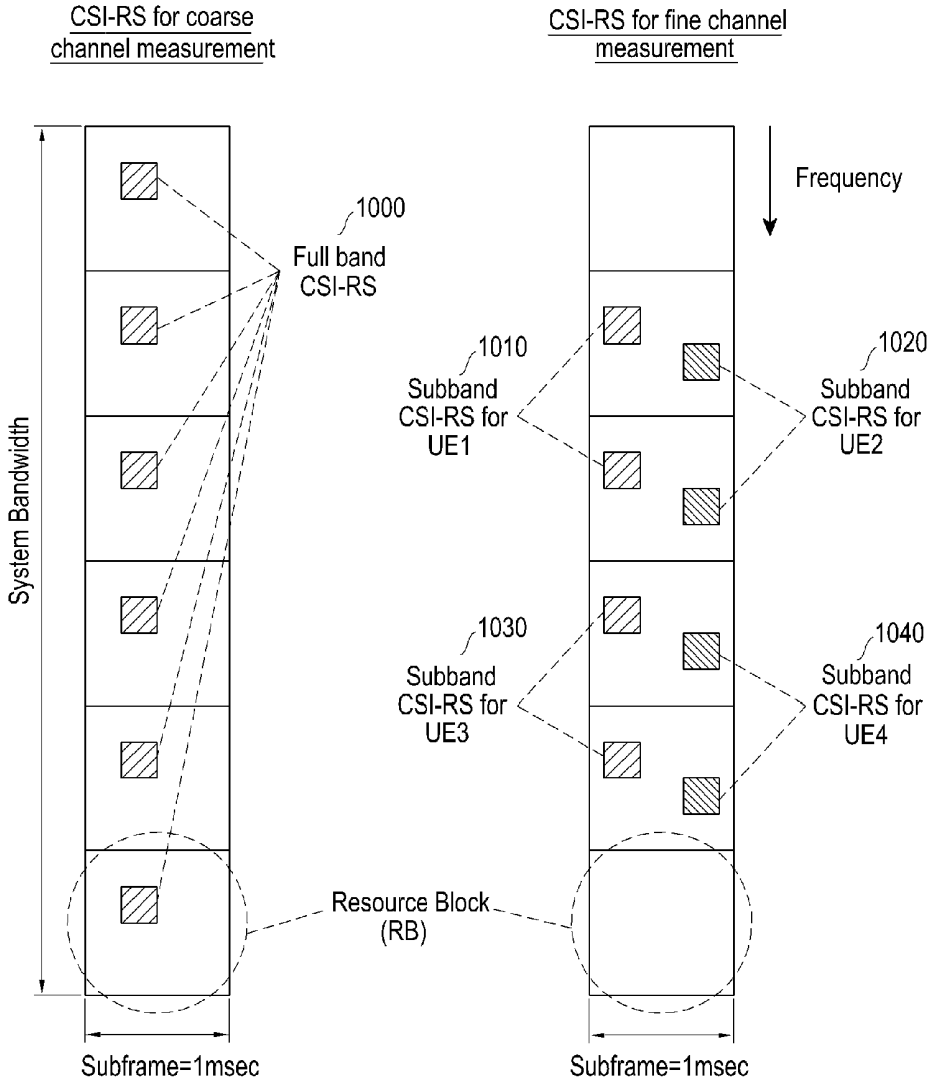

CSI-RS for coarse channel measurement
CSI-RS for fine channel measurement
Frequency
1000
Full band CSI-RS
1010
Subband CSI-RS for UE1
1020
Subband CSI-RS for UE2
1030
Subband CSI-RS for UE3
1040
Subband CSI-RS for UE4
System Bandwidth
Resource Block (RB)
Subframe=1msec
Subframe=1msec

FIG.10

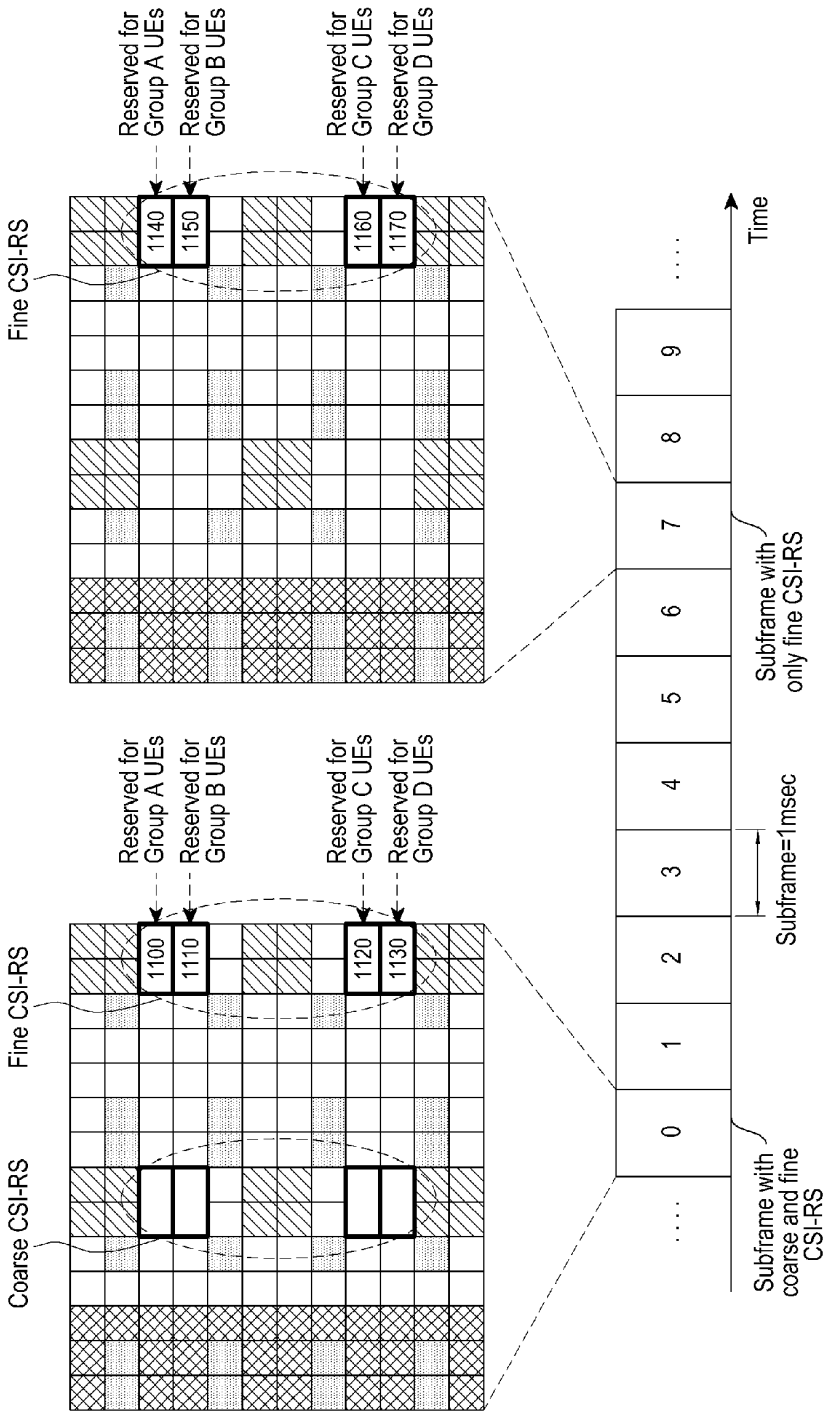

Reserved for Group A UEs
Reserved for Group B UEs
Reserved for Group C UEs
Reserved for Group D UEs
Fine CSI-RS
1140
1150
1160
1170
Coarse CSI-RS
1100
1110
1120
1130
Time
0
1
2
3
4
5
6
7
8
9
Subframe=1msec
Subframe with coarse and fine CSI-RS
Subframe with only fine CSI-RS

FIG.11

530

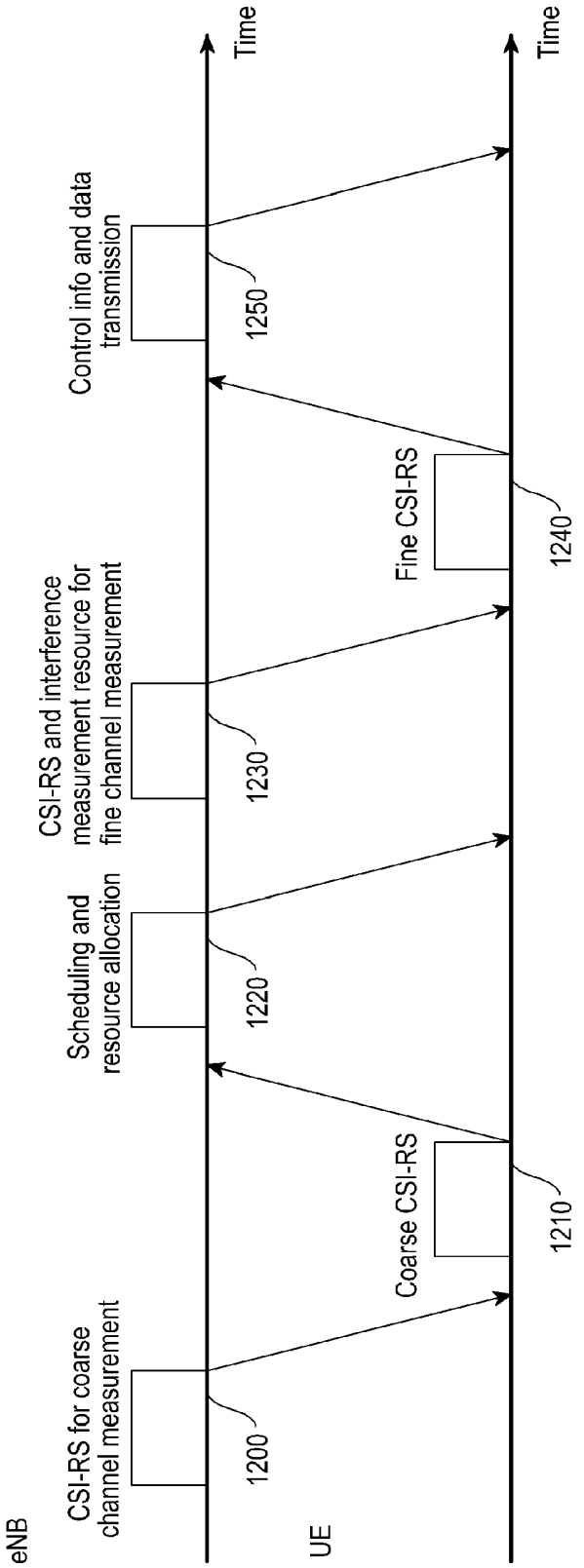

eNB
UE
Time
Time
CSI-RS for coarse channel measurement
1200
Coarse CSI-RS
1210
Scheduling and resource allocation
1220
CSI-RS and interference measurement resource for fine channel measurement
1230
Fine CSI-RS
1240
Control info and data transmission
1250

FIG.12

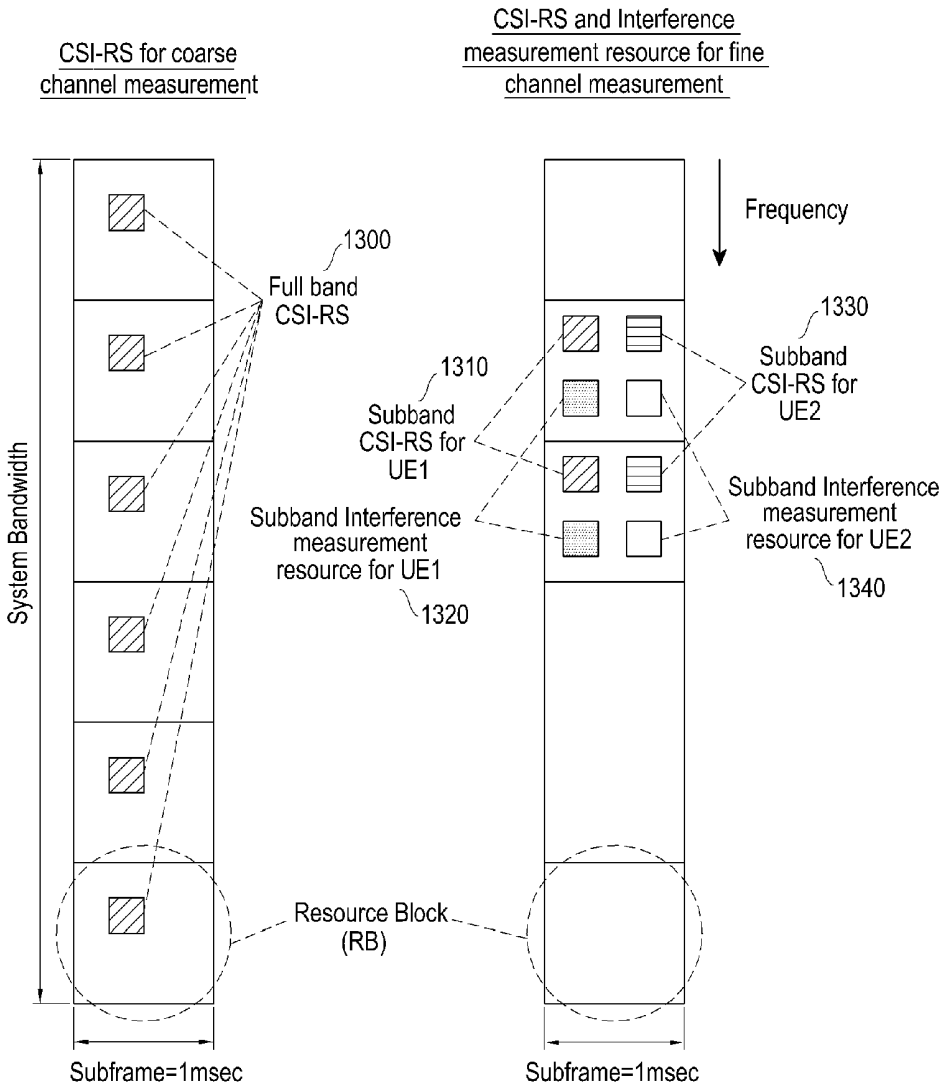

CSI-RS for coarse channel measurement
CSI-RS and Interference measurement resource for fine channel measurement
Frequency
System Bandwidth
1300
Full band CSI-RS
1310
Subband CSI-RS for UE1
1330
Subband CSI-RS for UE2
Subband Interference measurement resource for UE1
1320
Subband Interference measurement resource for UE2
1340
Resource Block (RB)
Subframe=1msec
Subframe=1msec

FIG.13

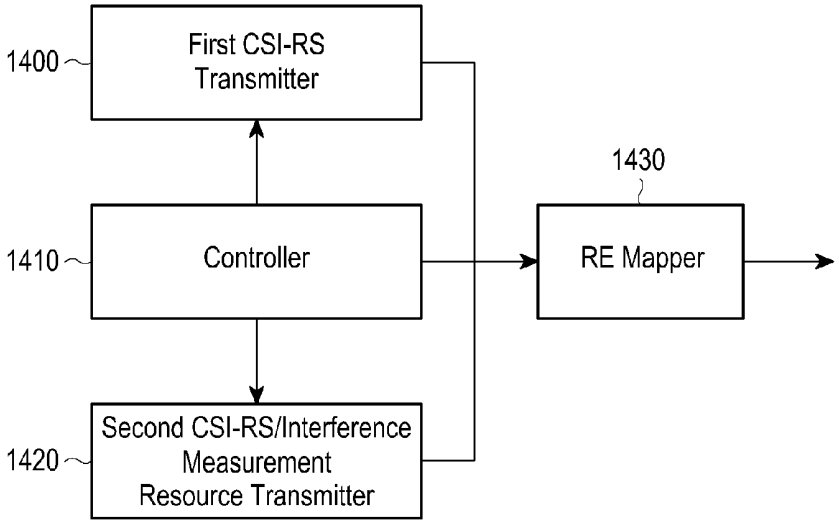

1400
First CSI-RS Transmitter
1430
1410
Controller
RE Mapper
1420
Second CSI-RS/Interference Measurement Resource Transmitter

FIG.14

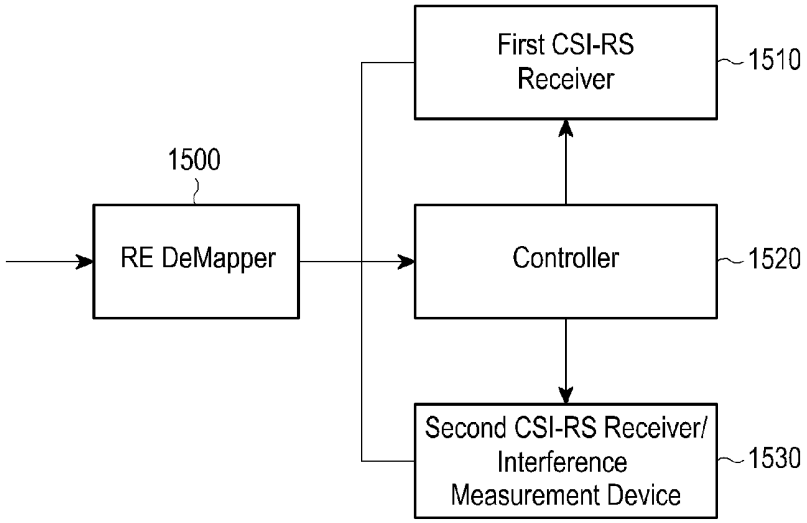

First CSI-RS Receiver
1510
1500
RE DeMapper
Controller
1520
Second CSI-RS Receiver/ Interference Measurement Device
1530

FIG.15

METHOD AND APPARATUS FOR TRANSMITTING AND RECEIVING REFERENCE SIGNAL

PRIORITY

[0001] This application claims the benefit under 35 U.S.C. §119(a) of a Korean patent application filed in the Korean Intellectual Property Office on Jan. 16, 2012 and assigned Serial No. 10-2012-0004666, the entire disclosure of which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a wireless mobile communication system. More particularly, the present invention relates to a method for effectively transmitting and receiving a Channel State Information-Reference Signal (CSI-RS) and measuring interference.

[0004] 2. Description of the Related Art

[0005] Current mobile communication systems are developing, beyond the initial level of providing voice-oriented services, into a high quality wireless packet data communication system in order to provide a data service and a multimedia service. To this end, various standardization organizations, such as the 3rd Generation Partnership Project (3GPP), the 3GPP2, and the Institute of Electrical and Electronics Engineers (IEEE), are preparing 3rd generation evolution mobile communication system standards employing multiple access schemes using multi-carriers. Recently, various mobile communication standards, including Long Term Evolution (LTE) of the 3GPP, Ultra Mobile Broadband (UMB) of the 3GPP2, and 802.16m of the IEEE, have been developed in order to support a high speed-high quality wireless packet data transmission service based on a multiple access scheme using a multi-carrier.

[0006] The current 3rd generation evolution mobile communication systems, such as LTE, UMB, and 802.16 m, are based on a multiple carrier multiple access scheme, employ multiple antennas based on a Multiple Input Multiple Output (MIMO) scheme, and use various technologies, such as beam-forming, Adaptive Modulation and Coding (AMC), channel sensitive scheduling, and the like. These technologies improve the system capacity performance by, for example, concentrating a transmission power of multiple antennas or controlling the quantity of data transmitted from the antennas according to the channel qualities and selectively transmitting data to a user having a good channel quality. These techniques are based on the channel state information between a base station or an evolved Node B (eNB) and a mobile station or a User Equipment (UE). Therefore, an eNB or a UE needs to measure the channel state between them, and a CSI-RS is used in the measurement. The eNB refers to an apparatus for downlink transmission and uplink reception, which is located at a predefined position, and one eNB performs transmission and reception with respect to cells. In one mobile communication system, a plurality of eNBs are geographically scattered and each eNB performs transmission and reception with respect to the cells.

[0007] A reference signal is a signal used for demodulation and decoding of a received data symbol by measuring channel states, such as the intensity or distortion of a channel, the intensity of interference, Gaussian noise, or the like, between an eNB and a UE. Furthermore, a receiver can determine the channel state of a wireless channel between the receiver and a transmitter by measuring an intensity of a signal received through the wireless channel, which has been transmitted with a predefined transmission power by the transmitter. The measured channel state of the wireless channel is used by the receiver to determine a data rate which the receiver will request from the transmitter.

[0008] The resources of time, frequency, and transmission power are limited in a mobile communication system. Therefore, an increase in the quantity of resources allocated to a reference signal may decrease the quantity of resources that can be allocated to transmission of traffic channels and thus may reduce the absolute quantity of transmitted data. In this case, although the performances of channel measurement and estimation may be improved, the reduced absolute quantity of transmitted data may rather decrease the performance of the entire system throughput. Therefore, in order to obtain an optimum performance in view of the entire system throughput, a proper distribution between resources for the reference signal and resources for transmission of traffic channels is necessary.

[0009] FIG. **1** illustrates transmission of various signals in a Physical Resource Block (PRB) pair in a Long Term Evolution-Advanced (LTE-A) system according to the related art.

[0010] Referring to FIG. **1**, one PRB pair includes 14 Orthogonal Frequency Division Multiplexing (OFDM) symbols along the time axis and 12 subcarriers along the frequency axis. The 14 OFDM symbols and the 12 subcarriers form 168 (=14×12) Resource Elements (REs), wherein each RE corresponds to a resource having an orthogonality with respect to a neighboring RE. In the PRB pair, a Physical Downlink Shared Channel (PDSCH) used for transmission of traffic data, a Cell-Specific Reference Signal (CRS) transmitted for each cell, a Physical Downlink Control Channel (PDCCH) used for transmission of a control signal, a Demodulation Reference Signal (DMRS) used for reception of a PDSCH, and a CSI-RS used for measuring a downlink channel state and generating channel state information are allocated different REs for transmission. The CSI-RS supported in an LTE-A system can support signals for one antenna port, 2 antenna ports, 4 antenna ports, and 8 antenna ports, and the number of REs allocated in one PRB pair are different according to the number of antenna ports of the CSI-RS as illustrated in FIG. **1**.

[0011] FIG. **2** illustrates a transmission of a CSI-RS having four antenna ports in one PRB pair in an LTE-A system according to the related art.

[0012] Referring to FIG. **2**, as indicated by reference numerals **200** and **210**, sequences for four CSI-RS antenna ports are spread by orthogonal codes, Code-Division-Multiplexed (CDM), and transmitted to four REs. The sequences for CSI-RS port **0** and CSI-RS port **1** are transmitted using the sequences for CSI-RS port **2** and CSI-RS port **3** and another RE pair. In this way, sequences for a plurality of CSI-RS antenna ports may be transmitted using a plurality of REs. In a case of an LTE-A system, since transmission to a maximum of 8 CSI-RS antenna ports is possible, an eNB can transmit CSI-RSs for a maximum of 8 transmission antennas.

[0013] In the case of an LTE-A system, transmission and reception can be performed using CSI-RSs supporting a maximum of 8 CSI-RS transmission antennas to one transmission point as described above. In a case of performing a beam forming transmission using a maximum of 8 transmis-

sion antennas, a beam forming gain of a maximum of 9 dB is obtained, so as to improve the Signal to Interference and Noise Ratio (SINR).

[0014] Therefore, a need exists for a method and an apparatus for transmitting a reference signal for effective data transmission and reception, measuring interference, and generating channel state information in a MIMO transmission and reception.

[0015] The above information is presented as background information only to assist with an understanding of the present disclosure. No determination has been made, and no assertion is made, as to whether any of the above might be applicable as prior art with regard to the present invention.

SUMMARY OF THE INVENTION

[0016] Aspects of the present invention are to address at least the above-mentioned problems and/or disadvantages and to provide at least the advantages described below. Accordingly, an aspect of the present invention is to provide a method and an apparatus for transmitting a reference signal for effective data transmission and reception, measuring interference, and generating channel state information in a Multiple Input Multiple Output (MIMO) transmission and reception.

[0017] Another aspect of the present invention is to provide an effective transmission and reception method in a MIMO system having scores or more transmission antennas.

[0018] In accordance with an aspect of the present invention, a method of transmitting a reference signal for generation of channel state information by an evolved Node B (eNB) in a wireless communication system is provided. The method includes transmitting a first reference signal to a plurality of User Equipments (UEs), receiving channel state information generated based on the first reference signal from the plurality of UEs, selecting candidate UEs to which wireless resources are to be allocated and transmitting second reference signals to the selected candidate UEs, receiving channel state information generated based on the second reference signals from the candidate UEs, and selecting final UEs, to which wireless resources are to be allocated, from the candidate UEs based on the channel state information generated based on the second reference signals, and transmitting control information for data reception to the selected final UEs.

[0019] In accordance with another aspect of the present invention, a method of receiving a reference signal for generation of channel state information by a UE in a wireless communication system is provided. The method includes receiving a first reference signal from an eNB, generating channel state information based on the first reference signal, and transmitting the generated channel state information to the eNB, receiving a second reference signal from the eNB, generating channel state information based on the second reference signal, and transmitting the generated channel state information to the eNB, and receiving control information for data reception from the eNB.

[0020] In accordance with another aspect of the present invention, an eNB apparatus for transmitting a reference signal for generation of channel state information in a wireless communication system is provided. The eNB apparatus includes a first reference signal transmitter for generating a first reference signal and for transmitting the first reference signal to a plurality of UEs, a second reference signal transmitter for receiving channel state information generated based on the first reference signal from the plurality of UEs, for selecting candidate UEs to which wireless resources are to be allocated, for generating second reference signals, and for transmitting the second reference signals to the selected candidate UEs, a controller for controlling the first reference signal transmitter and the second reference signal transmitter, for receiving channel state information generated based on the second reference signals from the candidate UEs, for selecting final UEs, to which wireless resources are to be allocated, from the candidate UEs based on the channel state information generated based on the second reference signals, and for transmitting control information for data reception to the selected final UEs, a mapper for mapping signals output from the first reference signal transmitter, the second reference signal transmitter, and the controller to wireless resources, and for transmitting the signals through the wireless resources.

[0021] In accordance with another aspect of the present invention, a UE apparatus for receiving a reference signal for generation of channel state information in a wireless communication system is provided. The UE apparatus includes a first reference signal receiver for receiving a first reference signal from an eNB and for generating channel state information based on the first reference signal, a second reference signal receiver for receiving a second reference signal from the eNB and for generating channel state information based on the second reference signal, a controller for receiving control information for data reception from the eNB and for controlling the first reference signal receiver and the second reference signal receiver, and a demapper for identifying the first reference signal, the second reference signal, and a control signal.

[0022] In accordance with another aspect of the present invention, a method of transmitting a reference signal for generation of channel state information by an eNB in a wireless communication system is provided. The method includes grouping a plurality of transmission antennas into a plurality of antenna groups, transmitting the reference signal to UEs in different time intervals or frequency intervals according to the antenna groups, and transmitting another reference signal for all of the antenna groups in an identical time interval or frequency interval.

[0023] In accordance with another aspect of the present invention, a method of transmitting a reference signal for generation of channel state information by an eNB in a wireless communication system is provided. The method includes grouping a plurality of beams transmitted through a plurality of transmission antennas into a plurality of beam groups, transmitting the reference signal to UEs in different time intervals or frequency intervals according to the beam groups, and transmitting another reference signal for all of the antenna groups in an identical time interval or frequency interval.

[0024] Other aspects, advantages, and salient features of the invention will become apparent to those skilled in the art from the following detailed description, which, taken in conjunction with the annexed drawings, discloses exemplary embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The above and other aspects, features, and advantages of certain exemplary embodiments of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings, in which:

[0026] FIG. **1** illustrates a transmission of various signals in a Physical Resource Block (PRB) pair in a Long Term Evolution-Advanced (LTE-A) system according to the related art;

[0027] FIG. **2** illustrates a transmission of a Channel State Information-Reference Signal (CSI-RS) having four antenna ports in one PRB pair in an LTE-A system according to the related art;

[0028] FIG. **3** illustrates a structure of a massive Multiple Input Multiple Output (MIMO) system according to an exemplary embodiment of the present invention;

[0029] FIG. **4** illustrates an antenna grouping according to an exemplary embodiment of the present invention;

[0030] FIG. **5** illustrates a transmission of CSI-RSs for massive MIMO according to an exemplary embodiment of the present invention;

[0031] FIG. **6** illustrates a transmission of CSI-RSs for massive MIMO by allocation of individual frequency resources according to an exemplary embodiment of the present invention;

[0032] FIG. **7** illustrates a grouping of a plurality of beams into five beam groups, wherein each beam group is transmitted in an individual time interval, according to an exemplary embodiment of the present invention;

[0033] FIG. **8** illustrates a transmission of CSI-RSs for a plurality of beams by allocating not only individual time resources but also individual frequency resources according to an exemplary embodiment of the present invention;

[0034] FIG. **9** illustrates a link adaptation method according to an exemplary embodiment of the present invention;

[0035] FIG. **10** illustrates a transmission of a first CSI-RS and a second CSI-RS in a frequency band according to an exemplary embodiment of the present invention;

[0036] FIG. **11** illustrates a transmission of first CSI-RSs and second CSI-RSs for respective subframes according to an exemplary embodiment of the present invention;

[0037] FIG. **12** illustrates a notification of an allocation-or-not of a second CSI-RS and an allocation of an interference measurement resource to a User Equipment (UE) by an evolved Node B (eNB) according to an exemplary embodiment of the present invention;

[0038] FIG. **13** illustrates an allocation of interference measurement resources in a frequency band according to an exemplary embodiment of the present invention;

[0039] FIG. **14** illustrates a transmission apparatus according to an exemplary embodiment of the present invention; and

[0040] FIG. **15** illustrates a reception apparatus according to an exemplary embodiment of the present invention.

[0041] Throughout the drawings, it should be noted that like reference numbers are used to depict the same or similar elements, features, and structures.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0042] The following description with reference to the accompanying drawings is provided to assist in a comprehensive understanding of exemplary embodiments of the invention as defined by the claims and their equivalents. It includes various specific details to assist in that understanding but these are to be regarded as merely exemplary. Accordingly, those of ordinary skill in the art will recognize that various changes and modifications of the embodiments described herein can be made without departing from the scope and spirit of the invention. In addition, descriptions of well-known functions and constructions may be omitted for clarity and conciseness.

[0043] The terms and words used in the following description and claims are not limited to the bibliographical meanings, but, are merely used by the inventor to enable a clear and consistent understanding of the invention. Accordingly, it should be apparent to those skilled in the art that the following description of exemplary embodiments of the present invention is provided for illustration purpose only and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

[0044] It is to be understood that the singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a component surface" includes reference to one or more of such surfaces.

[0045] By the term "substantially" it is meant that the recited characteristic, parameter, or value need not be achieved exactly, but that deviations or variations, including for example, tolerances, measurement error, measurement accuracy limitations and other factors known to those of skill in the art, may occur in amounts that do not preclude the effect the characteristic was intended to provide.

[0046] Furthermore, although the following detailed description of exemplary embodiments of the present invention mainly discusses an Orthogonal Frequency Division Multiplexing (OFDM) based wireless communication system, especially an Enhanced Universal Mobile Telecommunications System Terrestrial Radio Access (EUTRA) standard of the 3rd Generation Partnership Project (3GPP), the principal idea of the present invention can be applied to other communication systems having similar technical backgrounds and channel types with slight modifications without departing from the scope of the present invention.

[0047] First, an exemplary method of effective transmission and reception of a reference signal in a massive Multiple Input Multiple Output (MIMO) wireless communication system which transmits data by using scores or more transmission antennas will be described.

[0048] FIGS. **3** through **15**, discussed below, and the various exemplary embodiments used to describe the principles of the present disclosure in this patent document are by way of illustration only and should not be construed in any way that would limit the scope of the disclosure. Those skilled in the art will understand that the principles of the present disclosure may be implemented in any suitably arranged communications system. The terms used to describe various embodiments are exemplary. It should be understood that these are provided to merely aid the understanding of the description, and that their use and definitions in no way limit the scope of the invention. Terms first, second, and the like are used to differentiate between objects having the same terminology and are in no way intended to represent a chronological order, unless where explicitly stated otherwise. A set is defined as a non-empty set including at least one element.

[0049] FIG. **3** illustrates a structure of a massive MIMO system according to an exemplary embodiment of the present invention.

[0050] Referring to FIG. **3**, a base station transmitter (i.e., an evolved Node B (eNB)) **300** transmits a wireless signal through scores or more transmission antennas. The transmission antennas are arranged while maintaining a minimum distance (e.g., 0.5λ in FIG. **3**) between each other as indicated

by reference numeral **310**. For example, the minimum distance may be one-half of the wavelength of the transmitted wireless signal. In general, when a distance corresponding to one-half of a wavelength of a transmitted wireless signal is maintained between transmission antennas, the signal transmitted from each transmission antenna is influenced by a wireless channel having a low correlation. When a band of a transmitted wireless channel is 2 GHz, the minimum distance is 7.5 cm. As the band of the transmitted wireless channel becomes higher than 2 GHz, this distance becomes shorter.

[0051] Referring to FIG. **3**, the scores or more transmission antennas arranged in the eNB **300** are used in transmitting a signal to one User Equipment (UE) or a plurality of UEs as indicated by reference numeral **320**. A proper precoding scheme is applied to a plurality of transmission antennas, so as to enable simultaneous transmission to the plurality of transmission antennas. At this time, one UE can receive one or more spatial channels. In general, the number of spatial channels which one UE can receive is determined depending on the number of reception antennas owned by the UE and the channel condition. However, in the case of simultaneous transmission to a plurality of UEs as illustrated in FIG. **3**, signals transmitted to different UEs may cause interference (i.e., a multi-user MIMO interference) between them, according to the combination of precoding schemes. The multi-user MIMO interference has an influence which increases in proportion to the number of UEs simultaneously receiving a signal from an eNB, and weakens the signal receiving performance. More specifically, in a massive MIMO system as illustrated in FIG. **3**, the multi-user MIMO interference is a main factor having an influence on the performance.

[0052] Therefore, in order to effectively implement a massive MIMO system, a UE should precisely measure the channel state and the size of interference and transmit effective channel state information to an eNB by using the measured information. Upon receiving the channel state information from the UE, the eNB determines UEs to which it will make a downlink transmission, a data transmission speed for the transmission, and a precoding scheme to be applied. Since the massive MIMO system includes a large number of transmission antennas, an application of the reference signal transmission method of the related art and its measuring method used in the Long Term Evolution (LTE)/LTE-Advanced (LTE-A) system may cause performance degradation. Furthermore, the method of the related art can neither measure the multi-user MIMO interference precisely, which is caused by the simultaneous transmission to a plurality of UEs, nor reflect the interference in the channel state information.

[0053] Therefore, an exemplary embodiment of the present invention provides an effective Channel State Information-Reference Signal (CSI-RS) transmission and reception method in a massive MIMO system.

[0054] In a massive MIMO transmission and reception based on an LTE/LTE-A system, an important subject is to maintain the backward compatibility. Here, the backward compatibility refers to a function capable of transmitting or receiving a wireless signal to or from UEs of the related art having no capability of receiving a massive MIMO signal, according to a scheme of the related art other than the MIMO scheme, simultaneously while operating a massive MIMO function in an LTE/LTE-A system. For example, the backward compatibility needs a capability of simultaneously transmitting a wireless signal to both a UE supporting massive MIMO and a UE not supporting massive MIMO by using the same frequency and time resources while preventing performance degradation of the UE supporting massive MIMO during the transmission or reception of the signal transmitted to the UE not supporting massive MIMO.

[0055] In order to satisfy the conditions as described above, an exemplary embodiment of the present invention proposes a method of transmitting a CSI-RS for a massive MIMO system by using CSI-RS resources of the related art introduced in the LTE-A. The CSI-RS resources of the related art introduced in the LTE-A support a maximum of 8 transmission antennas. Therefore, in order to use the CSI-RS resources of the related art, a method capable of transmitting a signal through scores or more transmission antennas is needed. In order to transmit a CSI-RS through scores or more transmission antennas by using limited resources as described above, an eNB divides the transmission antennas into a plurality of groups.

[0056] FIG. **4** illustrates an antenna grouping according to an exemplary embodiment of the present invention.

[0057] Referring to FIG. **4**, 40 transmission antennas (as indicated by reference numeral **400**), which have been grouped into five antenna groups, are illustrated as an example of a massive MIMO system. One antenna group includes 8 transmission antennas. Although the grouping is made based on actual transmission antennas in FIG. **4**, the grouping may be made based on virtual transmission antennas other than the actual transmission antennas. Furthermore, the antenna grouping may be commonly applied to both the actual transmission antennas and the virtual transmission antennas. In general, a virtual transmission antenna refers to an individual antenna signal which can be identified by a UE, and is implemented by a signal transmitted from an actual transmission antenna.

[0058] CSI-RSs for massive MIMO are transmitted to each UE for each group of multiple antennas as illustrated in FIG. **4**, so that CSI-RSs for more transmission antennas than the 8 transmission antennas supported by the LTE-A are transmitted.

[0059] FIG. **5** illustrates transmission of CSI-RSs for massive MIMO according to an exemplary embodiment of the present invention.

[0060] Referring to FIG. **5**, the CSI-RSs for massive MIMO are transmitted at different time intervals according to the respective antenna groups in FIG. **4**. In FIG. **5**, one time interval corresponds to one subframe in an LTE/LTE-A system. The subframe is a time unit used for resource allocation in an LTE/LTE-A system and corresponds to 1 msec. For example, antenna groups **1** through **5** in FIG. **4** are allocated transmission time intervals and transmit CSI-RSs in the allocated transmission time intervals. In FIG. **4**, since each antenna group includes 8 transmission antennas, each antenna group transmits a CSI-RS in each transmission interval by using one CSI-RS resource (as indicated by reference numeral **500** of FIG. **5**) for 8 ports. In the transmission described above, each transmission antenna has an individual transmission resource in transmitting a CSI-RS, and the UE can measure the channel state in each transmission antenna. The channel state in each transmission antenna needs to be measured for determination of an optimum precoding scheme in massive MIMO. In contrast, UEs which do not support massive MIMO cannot receive signals transmitted from a large number of antennas as illustrated in FIG. **4** in a discriminated manner according to the antennas. For such UEs, separately from the CSI-RS **510** for massive MIMO, CSI-RSs **520**

for non-massive MIMO with respect to all antenna groups are transmitted. The CSI-RSs **520** may be transmitted through a virtual antenna. Furthermore, the CSI-RSs for non-massive MIMO may also be effectively used for simultaneous signal transmission to a plurality of UEs. UEs which do not support massive MIMO can receive non-massive MIMO CSI-RSs for a maximum of 8 transmission antennas supported in the LTE-A. Such UEs cannot receive the CSI-RSs **510** for massive MIMO of FIG. **5** and measure the channel state of each transmission antenna. Therefore, for such UEs, the eNB implements a smaller number of virtual transmission antennas than the number of actual transmission antennas and transmits a signal for these antennas through one CSI-RS resource. When CSI-RSs for non-massive MIMO are transmitted for the UEs which do not support massive MIMO as described above, the UEs cannot discriminately measure the channel state of the individual transmission antennas. However, a plurality of transmission antennas are allocated to each virtual transmission antenna and a relatively higher transmission power is thus used for signal transmission. Furthermore, the higher the transmission power allocated to each virtual transmission antenna, the more precise the channel state measured by a UE.

[0061] Although an individual time resource allocated to each antenna group is used for transmission of CSI-RSs for massive MIMO in FIG. **5**, not only the individual time resource but also an individual frequency resource may be allocated for transmission of the CSI-RSs for massive MIMO.

[0062] FIG. **6** illustrates a transmission of CSI-RSs for massive MIMO by allocation of individual frequency resources according to an exemplary embodiment of the present invention.

[0063] Referring to FIG. **6**, CSI-RSs **600** for massive MIMO are transmitted in a time interval corresponding to one subframe. It is noted from FIG. **6** that CSI-RSs **610** for a plurality of antenna groups are transmitted by different OFDM symbols or subcarriers within the same subframe.

[0064] In order to transmit the CSI-RSs for massive MIMO, it is possible to use not only the above two methods of allocating an individual time resource or an individual frequency resource to each antenna group as illustrated in FIGS. **5** and **6** but also a method of allocating time and frequency resources by complexly using the two methods.

[0065] In order to transmit the CSI-RSs for massive MIMO as illustrated in FIGS. **5** and **6**, an eNB should notify a UE of related control information before transmitting a CSI-RS. The control information is imperative for proper reception of the CSI-RSs for massive MIMO and proper determination of the channel state based on the received CSI-RSs by the UE. Such control information may include at least one of the following:

[0066] 1) Information on the number of transmission antennas which configure the CSI-RSs for massive MIMO;

[0067] 2) Information on the number of antenna groups which configure the CSI-RSs for massive MIMO;

[0068] 3) Information on the number of transmission antennas which configure each of the antenna groups configuring the CSI-RSs for massive MIMO;

[0069] 4) Information on the time and frequency resource positions at which the CSI-RSs for massive MIMO are transmitted, wherein this information includes positions of time and frequency resources at which a CSI-RS for each antenna group is transmitted;

[0070] 5) Time period by which the CSI-RSs for massive MIMO are transmitted;

[0071] 6) Information on the transmission power of the CSI-RSs for massive MIMO, which includes a ratio between the transmission power of the CSI-RSs and the transmission power of a Physical Downlink Shared Channel (PDSCH), and the like; and

[0072] 7) An initial state value used for generation of a scrambling sequence of the CSI-RSs for massive MIMO.

[0073] Furthermore, in relation to the non-massive MIMO, the control information may include at least one of the following:

[0074] 1) Information on the number of transmission antennas which configure the CSI-RSs for non-massive MIMO;

[0075] 2) Information on the time and frequency resource positions at which the CSI-RSs for non-massive MIMO are transmitted;

[0076] 3) Time period by which the CSI-RSs for non-massive MIMO are transmitted;

[0077] 4) Information on the transmission power of the CSI-RSs for non-massive MIMO, which includes a ratio between the transmission power of the CSI-RSs and the transmission power of PDSCH, and the like; and

[0078] 5) An initial state value used for generation of a scrambling sequence of the CSI-RSs for non-massive MIMO.

[0079] The information on the transmission power of the CSI-RSs for massive MIMO and the information on the transmission power of the CSI-RSs for non-massive MIMO are control information used for a UE to receive each CSI-RS and determine a precise channel state. Among the above information, the control information relating to the CSI-RSs for massive MIMO and the control information relating to the CSI-RSs for non-massive MIMO are transferred to the UE, separately from the CSI-RSs. According to whether the information relates to massive MIMO or non-massive MIMO, different methods are used in determining the channel state. Therefore, for effective communication, the UE needs to know whether the above two types of information are for massive MIMO or non-massive MIMO. For example, the UE may receive both the control information relating to the CSI-RSs for massive MIMO and the control information relating to the CSI-RSs for non-massive MIMO, and the eNB may send additional control information, by which it is possible to determine whether the control information is for massive MIMO or for non-massive MIMO, to the UE.

[0080] The above description discusses a method of transmitting CSI-RSs for massive MIMO after dividing the CSI-RSs according to the antenna groups. In this method, a UE determines the channel state information by measuring the channel state of each antenna. Therefore, allocation of individual transmission resources is imperative for channel measurement of each antenna. This method can be effectively used when sufficient transmission power can be allocated to each transmission antenna. In contrast, when it is impossible to allocate a sufficient transmission power to each transmission antenna, it is more efficient to generate a plurality of beams by an eNB and select one or more beams among the generated beams by the UE, than to measure the channel state of each antenna. In the method of using a plurality of beams as described above, each beam is transmitted using an individual transmission resource and beams are generated using the same multiple transmission antennas, but different precoding schemes are applied to the antennas according to the beams. For example, although beam**1** and beam**2** are trans-

mitted using the same 40 transmission antennas, the precoding scheme applied to beam**1** and the precoding scheme applied to beam**2** are different from each other.

[0081] When CSI-RSs for massive MIMO are transmitted using a plurality of beams transmitted after being differently precoded, the plurality of beams may be grouped into a plurality of beam groups for transmission, as in the above case of grouping the multiple transmission antennas into multiple antenna groups for transmission.

[0082] FIG. **7** illustrates a grouping of a plurality of beams into five beam groups, wherein each beam group is transmitted in an individual time interval, according to an exemplary embodiment of the present invention.

[0083] Referring to FIG. **7**, five beam groups **710** are illustrated, each antenna group includes 8 transmission antennas, and each antenna group transmits CSI-RSs by using one CSI-RS resource **700** for 8 ports in each transmission interval. Although CSI-RSs for massive MIMO are transmitted using a particular CSI-RS resource within a subframe as indicated by reference numeral **720**, CSI-RSs for a large number of beams may be transmitted by performing transmission for different beam groups according to subframes.

[0084] FIG. **8** illustrates a transmission of CSI-RSs for a plurality of beams by allocating not only individual time resources but also individual frequency resources according to an exemplary embodiment of the present invention.

[0085] Referring to FIG. **8**, CSI-RSs **800** for massive MIMO transmitted in a time interval corresponding to one subframe and individual frequency resources **810** are illustrated.

[0086] Hereinafter, a link adaptation method in a massive MIMO system is described.

[0087] For effective data transmission and reception using massive MIMO, it is imperative to efficiently use multi-user MIMO which simultaneously transmits a wireless signal to a plurality of UEs. A system using massive MIMO may have scores or more transmission antennas. In order to use such a large number of antennas, simultaneous transmission of wireless signals to a large number of UEs is needed. In the case of simultaneously transmitting wireless signals to a large number of UEs, a signal for other UEs may generate a multi-user MIMO interference and the size of the interference increases according to an increase in the number of UEs participating in the multi-user MIMO. For example, in the case of performing multi-user MIMO for simultaneous transmission to 10 UEs, one UE among the 10 UEs may be subjected to multi-user MIMO interference by the signals transmitted from the other 9 UEs, which causes performance degradation of the one UE.

[0088] Furthermore, since signal transmission to a large number of UEs is simultaneously performed, it may be necessary to use, in spite of an optimum precoding in view of a particular UE, another precoding in consideration of the quantity of interference incurred to another UE. In a case of an LTE/LTE-A system, a UE notifies an eNB of a precoding optimum for the UE together with information on supportable data rates when the optimum precoding is applied. Since the information on the supportable data rates is available only when the precoding is applied, it is impossible to know the data rates which the UE can support when the eNB applies a precoding which is not requested by the UE. In general, this problem is known as an inaccuracy of the link adaption.

[0089] An exemplary embodiment of the present invention proposes a link adaptation method for addressing the problems occurring due to the inaccuracy of the link adaption as described above.

[0090] FIG. **9** illustrates a link adaptation method according to an exemplary embodiment of the present invention.

[0091] Referring to FIG. **9**, an eNB transmits a CSI-RS (i.e., a coarse CSI) **900** for first channel measurement to a UE. Upon receiving the CSI-RS, the UE notifies the eNB of first channel state information **910** by using the CSI-RS. When the CSI-RS **900** for the first channel measurement is a periodic signal, the first channel state information **910** may also be periodically notified information. The first channel state information **910** may be notified of by each of multiple UEs. By using the notified first channel state information as described above, the eNB first determines UEs to which wireless resources for data transmission are to be allocated, in the step indicated by reference numeral **920**. The selected UEs are known as wireless resource allocation candidate UEs. In the step indicated by reference numeral **930**, the wireless resource allocation candidate UEs determined by the eNB in the step indicated by reference numeral **920** are notified that they should receive second CSI-RSs from the eNB. The wireless resource allocation **920** and the second CSI-RS notification **930** may be simultaneously performed in the same time interval. In the step indicated by reference numeral **940**, the UE having received the second CSI-RS (i.e., fine CSI-RS) notifies the eNB of second channel state information by using the second CSI-RS. Upon receiving the second channel state information, the eNB selects UEs to which actual downlink wireless resources are to be allocated, and transmits control information needed for reception of a traffic channel to the selected UEs, in the step indicated by reference numeral **950**. The UEs allocated the actual downlink wireless resources may be different from the wireless resource allocation candidate UEs.

[0092] The second CSI-RS is different from the first CSI-RS in view of at least one of the following:

[0093] 1) The first CSI-RS is a signal simultaneously received by a plurality of UEs, while different signals according to UEs are allocated and transmitted as the second CSI-RSs;

[0094] 2) The first CSI-RS is a signal which is periodically transmitted and received by a plurality of UEs, while the second CSI-RS is received by only some of the UEs having received the first CSI-RS and the eNB determines whether to transmit the second CSI-RS;

[0095] 3) The first CSI-RS is transmitted through all frequency bands, in order to enable a UE to measure all frequency bands and find the best frequency band. In contrast, the second CSI-RS is transmitted in fewer than all of the frequency bands according to a determination of the eNB, because the eNB has already found a frequency band most proper for the UE; and

[0096] 4) A UE having measured the first CSI-RS determines an optimum precoding based on the first CSI-RS. In contrast, the second CSI-RS does not require a process of determining an optimum precoding since it is a signal to which a precoding determined to be optimum for a corresponding UE by the eNB has been already applied.

[0097] The second channel state information transmitted by the UE having received the second CSI-RS may be reported by means of a value relative to the first channel state information. For example, if a Signal to Interference and

Noise Ratio (SINR) or a data rate among the first channel state information is A and an SINR or a data rate measured by a UE having received a second CSI-RS is (A+Δ), the UE does not notify (A+Δ) but notifies only Δ as the second channel state information. Such transmission of a relative value as the channel state information as described above reduces the information quantity of the second channel state information, so as to reduce the overhead in the uplink transmission by the UE.

[0098] FIG. **10** illustrates a transmission of a first CSI-RS and a second CSI-RS in a frequency band according to an exemplary embodiment of the present invention.

[0099] Referring to FIG. **10**, the first CSI-RS **1000** is a signal which is transmitted in all Resource Blocks (RBs) of the system bandwidth and is received by a plurality of UEs. In contrast, the second CSI-RSs **1010**, **1020**, **1030**, and **1040** are signals, which may be individually allocated to UEs and may be transmitted in only some of the RBs of the system bandwidth. Furthermore, as illustrated in FIG. **10**, a plurality of second CSI-RSs may be transmitted in the same subframe and RB. For example, although the second CSI-RSs **1010** and **1020** are signals for different UEs, they are transmitted using the same RB in the same subframe.

[0100] In order to receive the second CSI-RSs, the eNB should transfer control information for receiving the second CSI-RSs to the UE. The control information for receiving the second CSI-RSs may be notified to the UE by the eNB through transmission as indicated by reference numeral **920** in FIG. **9**. The control information includes at least one of the following:

[0101] 1) Information on a UE to which the second CSI-RS corresponds. This information may be transmitted either by defining separate control information or by initializing a Cyclic Redundancy Check (CRC) code of a control channel into UE-specific indicator information (UE ID);

[0102] 2) Information on a frequency band (i.e., an RB) to which the second CSI-RS is transmitted;

[0103] 3) Information on a time interval (i.e., a subframe) to which the second CSI-RS is transmitted;

[0104] 4) Information on a CSI-RS transmission resource used for transmission of the second CSI-RS when a plurality of CSI-RS transmission resources exists within the RB and the subframe through which the second CSI-RS is transmitted;

[0105] 5) Information on the number of transmission antenna ports through which the second CSI-RS is transmitted; and

[0106] 6) Ratio of transmission power between the second CSI-RS and a PDSCH transmitted for a data signal.

[0107] The control information is imperative for reception of a second CSI-RS allocated to a UE by the UE. Moreover, the eNB may notify a corresponding UE of information needed for reception of a second CSI-RS allocated to UEs other than the corresponding UE. The reason why the eNB notifies a UE of information needed for reception of a second CSI-RS allocated to the other UEs is in order to enable the UE to measure the multi-user MIMO interference generated at the time of multi-user MIMO transmission by receiving the second CSI-RS allocated to the other UEs. In order to receive the second CSI-RS allocated to the other UEs for measurement of the multi-user MIMO interference, information imperative for reception of the second CSI-RS allocated to the other UEs is needed as is the information imperative for reception of the second CSI-RS allocated to the UE itself. The information imperative for reception of the second CSI-RS may be transmitted through a Physical Downlink Control Channel (PDCCH) or an Enhanced-PDCCH (E-PDCCH), which are control channels supported in the LTE/LTE-A. Notification of all information relating to the second CSI-RS to a UE by using a PDCCH or an E-PDCCH as described above may generate an excessive downlink overhead. In order to avoid such an excessive downlink overhead, some of the information may be set using a higher layer signaling while only indispensible information is transmitted using a PDCCH or an E-PDCCH.

[0108] Furthermore, the second CSI-RS of FIG. **10** is not transmitted in all frequency bands but is transmitted in fewer than all of the frequency bands. The reason why the second CSI-RS is transmitted in fewer than all of the frequency bands is to transmit the second CSI-RS in the same band as the frequency band in which a data signal is transmitted. Accordingly, it is possible to precisely determine the channel state of the frequency band in which the data is transmitted. One method capable of reducing the quantity of control information for the second CSI-RS, which should be transmitted through a PDCCH or an E-PDCCH, is to semi-statically set the transmission resources for the second CSI-RS.

[0109] FIG. **11** illustrates a transmission of first CSI-RSs and second CSI-RSs for respective subframes according to an exemplary embodiment of the present invention.

[0110] Referring to FIG. **11**, first CSI-RSs and second CSI-RSs are simultaneously transmitted in subframe **0**. In subframe **0**, both the first CSI-RSs and second CSI-RSs are transmitted using CSI-RS transmission resources **1100**, **1110**, **1120**, and **1130**. In subframe **7**, only the second CSI-RSs are transmitted using CSI-RS transmission resources **1140**, **1150**, **1160**, and **1170**. Furthermore, it is noted that the CSI-RS transmission resources **1100**, **1110**, **1120**, and **1130** have been allocated to UEs appointed by the eNB. For example, the CSI-RS transmission resource **1100** has been allocated to enable UEs belonging to Group A to receive the second CSI-RS. For example, when a UE belonging to Group A receives a notification from the eNB that a second CSI-RS for the UE itself is allocated to a particular RB or RBs, the UE can identify a CSI-RS transmission resource in which the second CSI-RS for the UE itself exists, among a plurality of CSI-RS transmission resources existing in the particular RB or RBs. This method can reduce the downlink overhead because it makes it unnecessary for the UE to transmit, through a PDCCH or an E-PDCCH, separate control information about which one is allocated among a plurality of CSI-RS transmission resources. Furthermore, when a UE belonging to Group A in FIG. **11** receives a notification from the eNB that a second CSI-RS for the UE itself is allocated to a particular RB(s), the UE can identify that the second CSI-RS for the UE itself exists in the CSI-RS transmission resource **1100** and that CSI-RSs for other UEs exist in the other CSI-RS transmission resources **1110**, **1120**, and **1130**. By using this information, the UE can determine a multi-user MIMO interference generated in the same RB(s) as that of the UE itself by measuring the reception power carried by the CSI-RS transmission resources **1110**, **1120**, and **1130**.

[0111] When predefined CSI-RS resources are set for the second CSI-RSs as illustrated in FIG. **11**, at least one of the following should be notified to a UE by using a higher layer signaling:

[0112] 1) Information on CSI-RS transmission resources for the second CSI-RSs to be allocated to the UE; and

[0113] 2) Information on CSI-RS transmission resources for the second CSI-RSs to be allocated to other UEs.

[0114] When the UE having received the information described above receives a notification that a second CSI-RS has been allocated to itself through a PDCCH or an E-PDCCH, the UE receives a signal for measurement of a wireless channel in the CSI-RS transmission resource through which the second CSI-RS of the UE itself is transmitted and receives a signal for measurement of a multi-user MIMO interference in the other CSI-RS transmission resource.

[0115] Hereinafter, an exemplary method of measuring an interference signal in a massive MIMO system will be described.

[0116] For effective data transmission and reception using massive MIMO, a UE needs to effectively determine a multi-user MIMO interference generated in massive MIMO transmission and reception. Although the above description proposes an exemplary method of measuring a multi-user MIMO interference by using second CSI-RSs allocated to other UEs, exemplary embodiments of the present invention can be applied to a method of measuring a multi-user MIMO interference by directly measuring second CSI-RSs allocated to other UEs and a method of measuring a multi-user MIMO interference by allocating an interference measurement resource to each UE to which a second CSI-RS is allocated.

[0117] The interference measurement resource refers to a wireless resource used when a particular UE measures the size of interference applied to the particular UE itself, and is used when a UE has received a second CSI-RS and needs to determine a precise channel state information. The interference measurement resource includes one or more REs, through which a wireless signal transmitted to a UE allocated the interference measurement resource is not carried and only wireless signals transmitted to the other UEs are carried. For example, when UE**1** has been allocated a particular interference measurement resource, the eNB transmits only transmission signals for the other UEs without transmitting a transmission signal for UE**1** through the particular interference measurement resource, so that UE**1** can measure only the multi-user MIMO interference. The UE having received only the transmission signals for the other UEs through the particular interference measurement resource can measure a precise multi-user MIMO interference.

[0118] Each UE may be notified of whether the interference measurement resource has been allocated or not, through a PDCCH or an E-PDCCH. In this case, the eNB may notify allocation of the interference measurement resource to the UE simultaneously while notifying whether the second CSI-RS has been allocated.

[0119] FIG. **12** illustrates a notification of an allocation-or-not of a second CSI-RS and an allocation of an interference measurement resource to a UE by an eNB according to an exemplary embodiment of the present invention.

[0120] Referring to FIG. **12**, it is the same as FIG. **9** except for the part indicated by reference numeral **1230**. For example, in FIG. **12**, an eNB transmits a CSI-RS (i.e., a coarse CSI) **1200** for first channel measurement to a UE. Upon receiving the CSI-RS, the UE notifies the eNB of first channel state information **1210** by using the CSI-RS. When the CSI-RS **1200** for the first channel measurement is a periodic signal, the first channel state information **1210** may also be periodically notified information. The first channel state information **1210** may be notified of by each of multiple UEs. By using the notified first channel state information as described above, the eNB selects wireless resource allocation candidate UEs, in the step indicated by reference numeral **1220**. In the step indicated by reference numeral **1230**, the wireless resource allocation candidate UEs determined by the eNB in the step indicated by reference numeral **1220** are notified that they should receive second CSI-RSs from the eNB. Furthermore, in the step indicated by reference numeral **1220**, the eNB notifies allocation of the second CSI-RS and the interference measurement resource to the UE. The wireless resource allocation **1220** and the second CSI-RS notification **1230** may be simultaneously performed in the same time interval. In the step indicated by reference numeral **1240**, the UE having received the second CSI-RS (i.e., fine CSI-RS) notifies the eNB of second channel state information by using the second CSI-RS. Upon receiving the second channel state information, the eNB selects UEs to which actual downlink wireless resources are to be allocated, and transmits control information needed for reception of a traffic channel to the selected UEs, in the step indicated by reference numeral **1250**.

[0121] The control information for notification of the interference measurement resource transmitted in the step indicated by reference numeral **1230** includes at least one of the following:

[0122] 1) Information on a UE to which the interference measurement resource corresponds. This information may be transmitted either by defining separate control information or by initializing a CRC code of a control channel into UE-specific indicator information (UE ID);

[0123] 2) Information on a frequency band (i.e., an RB) in which the interference measurement resource exists;

[0124] 3) Information on a time interval (i.e., a subframe) in which the interference measurement resource exists; and

[0125] 4) Information on a CSI-RS transmission resource to be used for transmission of the interference measurement resource when a plurality of interference measurement resources exists within the RB and the subframe through which the interference measurement resource is transmitted.

[0126] In addition to the exemplary method illustrated in FIG. **12** in which an interference measurement resource is allocated using a control channel, such as a PDCCH or an E-PDCCH, there is an exemplary method in which an interference measurement resource of a fixed position is allocated using a higher layer signaling. In this exemplary method, when a UE is allocated a second CSI-RS, the UE uses an interference measurement resource set through a higher layer signaling among RBs in which the second CSI-RSs exist. This exemplary method is advantageous in that it is not necessary to transmit separate control information through a PDCCH or an E-PDCCH in order to allocate an interference measurement resource. Another exemplary method is to link an interference measurement resource and a CSI-RS transmission resource of a second CSI-RS. In this exemplary method, an interference measurement resource allocated to a UE becomes different according to the CSI-RS transmission resource used by the second CSI-RS allocated to the UE.

[0127] FIG. **13** illustrates an allocation of interference measurement resources in a frequency band according to an exemplary embodiment of the present invention.

[0128] Referring to FIG. **13**, the first CSI-RS **1300** is a signal which is transmitted in all RBs of the system bandwidth and is received by a plurality of UEs. A specific second CSI-RS and a specific interference measurement resource have been allocated to each of the two UEs in the two same

RBs. UE1 measures the channel state of the wireless channel by using the second CSI-RSs **1310** and measures the quantity of interference by using the interference measurement resources **1320**. UE2 measures the channel state of the wireless channel by using the second CSI-RSs **1330** and measures the quantity of interference by using the interference measurement resources **1340**. It is noted that the interference measurement resources and the second CSI-RSs occupy the same frequency band. Such occupying of the same frequency band is intended to enable channel estimation and interference measurement to be performed in the frequency band in which actual data is to be transmitted, so as to obtain a more precise determination of the channel state information. Furthermore, the interference measurement resources and the second CSI-RSs are not transmitted in all frequency bands but are transmitted in fewer than all of the frequency bands. Such transmission in fewer than all of the frequency bands is also performed in only the same band as a particular frequency band in which a data signal is to be transmitted, so as to obtain a more precise determination of the channel state information of the particular frequency band in which the data signal is to be transmitted.

[0129] FIG. **14** illustrates a transmission apparatus according to an exemplary embodiment of the present invention.

[0130] Referring to FIG. **14**, a controller **1410** determines whether to transmit a signal generated in a first CSI-RS transmitter **1400** and a signal generated in a second CSI-RS/interference measurement resource transmitter **1420**. As described above, the first CSI-RS signal is a periodically transmitted signal and is transmitted in order to measure channels for a plurality of transmission antennas or a plurality of beams generated by a plurality of transmission antennas. In contrast, in the case of the second CSI-RS, the eNB determines, in each subframe, a time interval in which the second CSI-RS is to be transmitted, a UE to which the second CSI-RS is to be transmitted, and a frequency band in which the second CSI-RS is to be transmitted. Thereafter, the signal is transmitted while being carried by a Resource Element (RE) to be transmitted by an RE mapper **1430**. Furthermore, the controller **1410** notifies control information on transmission of the second CSI-RS and the interference measurement resource to each UE by using a PDCCH or an E-PDCCH. Here, the information needed for reception of the second CSI-RS or the interference measurement resource by each UE may include a part which the UE can determine according to a predefined rule between the UE and an eNB.

[0131] FIG. **15** illustrates a reception apparatus according to an exemplary embodiment of the present invention.

[0132] Referring to FIG. **15**, received wireless signals are classified into first CSI-RSs, second CSI-RSs, and interference measurement resources by an RE demapper **1500**, which are then input to a first CSI-RS receiver **1510** and a second CSI-RS/interference measurement resource receiver **1530**, respectively. The first CSI-RS receiver **1510** is a receiver for receiving signals transmitted in all frequency bands, and the second CSI-RS/interference measurement resource receiver **1530** is a receiver for receiving only signals transmitted in the time intervals and frequency bands allocated by the eNB. A controller **1520** determines the time interval and the frequency band in which the second CSI-RS/interference measurement resource receiver **1530** is to receive a signal. The controller **1520** is notified of the determination by receiving a PDCCH or an E-PDCCH from the eNB or identifies the corresponding information based on a predefined rule between the eNB and the UE as described above.

[0133] According to exemplary embodiments of the present invention, it is possible to effectively transmit a reference signal in a MIMO system having scores or more transmission antennas. Furthermore, according to exemplary embodiments of the present invention, it is possible to allocate resources to a reference signal and measure an interference signal in a MIMO system having scores or more transmission antennas.

[0134] While the invention has been shown and described with reference to certain exemplary embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the appended claims and their equivalents.

What is claimed is:

1. A method of transmitting a reference signal for generation of channel state information by an evolved Node B (eNB) in a wireless communication system, the method comprising:

transmitting a first reference signal to a plurality of User Equipments (UEs);

receiving channel state information generated based on the first reference signal from the plurality of UEs;

selecting candidate UEs to which wireless resources are to be allocated and transmitting second reference signals to the selected candidate UEs;

receiving channel state information generated based on the second reference signals from the candidate UEs; and

selecting final UEs, to which wireless resources are to be allocated, from the candidate UEs based on the channel state information generated based on the second reference signals, and transmitting control information for data reception to the selected final UEs.

2. The method of claim **1**, wherein the transmitting of the second reference signals comprises transmitting information on wireless resources to be allocated to the candidate UEs and control information for reception of the second reference signals.

3. The method of claim **1**, wherein the second reference signals are different according to UEs to which the second reference signals are allocated.

4. The method of claim **1**, wherein the first reference signal is transmitted through all frequency bands and the second reference signals are transmitted in fewer than all frequency bands.

5. The method of claim **3**, wherein the second reference signals for different UEs are transmitted in an identical subframe by using an identical resource block.

6. The method of claim **2**, wherein the control information comprises one or more combinations of information on a UE receiving the second reference signal, information on time and frequency resources through which the second reference signal is transmitted, information on transmission antenna ports through which the second reference signal is transmitted, and information on transmission power of the second reference signal.

7. The method of claim **2**, wherein the transmitting of the second reference signals further comprises transmitting information on interference measurement resources to be allocated to the candidate UEs.

8. The method of claim **7**, wherein the information on the interference measurement resources comprises one or more combinations of information on UEs to which the interfer-

ence measurement resources have been allocated, frequency and time information on the interference measurement resources, and information on an interference signal to be measured when a plurality of interference measurement resources exist within an identical time or frequency resource.

9. The method of claim **2**, wherein the channel state information generated based on the second reference signals has a relative value with respect to the channel state information generated based on the first reference signal.

10. A method of receiving a reference signal for generation of channel state information by a User Equipment (UE) in a wireless communication system, the method comprising:

receiving a first reference signal from an evolved Node B (eNB), generating channel state information based on the first reference signal, and transmitting the generated channel state information to the eNB;

receiving a second reference signal from the eNB, generating channel state information based on the second reference signal, and transmitting the generated channel state information to the eNB; and

receiving control information for data reception from the eNB.

11. The method of claim **10**, wherein the receiving of the second reference signal comprises receiving wireless resource allocation information and control information for reception of the second reference signals.

12. The method of claim **10**, wherein the second reference signals are different according to UEs to which the second reference signals are allocated.

13. The method of claim **10**, wherein the first reference signal is transmitted through all frequency bands and the second reference signals are transmitted in fewer than all frequency bands.

14. The method of claim **12**, wherein the second reference signals for different UEs are transmitted in an identical subframe by using an identical resource block.

15. The method of claim **12**, wherein the control information comprises one or more combinations of information on the UE receiving the second reference signal, information on time and frequency resources through which the second reference signal is transmitted, information on transmission antenna ports through which the second reference signal is transmitted, and information on transmission power of the second reference signal.

16. The method of claim **15**, wherein, in the generating of the channel state information based on the second reference signal, a second reference signal received through a resource other than a resource through which the second reference signal for the UE is received, is determined as an interference signal.

17. The method of claim **12**, wherein the receiving of the second reference signal further comprises receiving information on interference measurement resources.

18. The method of claim **13**, wherein the information on the interference measurement resources comprises one or more combinations of information on UEs to which the interference measurement resources have been allocated, frequency and time information on the interference measurement resources, and information on an interference signal to be measured when a plurality of interference measurement resources exist within an identical time or frequency resource.

19. The method of claim **10**, wherein the channel state information generated based on the second reference signal has a relative value with respect to the channel state information generated based on the first reference signal.

20. An evolved Node B (eNB) apparatus for transmitting a reference signal for generation of channel state information in a wireless communication system, the eNB apparatus comprising:

a first reference signal transmitter for generating a first reference signal and for transmitting the first reference signal to a plurality of User Equipments (UEs);

a second reference signal transmitter for receiving channel state information generated based on the first reference signal from the plurality of UEs, for selecting candidate UEs to which wireless resources are to be allocated, for generating second reference signals, and for transmitting the second reference signals to the selected candidate UEs;

a controller for controlling the first reference signal transmitter and the second reference signal transmitter, for receiving channel state information generated based on the second reference signals from the candidate UEs, for selecting final UEs, to which wireless resources are to be allocated, from the candidate UEs based on the channel state information generated based on the second reference signals, and for transmitting control information for data reception to the selected final UEs; and

a mapper for mapping signals output from the first reference signal transmitter, the second reference signal transmitter, and the controller to wireless resources, and for transmitting the signals through the wireless resources.

21. The eNB apparatus of claim **20**, wherein the second reference signal transmitter transmits information on wireless resources to be allocated to the candidate UEs and control information for reception of the second reference signals.

22. The eNB apparatus of claim **20**, wherein the second reference signals are different according to UEs to which the second reference signals are allocated.

23. The eNB apparatus of claim **20**, wherein the first reference signal is transmitted through all frequency bands and the second reference signals are transmitted in fewer than all frequency bands.

24. The eNB apparatus of claim **22**, wherein the mapper transmits the second reference signals for different UEs by mapping the second reference signals to an identical resource block within an identical subframe.

25. The eNB apparatus of claim **21**, wherein the control information comprises one or more combinations of information on a UE receiving the second reference signal, information on time and frequency resources through which the second reference signal is transmitted, information on transmission antenna ports through which the second reference signal is transmitted, and information on transmission power of the second reference signal.

26. The eNB apparatus of claim **21**, wherein the second reference signal transmitter transmits information on interference measurement resources to be allocated to the candidate UEs.

27. The eNB apparatus of claim **26**, wherein the information on the interference measurement resources comprises one or more combinations of information on UEs to which the interference measurement resources have been allocated, frequency and time information on the interference measure-

ment resources, and information on an interference signal to be measured when a plurality of interference measurement resources exist within an identical time or frequency resource.

28. The eNB apparatus of claim **21**, wherein the channel state information generated based on the second reference signals has a relative value with respect to the channel state information generated based on the first reference signal.

29. A User Equipment (UE) apparatus for receiving a reference signal for generation of channel state information in a wireless communication system, the UE apparatus comprising:

a first reference signal receiver for receiving a first reference signal from an evolved Node B (eNB) and for generating channel state information based on the first reference signal;

a second reference signal receiver for receiving a second reference signal from the eNB and for generating channel state information based on the second reference signal;

a controller for receiving control information for data reception from the eNB and for controlling the first reference signal receiver and the second reference signal receiver; and

a demapper for identifying the first reference signal, the second reference signal, and a control signal.

30. The UE apparatus of claim **29**, wherein the second reference signal receiver receives wireless resource allocation information and control information for reception of the second reference signals.

31. The UE apparatus of claim **29**, wherein the second reference signals are different according to UEs to which the second reference signals are allocated.

32. The UE apparatus of claim **29**, wherein the first reference signal is transmitted through all frequency bands and the second reference signals are transmitted in fewer than all frequency bands.

33. The UE apparatus of claim **31**, wherein the second reference signals for different UEs are transmitted in an identical subframe by using an identical resource block.

34. The UE apparatus of claim **31**, wherein the control information comprises one or more combinations of information on the UE receiving the second reference signal, information on time and frequency resources through which the second reference signal is transmitted, information on transmission antenna ports through which the second reference signal is transmitted, and information on transmission power of the second reference signal.

35. The UE apparatus of claim **34**, wherein the second reference signal receiver generates the channel state information by determining a second reference signal received through a resource, other than a resource through which the second reference signal for the UE is received, as an interference signal.

36. The UE apparatus of claim **31**, wherein the second reference signal receiver receives information on interference measurement resources.

37. The UE apparatus of claim **36**, wherein the information on the interference measurement resources comprises one or more combinations of information on UEs to which the interference measurement resources have been allocated, frequency and time information on the interference measurement resources, and information on an interference signal to be measured when a plurality of interference measurement resources exist within an identical time or frequency resource.

38. The UE apparatus of claim **31**, wherein the channel state information generated based on the second reference signal has a relative value with respect to the channel state information generated based on the first reference signal.

39. A method of transmitting a reference signal for generation of channel state information by an evolved Node B (eNB) in a wireless communication system, the method comprising:

grouping a plurality of transmission antennas into a plurality of antenna groups; and

transmitting the reference signal to User Equipments (UEs) in different time intervals or frequency intervals according to the antenna groups, and transmitting another reference signal for all of the antenna groups in an identical time interval or frequency interval.

40. The method of claim **39**, further comprising:

allocating physical resource blocks for transmission of the reference signal according to a number of antennas in each of the antenna groups.

41. The method of claim **39**, further comprising:

transmitting control information for transmission of the reference signal to the UE, before transmitting the reference signal.

42. The method of claim **41**, wherein the control information comprises one or more combinations of:

a number of the transmission antennas, a number of the antenna groups, a number of antennas in each of the antenna groups, positions of time and frequency resources through which the reference signal is transmitted, a period by which the reference signal is transmitted, information on a transmission power of the reference signal, and an initial state value used to generate a scrambling sequence of the reference signal.

43. The method of claim **42**, wherein the control information further comprises one or more combinations of:

a number of transmission antennas for the another reference signal for all of the antenna groups, positions of time and frequency resources through which the another reference signal for all of the antenna groups is transmitted, a period by which the another reference signal for all of the antenna groups is transmitted, information on a transmission power of the another reference signal for all of the antenna groups, and an initial state value used to generate a scrambling sequence of the another reference signal for all of the antenna groups.

44. A method of transmitting a reference signal for generation of channel state information by an evolved Node B (eNB) in a wireless communication system, the method comprising:

grouping a plurality of beams transmitted through a plurality of transmission antennas into a plurality of beam groups; and

transmitting the reference signal to User Equipments (UEs) in different time intervals or frequency intervals according to the beam groups, and transmitting another reference signal for all of the antenna groups in an identical time interval or frequency interval.

45. The method of claim **44**, further comprising:

allocating physical resource blocks for transmission of the reference signal according to a number of antennas in each of the beam groups.

46. The method of claim **45**, further comprising:

transmitting control information for transmission of the reference signal to the UE, before transmitting the reference signal.

47. The method of claim **45**, wherein the control information comprises one or more combinations of:

a number of the transmission antennas, a number of the beam groups, positions of time and frequency resources through which the reference signal is transmitted, a period by which the reference signal is transmitted, information on a transmission power of the reference signal, and an initial state value used to generate a scrambling sequence of the reference signal.

48. The method of claim **47**, wherein the control information further comprises one or more combinations of:

a number of transmission antennas for the another reference signal for all of the beam groups, positions of time and frequency resources through which the another reference signal for all of the beam groups is transmitted, a period by which the another reference signal for all of the beam groups is transmitted, information on a transmission power of the another reference signal for all of the beam groups, and an initial state value used to generate a scrambling sequence of the another reference signal for all of the beam groups.

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Vitthaladevuni et al.

(54) **SIGNALLING OF MULTIPLE-USER MULTIPLE-INPUT AND MULTIPLE-OUTPUT TRANSMISSIONS IN HIGH-SPEED PACKET ACCESS SYSTEMS**

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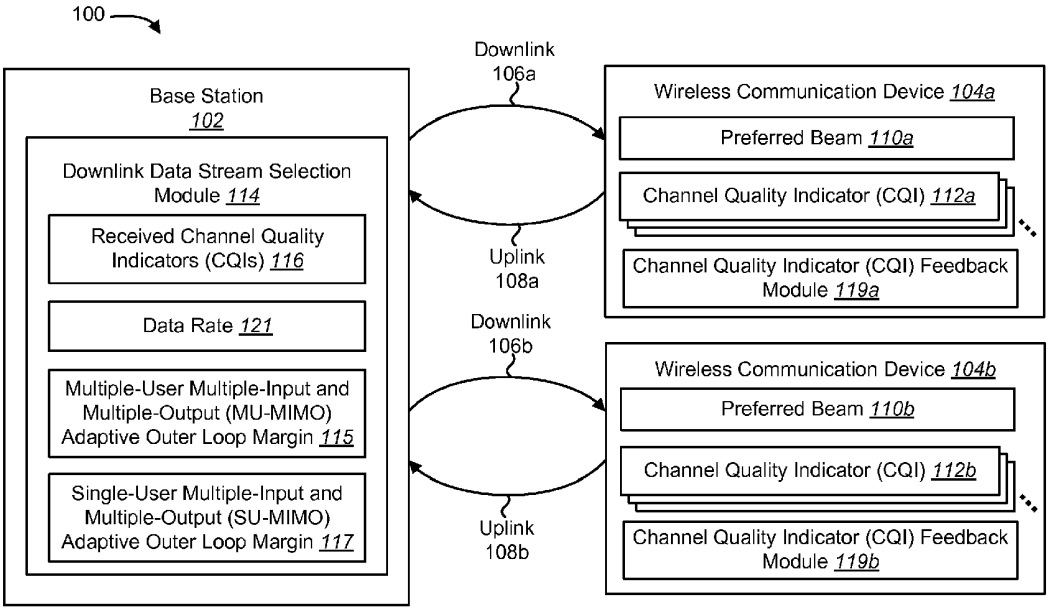
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(57) **ABSTRACT**

A method for signaling multiple-user multiple-input and multiple-output in a high speed packet access system is described. A multiple-user multiple-input and multiple-output parameter is determined. A message that includes the multiple-user multiple-input and multiple-output parameter is determined. The message is sent to a wireless device. The method may be performed by a user equipment, a Node B or a radio network controller.



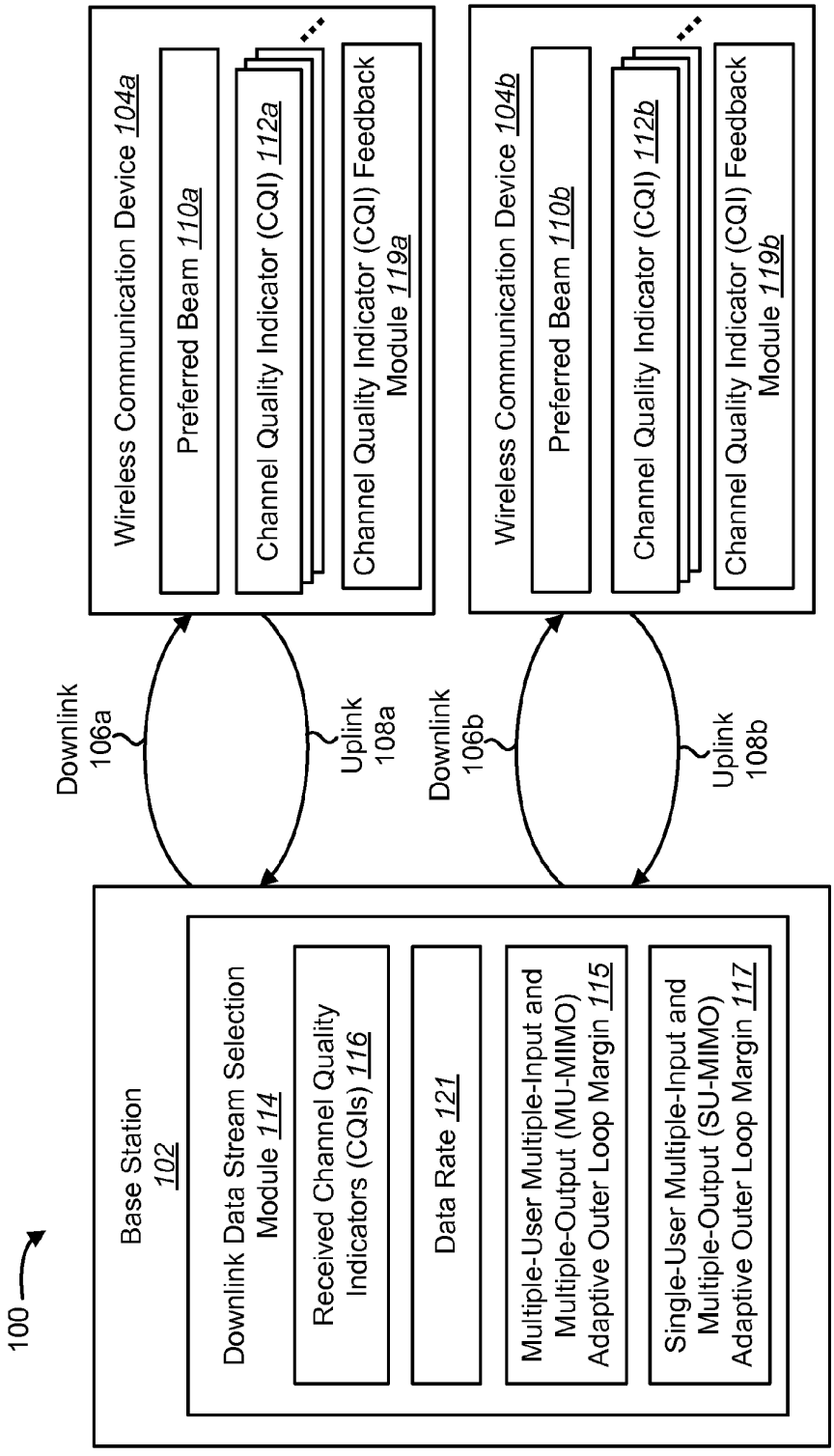

100
Base Station 102
Downlink Data Stream Selection Module 114
Received Channel Quality Indicators (CQIs) 116
Data Rate 121
Multiple-User Multiple-Input and Multiple-Output (MU-MIMO) Adaptive Outer Loop Margin 115
Single-User Multiple-Input and Multiple-Output (SU-MIMO) Adaptive Outer Loop Margin 117
Downlink 106a
Uplink 108a
Downlink 106b
Uplink 108b
Wireless Communication Device 104a
Preferred Beam 110a
Channel Quality Indicator (CQI) 112a
Channel Quality Indicator (CQI) Feedback Module 119a
Wireless Communication Device 104b
Preferred Beam 110b
Channel Quality Indicator (CQI) 112b
Channel Quality Indicator (CQI) Feedback Module 119b

FIG. 1

547

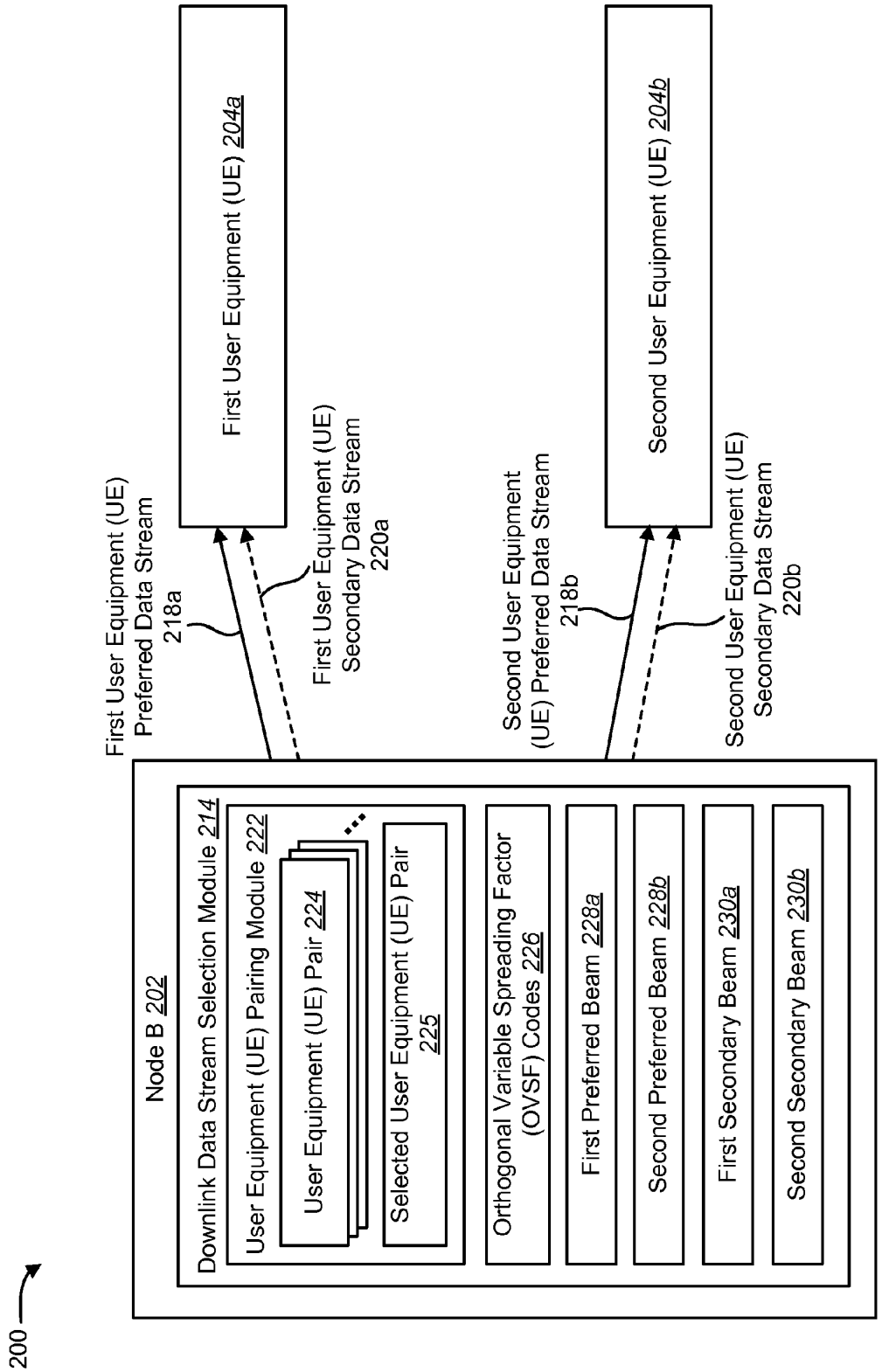

200
Node B 202
Downlink Data Stream Selection Module 214
User Equipment (UE) Pairing Module 222
User Equipment (UE) Pair 224
Selected User Equipment (UE) Pair 225
Orthogonal Variable Spreading Factor (OVSF) Codes 226
First Preferred Beam 228a
Second Preferred Beam 228b
First Secondary Beam 230a
Second Secondary Beam 230b
First User Equipment (UE) Preferred Data Stream 218a
First User Equipment (UE) Secondary Data Stream 220a
Second User Equipment (UE) Preferred Data Stream 218b
Second User Equipment (UE) Secondary Data Stream 220b
First User Equipment (UE) 204a
Second User Equipment (UE) 204b
548

FIG. 2

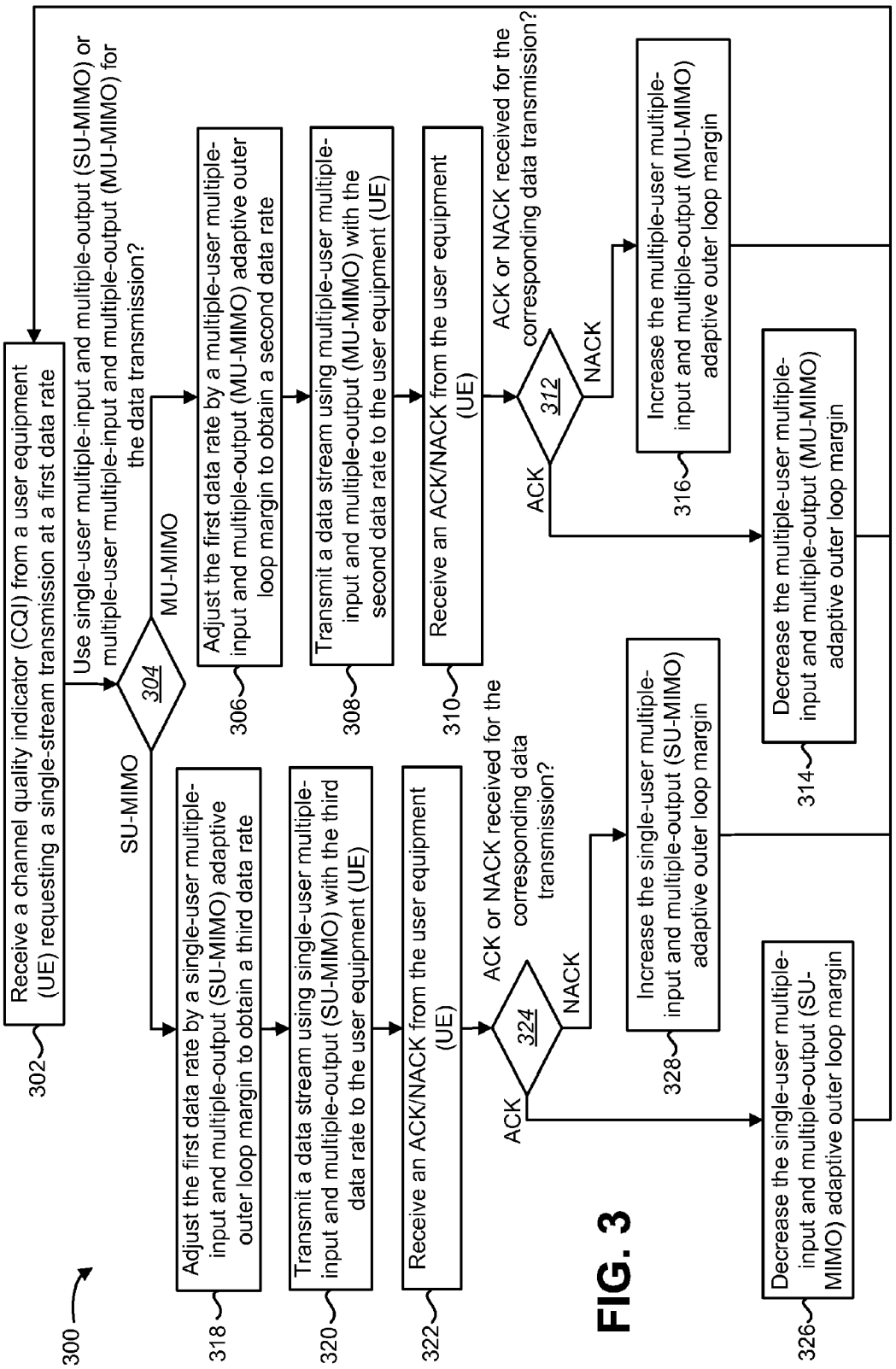

300
302
Receive a channel quality indicator (CQI) from a user equipment (UE) requesting a single-stream transmission at a first data rate
Use single-user multiple-input and multiple-output (SU-MIMO) or multiple-user multiple-input and multiple-output (MU-MIMO) for the data transmission?
304
SU-MIMO
MU-MIMO
318
Adjust the first data rate by a single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin to obtain a third data rate
320
Transmit a data stream using single-user multiple-input and multiple-output (SU-MIMO) with the third data rate to the user equipment (UE)
322
Receive an ACK/NACK from the user equipment (UE)
ACK or NACK received for the corresponding data transmission?
324
ACK
NACK
328
Increase the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin
326
Decrease the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin
306
Adjust the first data rate by a multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin to obtain a second data rate
308
Transmit a data stream using multiple-user multiple-input and multiple-output (MU-MIMO) with the second data rate to the user equipment (UE)
310
Receive an ACK/NACK from the user equipment (UE)
ACK or NACK received for the corresponding data transmission?
312
ACK
NACK
316
Increase the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin
314
Decrease the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin
549

FIG. 3

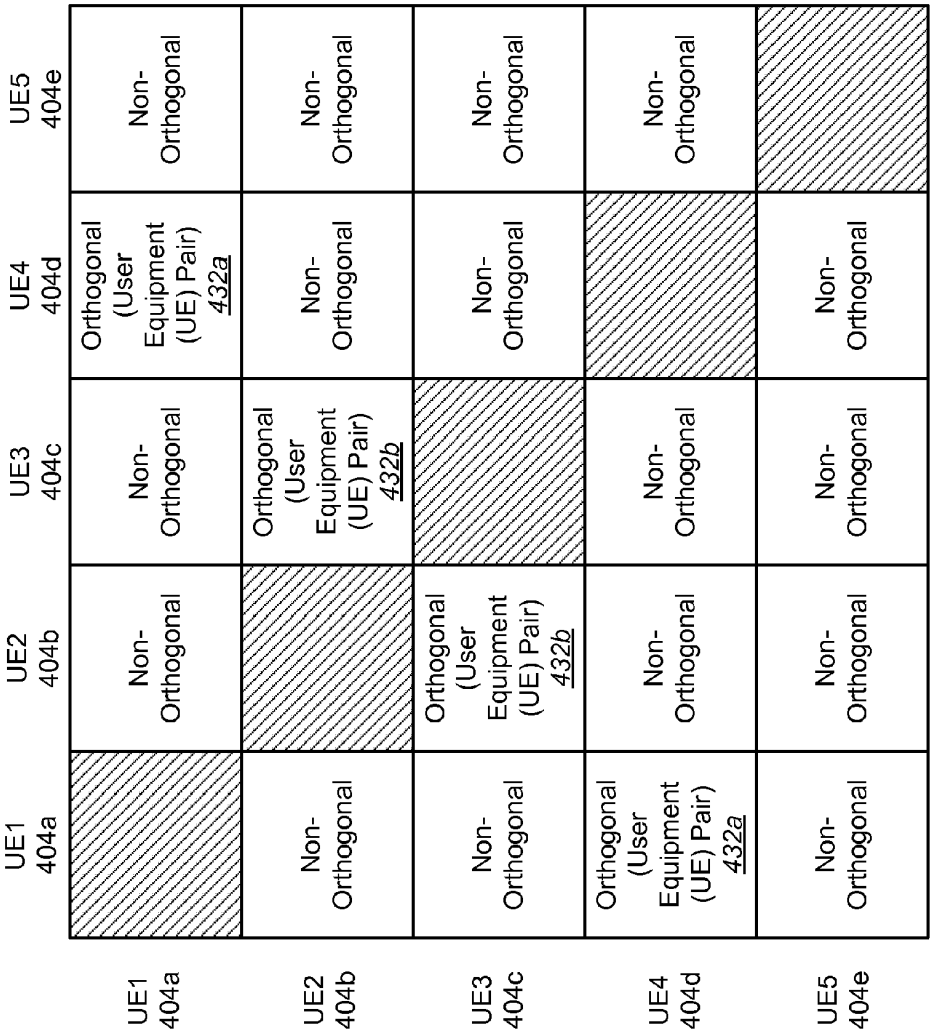

UE1 404a
UE2 404b
UE3 404c
UE4 404d
UE5 404e
Non-Orthogonal
Orthogonal (User Equipment (UE) Pair) 432a
Orthogonal (User Equipment (UE) Pair) 432b
550

FIG. 4

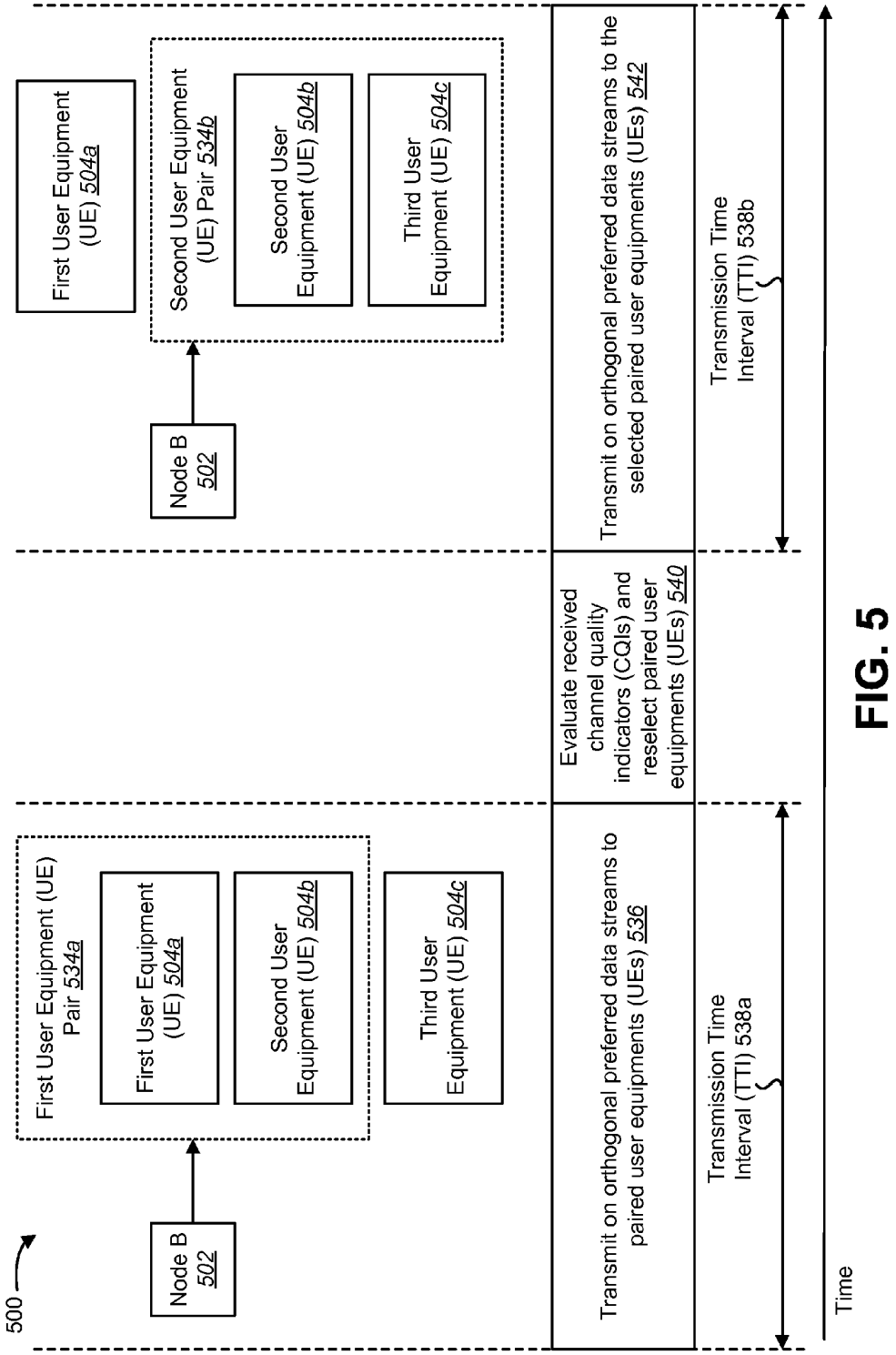

500
Node B 502
First User Equipment (UE) Pair 534a
First User Equipment (UE) 504a
Second User Equipment (UE) 504b
Third User Equipment (UE) 504c
Transmit on orthogonal preferred data streams to paired user equipments (UEs) 536
Transmission Time Interval (TTI) 538a
Evaluate received channel quality indicators (CQIs) and reselect paired user equipments (UEs) 540
Node B 502
Second User Equipment (UE) Pair 534b
First User Equipment (UE) 504a
Second User Equipment (UE) 504b
Third User Equipment (UE) 504c
Transmit on orthogonal preferred data streams to the selected paired user equipments (UEs) 542
Transmission Time Interval (TTI) 538b
Time

FIG. 5

551

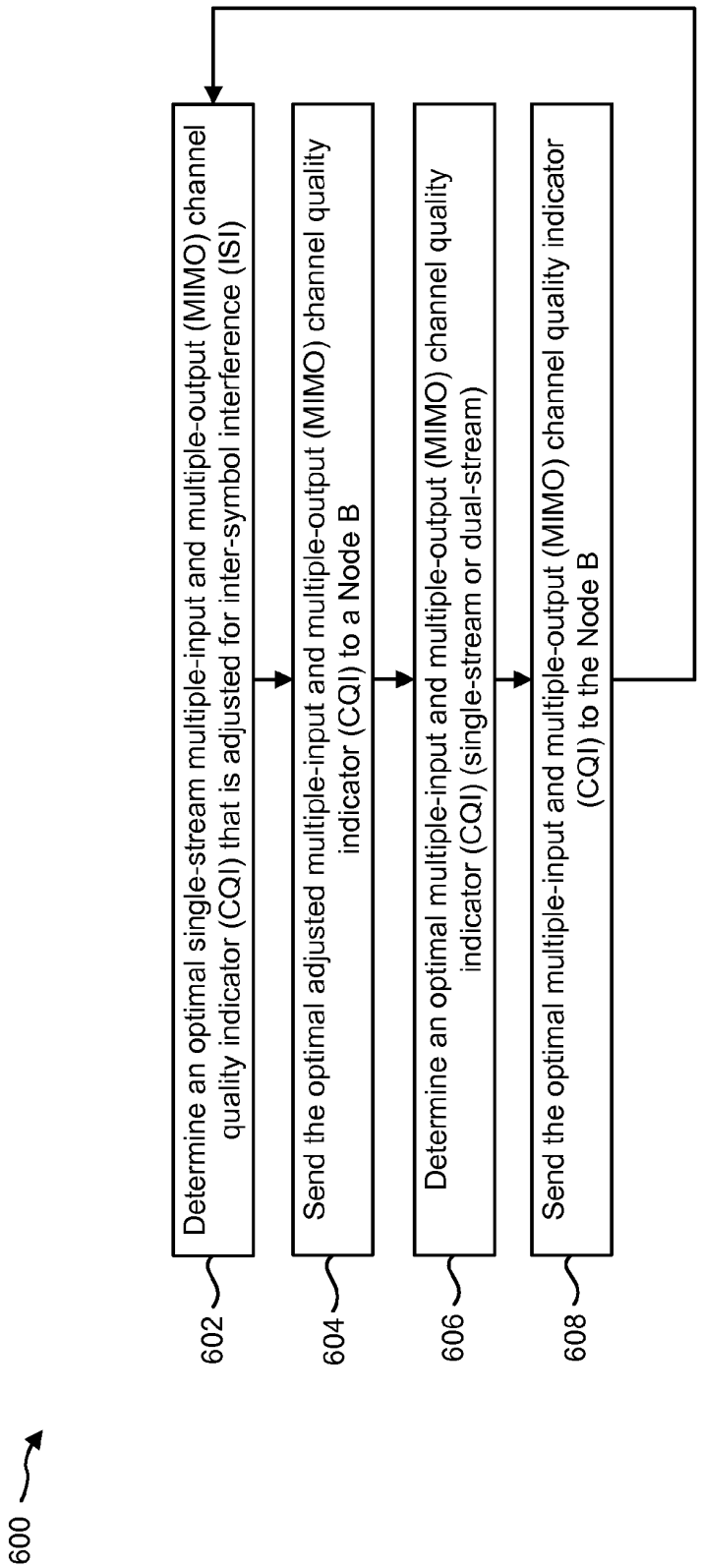

600
602
Determine an optimal single-stream multiple-input and multiple-output (MIMO) channel quality indicator (CQI) that is adjusted for inter-symbol interference (ISI)
604
Send the optimal adjusted multiple-input and multiple-output (MIMO) channel quality indicator (CQI) to a Node B
606
Determine an optimal multiple-input and multiple-output (MIMO) channel quality indicator (CQI) (single-stream or dual-stream)
608
Send the optimal multiple-input and multiple-output (MIMO) channel quality indicator (CQI) to the Node B
552

FIG. 6

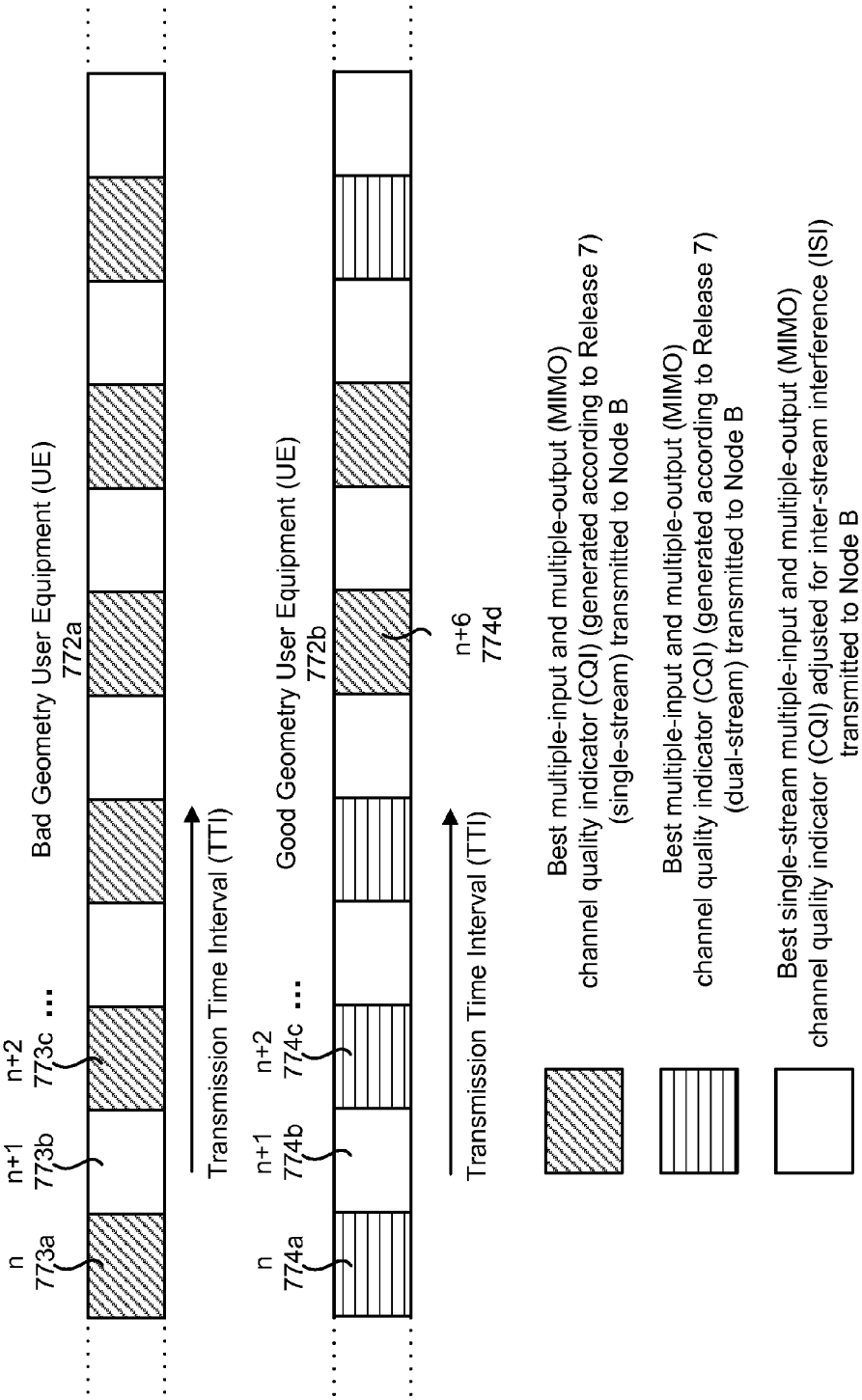

Bad Geometry User Equipment (UE)
772a
n
773a
n+1
773b
n+2
773c
...
Transmission Time Interval (TTI)
Good Geometry User Equipment (UE)
772b
n
774a
n+1
774b
n+2
774c
...
n+6
774d
Transmission Time Interval (TTI)
Best multiple-input and multiple-output (MIMO) channel quality indicator (CQI) (generated according to Release 7) (single-stream) transmitted to Node B
Best multiple-input and multiple-output (MIMO) channel quality indicator (CQI) (generated according to Release 7) (dual-stream) transmitted to Node B
Best single-stream multiple-input and multiple-output (MIMO) channel quality indicator (CQI) adjusted for inter-stream interference (ISI) transmitted to Node B

FIG. 7

553

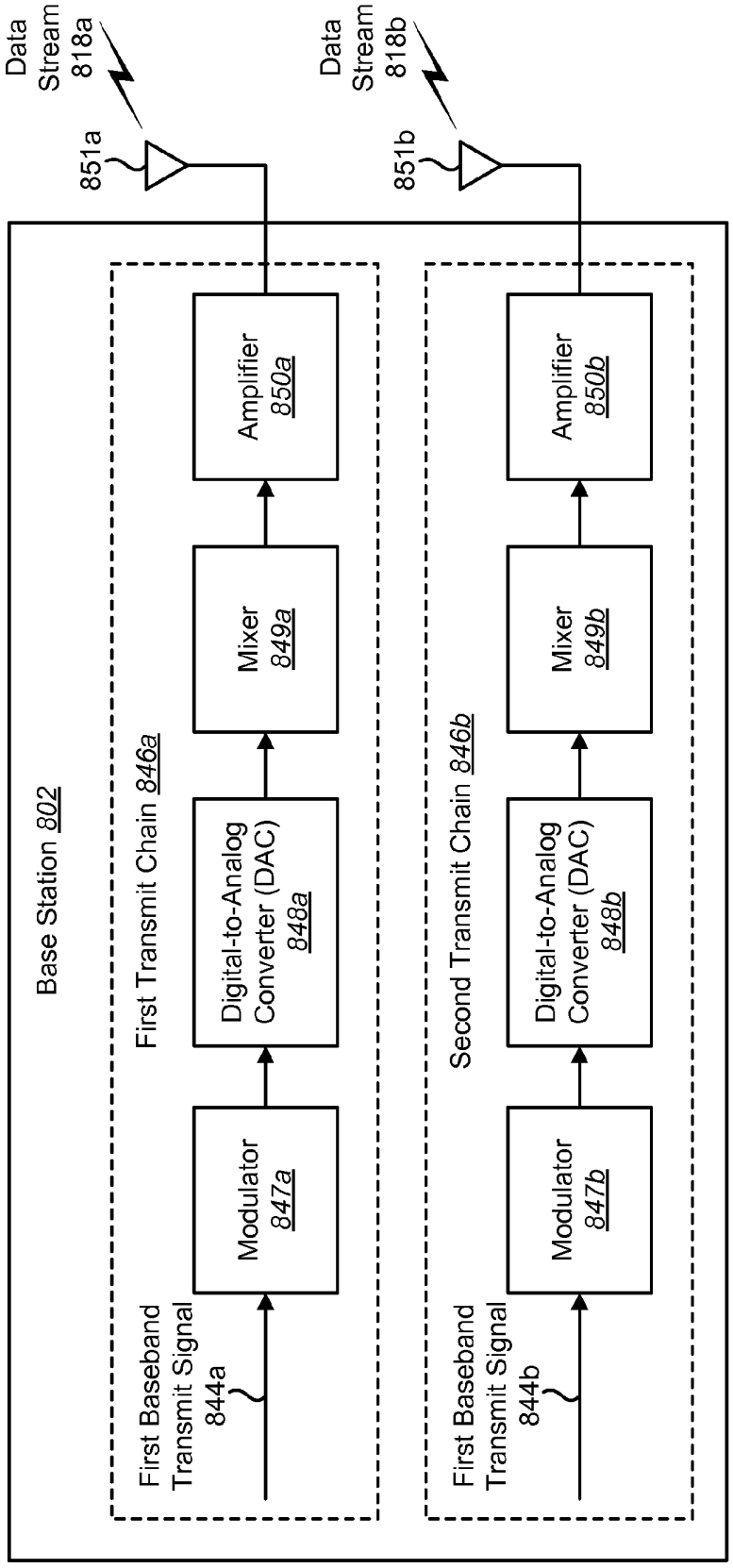

Data Stream 818a
Data Stream 818b
851a
851b
Base Station 802
First Transmit Chain 846a
Second Transmit Chain 846b
First Baseband Transmit Signal 844a
First Baseband Transmit Signal 844b
Modulator 847a
Modulator 847b
Digital-to-Analog Converter (DAC) 848a
Digital-to-Analog Converter (DAC) 848b
Mixer 849a
Mixer 849b
Amplifier 850a
Amplifier 850b

FIG. 8

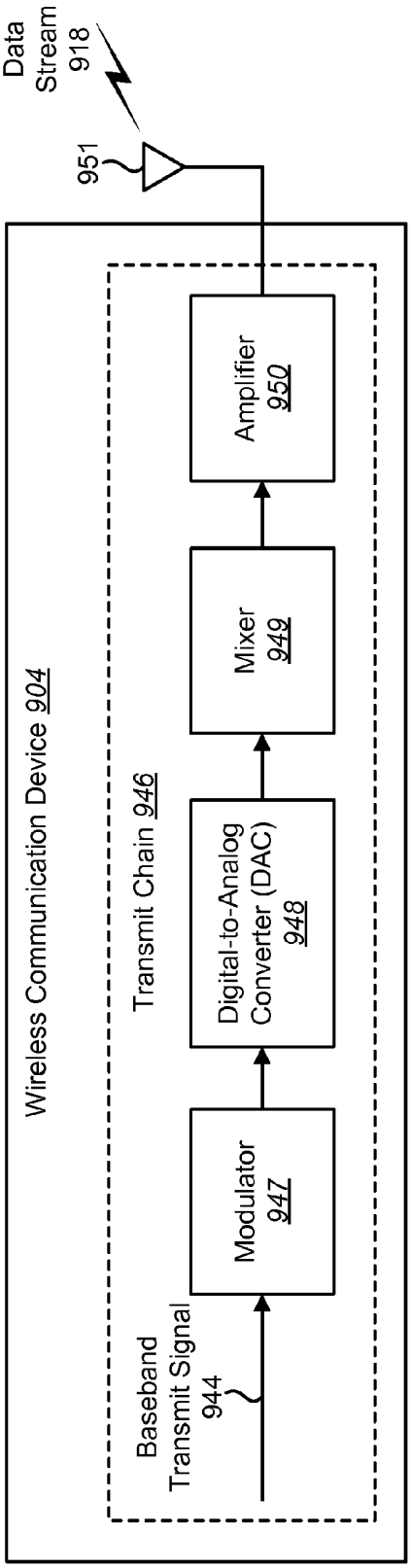

Data Stream 918
951
Wireless Communication Device 904
Transmit Chain 946
Amplifier 950
Mixer 949
Digital-to-Analog Converter (DAC) 948
Modulator 947
Baseband Transmit Signal 944

FIG. 9

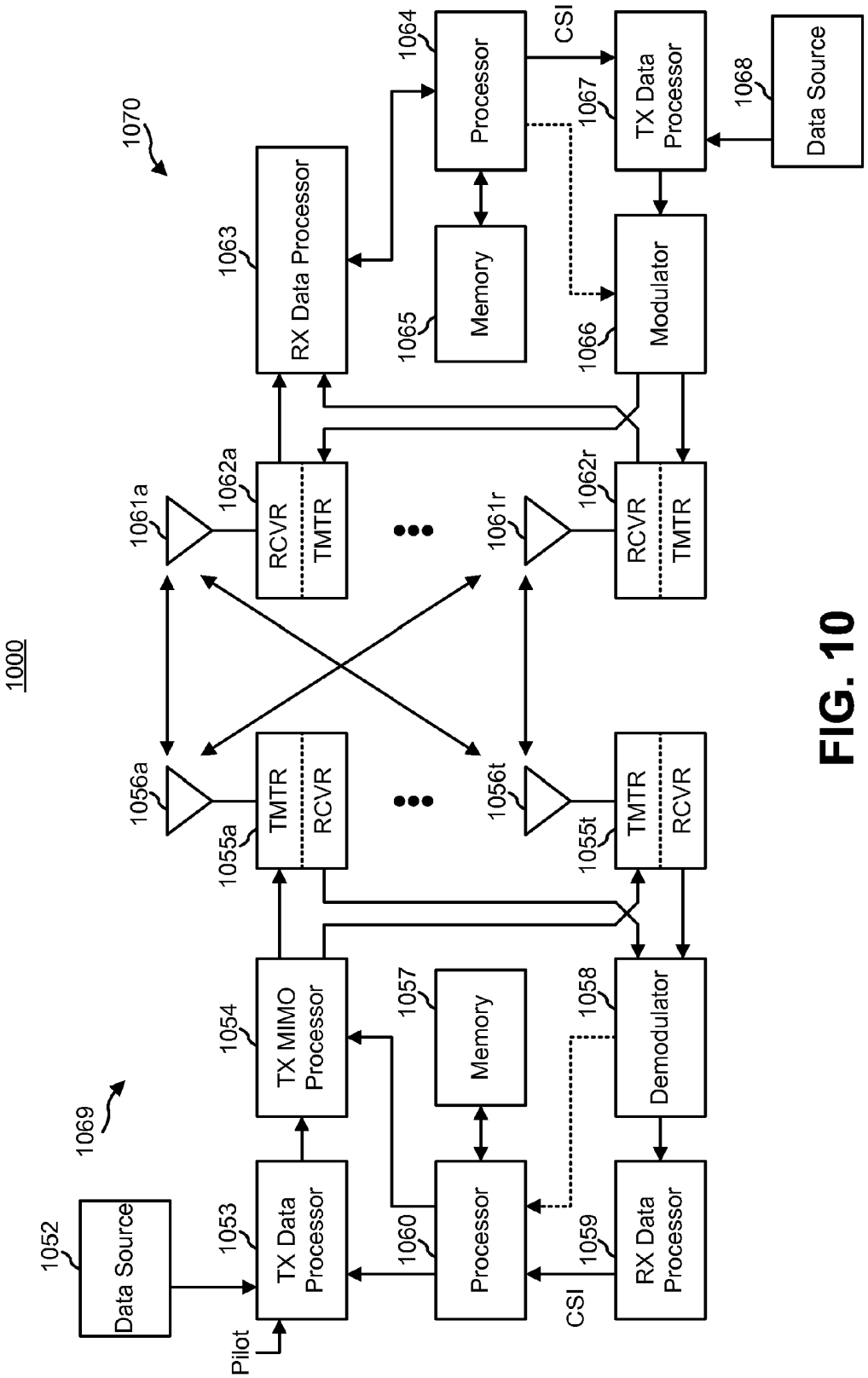

1000
1070
1069
1052
Data Source
1053
TX Data Processor
Pilot
1054
TX MIMO Processor
1056a
1055a
TMTR
RCVR
1061a
1062a
RCVR
TMTR
1063
RX Data Processor
1064
Processor
CSI
1067
TX Data Processor
1068
Data Source
1065
Memory
1066
Modulator
1061r
1062r
RCVR
TMTR
1056t
1055t
TMTR
RCVR
1057
Memory
1058
Demodulator
1060
Processor
CSI
1059
RX Data Processor

FIG. 10

556

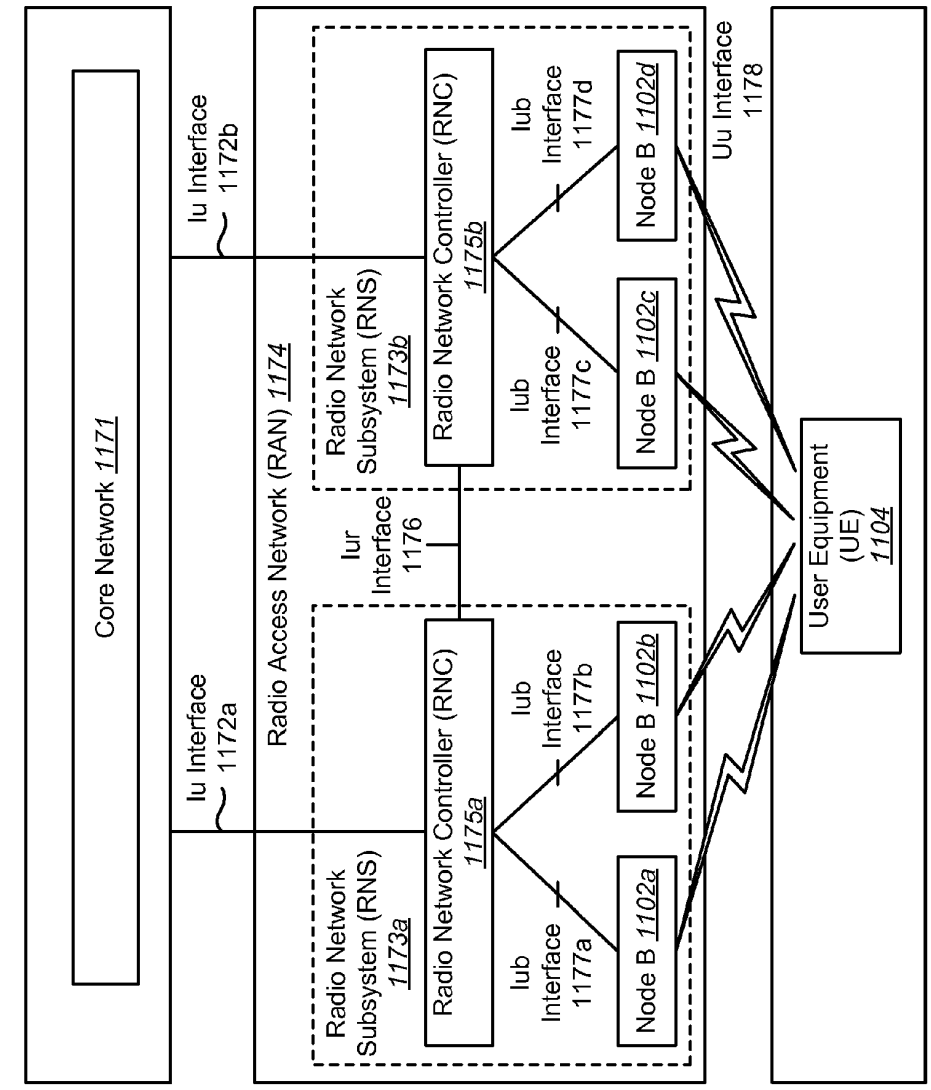

1100
Core Network 1171
Iu Interface 1172a
Iu Interface 1172b
Radio Access Network (RAN) 1174
Radio Network Subsystem (RNS) 1173a
Radio Network Controller (RNC) 1175a
Iub Interface 1177a
Iub Interface 1177b
Node B 1102a
Node B 1102b
Iur Interface 1176
Radio Network Subsystem (RNS) 1173b
Radio Network Controller (RNC) 1175b
Iub Interface 1177c
Iub Interface 1177d
Node B 1102c
Node B 1102d
Uu Interface 1178
User Equipment (UE) 1104

FIG. 11

557

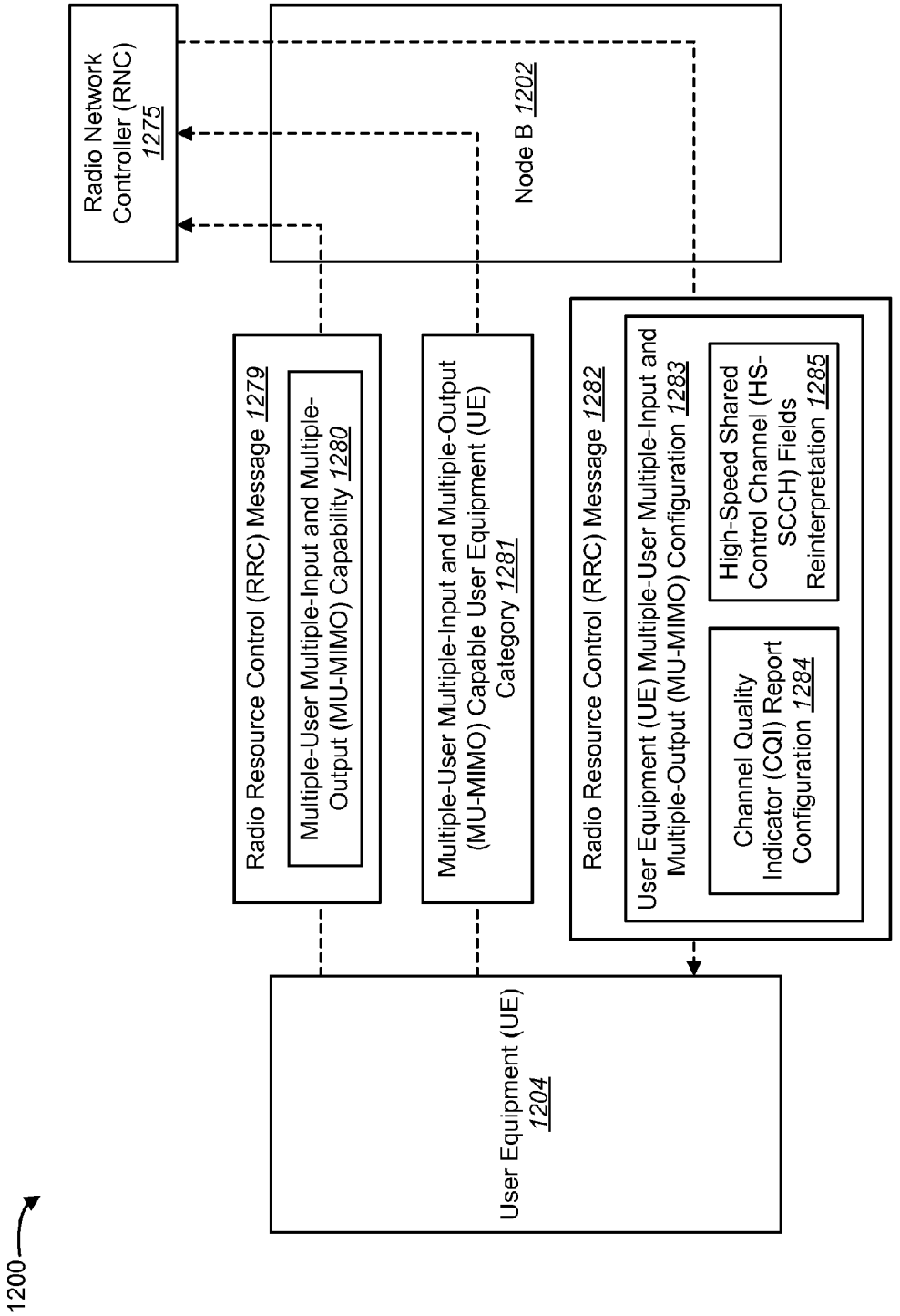

1200
Radio Network Controller (RNC) 1275
Node B 1202
Radio Resource Control (RRC) Message 1279
Multiple-User Multiple-Input and Multiple-Output (MU-MIMO) Capability 1280
Multiple-User Multiple-Input and Multiple-Output (MU-MIMO) Capable User Equipment (UE) Category 1281
Radio Resource Control (RRC) Message 1282
User Equipment (UE) Multiple-User Multiple-Input and Multiple-Output (MU-MIMO) Configuration 1283
High-Speed Shared Control Channel (HS-SCCH) Fields Reinterpretation 1285
Channel Quality Indicator (CQI) Report Configuration 1284
User Equipment (UE) 1204
558

FIG. 12

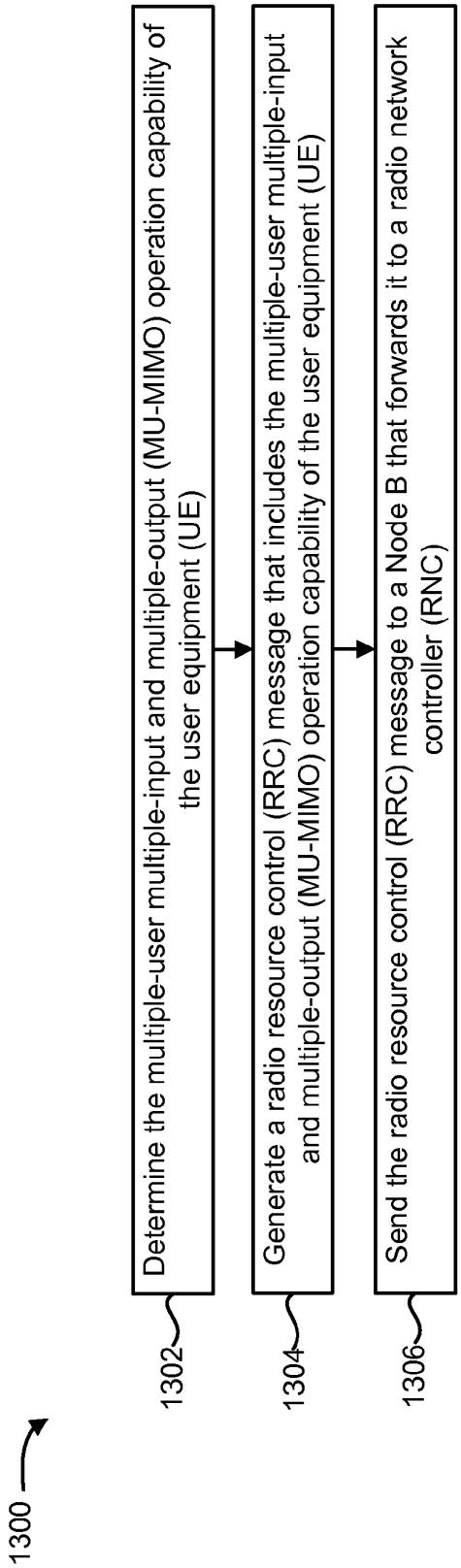

1300
1302
Determine the multiple-user multiple-input and multiple-output (MU-MIMO) operation capability of the user equipment (UE)
1304
Generate a radio resource control (RRC) message that includes the multiple-user multiple-input and multiple-output (MU-MIMO) operation capability of the user equipment (UE)
1306
Send the radio resource control (RRC) message to a Node B that forwards it to a radio network controller (RNC)

FIG. 13

559

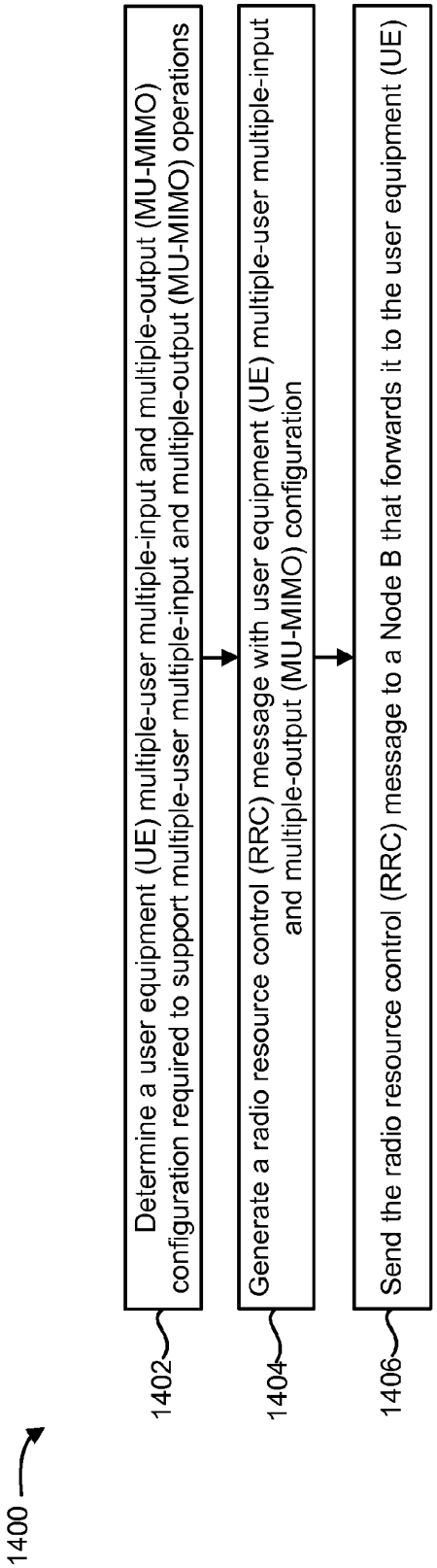

1400
1402
Determine a user equipment (UE) multiple-user multiple-input and multiple-output (MU-MIMO) configuration required to support multiple-user multiple-input and multiple-output (MU-MIMO) operations
1404
Generate a radio resource control (RRC) message with user equipment (UE) multiple-user multiple-input and multiple-output (MU-MIMO) configuration
1406
Send the radio resource control (RRC) message to a Node B that forwards it to the user equipment (UE)

FIG. 14

560

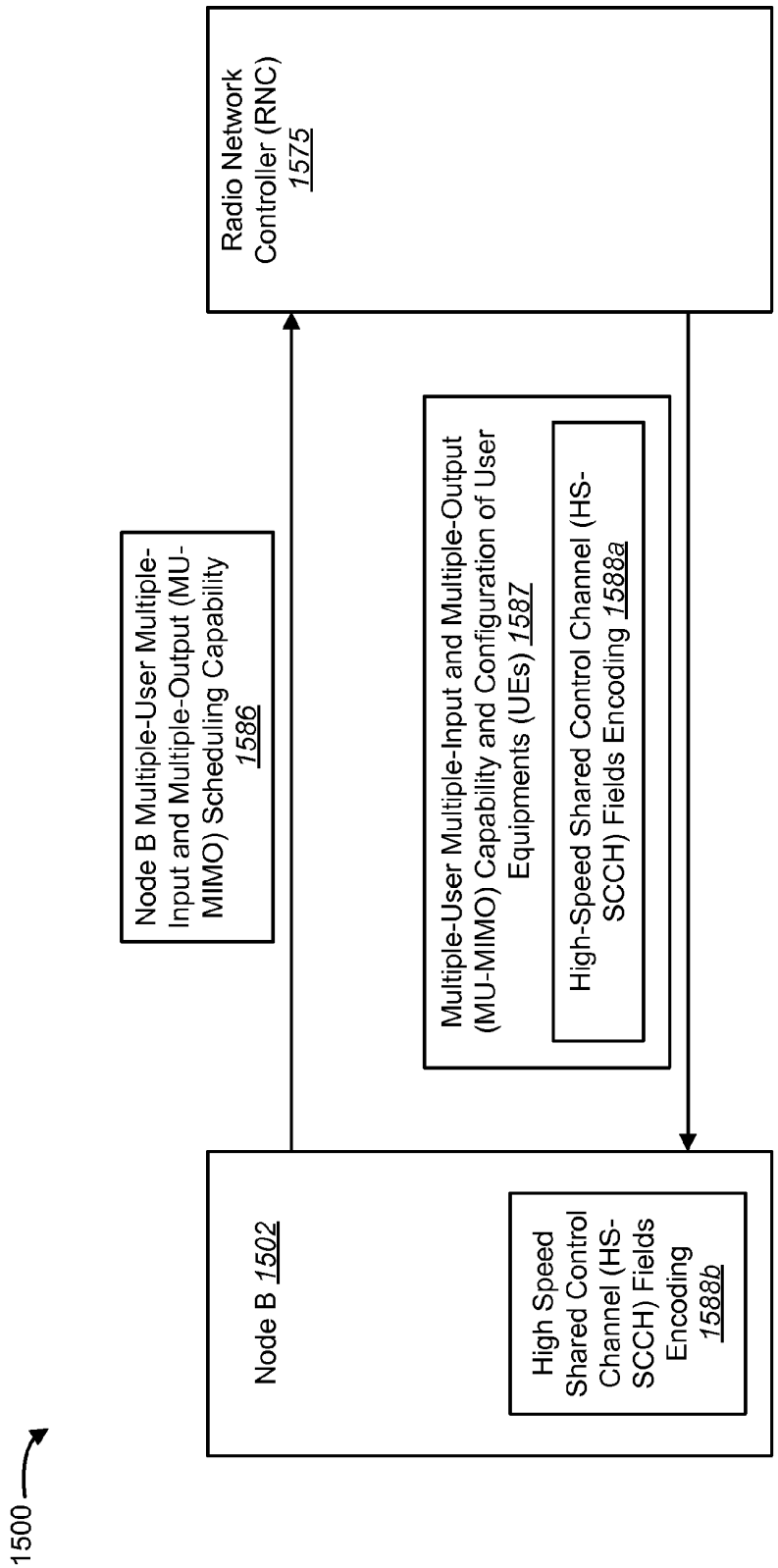

1500
Node B 1502
High Speed Shared Control Channel (HS-SCCH) Fields Encoding 1588b
Node B Multiple-User Multiple-Input and Multiple-Output (MU-MIMO) Scheduling Capability 1586
Multiple-User Multiple-Input and Multiple-Output (MU-MIMO) Capability and Configuration of User Equipments (UEs) 1587
High-Speed Shared Control Channel (HS-SCCH) Fields Encoding 1588a
Radio Network Controller (RNC) 1575
561

FIG. 15

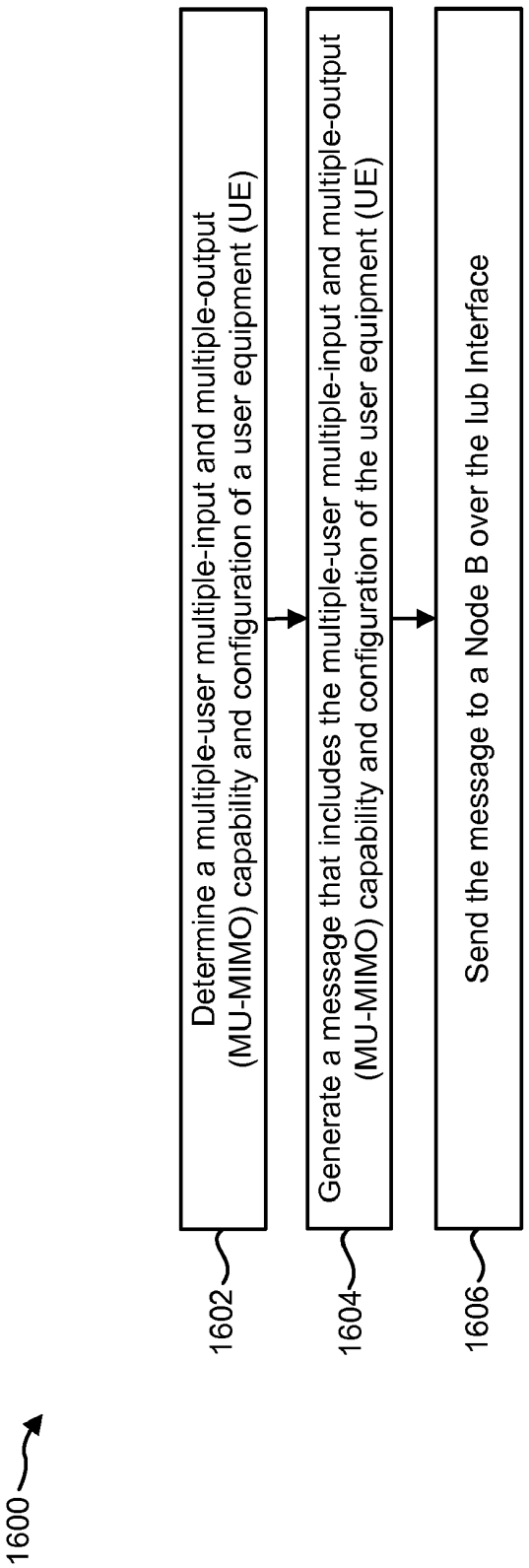

1600
Determine a multiple-user multiple-input and multiple-output (MU-MIMO) capability and configuration of a user equipment (UE)
Generate a message that includes the multiple-user multiple-input and multiple-output (MU-MIMO) capability and configuration of the user equipment (UE)
Send the message to a Node B over the Iub Interface
1602
1604
1606

FIG. 16

562

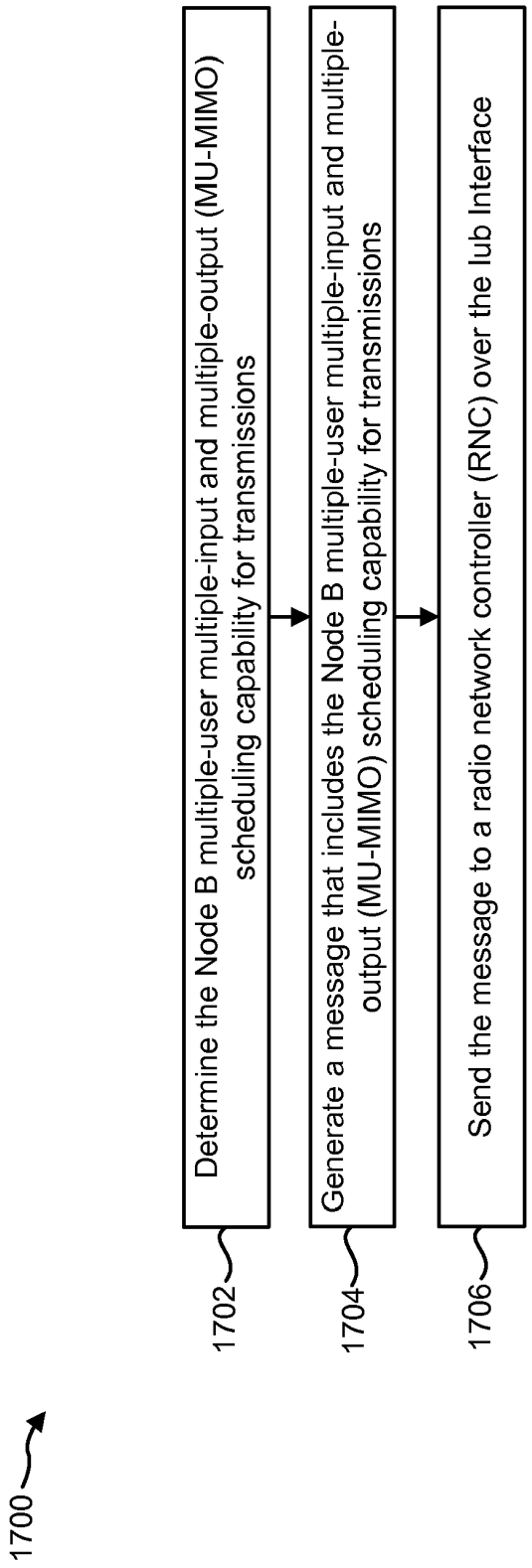

1700
Determine the Node B multiple-user multiple-input and multiple-output (MU-MIMO) scheduling capability for transmissions
1702
Generate a message that includes the Node B multiple-user multiple-input and multiple-output (MU-MIMO) scheduling capability for transmissions
1704
Send the message to a radio network controller (RNC) over the Iub Interface
1706

FIG. 17

563

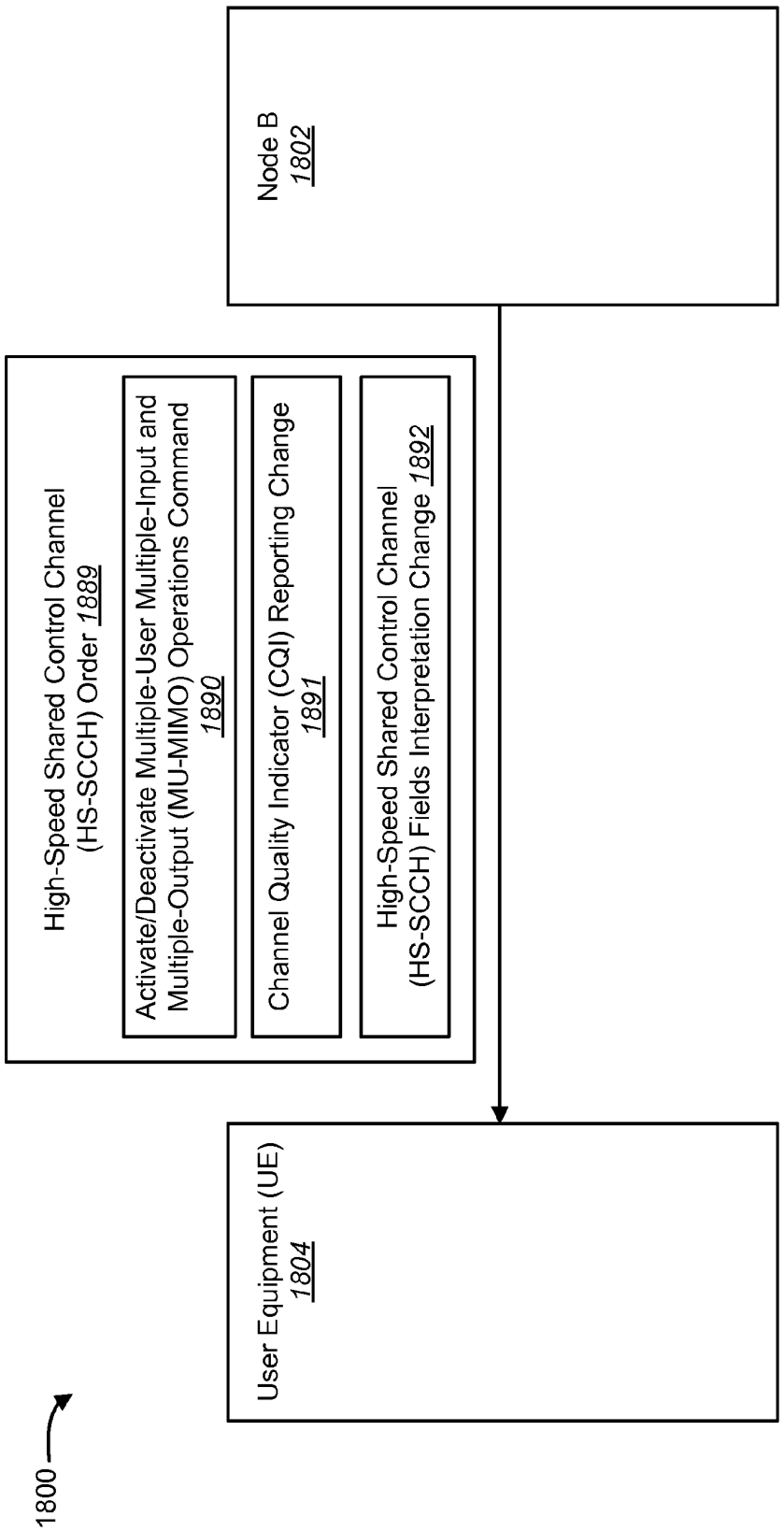

Node B
1802
High-Speed Shared Control Channel
(HS-SCCH) Order 1889
Activate/Deactivate Multiple-User Multiple-Input and Multiple-Output (MU-MIMO) Operations Command 1890
Channel Quality Indicator (CQI) Reporting Change 1891
High-Speed Shared Control Channel (HS-SCCH) Fields Interpretation Change 1892
User Equipment (UE)
1804
1800
564

FIG. 18

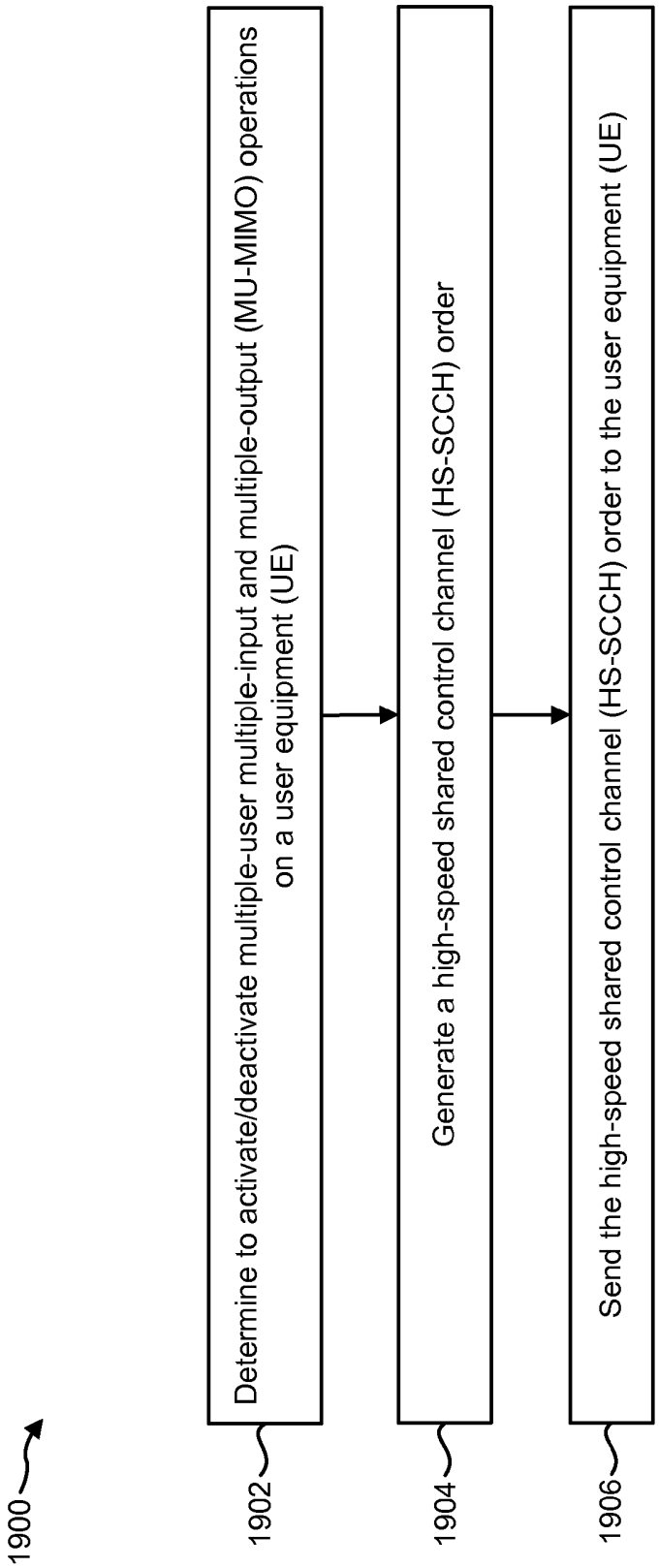

1900
Determine to activate/deactivate multiple-user multiple-input and multiple-output (MU-MIMO) operations on a user equipment (UE)
1902
Generate a high-speed shared control channel (HS-SCCH) order
1904
Send the high-speed shared control channel (HS-SCCH) order to the user equipment (UE)
1906

FIG. 19

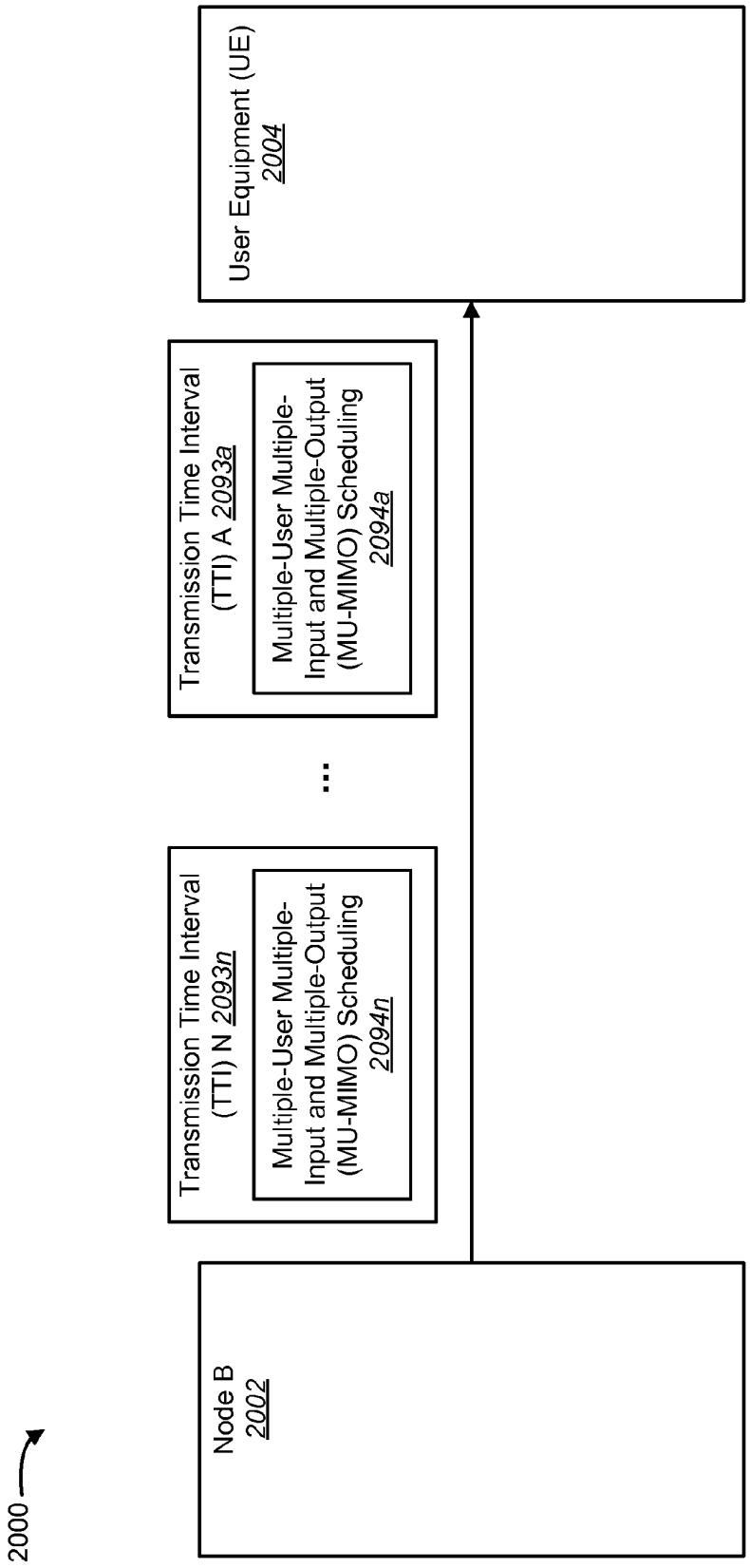

2000
Node B
2002
Transmission Time Interval (TTI) N 2093n
Multiple-User Multiple-Input and Multiple-Output (MU-MIMO) Scheduling 2094n
...
Transmission Time Interval (TTI) A 2093a
Multiple-User Multiple-Input and Multiple-Output (MU-MIMO) Scheduling 2094a
User Equipment (UE)
2004

FIG. 20

566

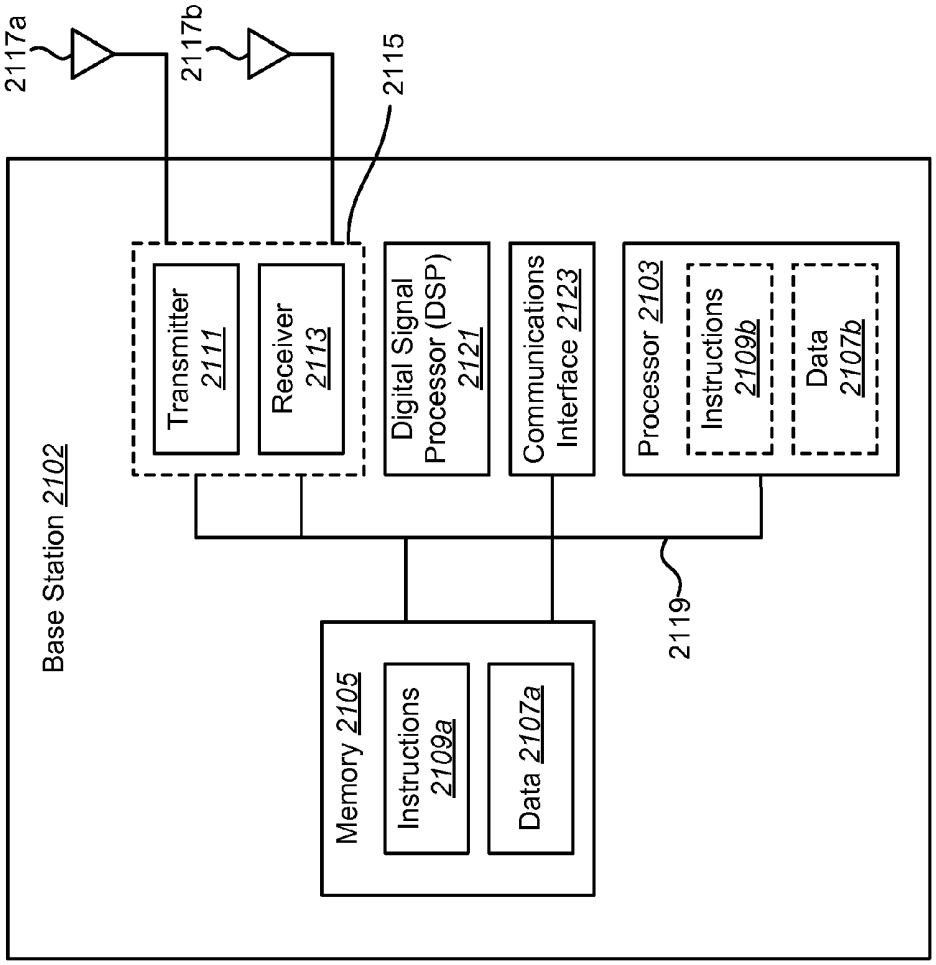

2117a
2117b
2115
Base Station 2102
Transmitter 2111
Receiver 2113
Digital Signal Processor (DSP) 2121
Communications Interface 2123
Processor 2103
Instructions 2109b
Data 2107b
2119
Memory 2105
Instructions 2109a
Data 2107a

FIG. 21

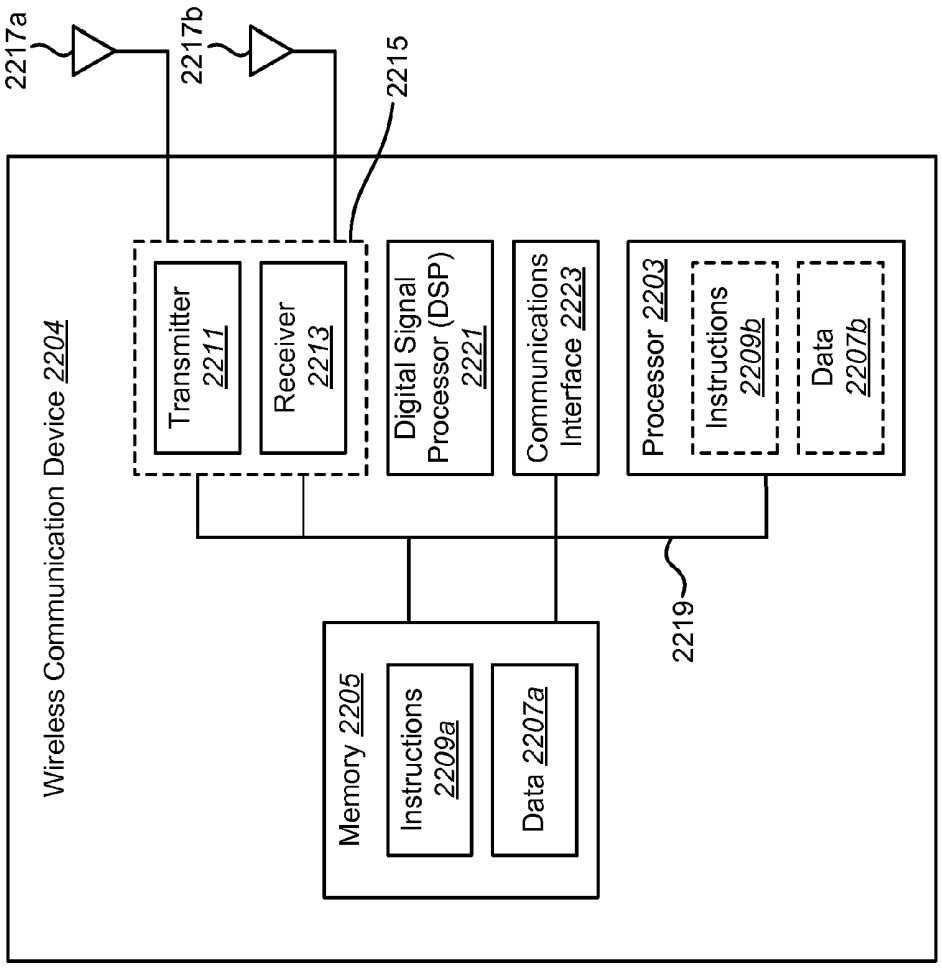

2217a
2217b
2215
Wireless Communication Device 2204
Transmitter 2211
Receiver 2213
Digital Signal Processor (DSP) 2221
Communications Interface 2223
Processor 2203
Instructions 2209b
Data 2207b
2219
Memory 2205
Instructions 2209a
Data 2207a

FIG. 22

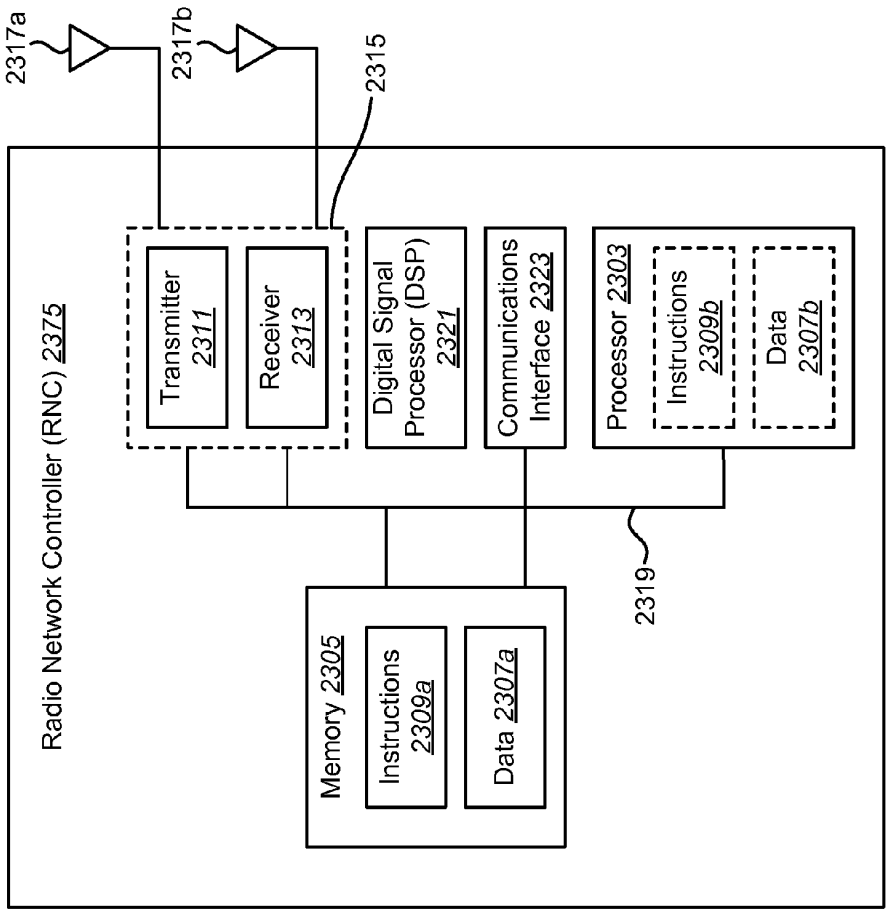

2317a
2317b
2315
Radio Network Controller (RNC) 2375
Transmitter 2311
Receiver 2313
Digital Signal Processor (DSP) 2321
Communications Interface 2323
Processor 2303
Instructions 2309b
Data 2307b
2319
Memory 2305
Instructions 2309a
Data 2307a

FIG. 23

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SIGNALLING OF MULTIPLE-USER MULTIPLE-INPUT AND MULTIPLE-OUTPUT TRANSMISSIONS IN HIGH-SPEED PACKET ACCESS SYSTEMS

RELATED APPLICATIONS

[0001] This application is related to and claims priority from U.S. Provisional Patent Application Ser. No. 61/262,115, filed Nov. 17, 2009, for "SIGNALING OF MU-MIMO TRANSMISSIONS FROM NODE-B."

TECHNICAL FIELD

[0002] The present disclosure relates generally to wireless communication systems. More specifically, the present disclosure relates to systems and methods for signaling of multiple-user multiple-input and multiple-output (MU-MIMO) transmissions in high-speed packet access (HSPA) systems.

BACKGROUND

[0003] Wireless communication systems are widely deployed to provide various types of communication content such as voice, video, data, and so on. These systems may be multiple-access systems capable of supporting simultaneous communication of multiple terminals with one or more base stations.

[0004] A problem that must be dealt with in all communication systems is fading or other interference. There may be problems with decoding the signals received. One way to deal with these problems is by utilizing beamforming. With beamforming, instead of using each transmit antenna to transmit a spatial stream, the transmit antennas each transmit a linear combination of the spatial streams, with the combination being chosen so as to optimize the response at the receiver.

[0005] Smart antennas are arrays of antenna elements, each of which receive a signal to be transmitted with a predetermined phase offset and relative gain. The net effect of the array is to direct a (transmit or receive) beam in a predetermined direction. The beam is steered by controlling the phase and gain relationships of the signals that excite the elements of the array. Thus, smart antennas direct a beam to each individual mobile unit (or multiple mobile units) as opposed to radiating energy to all mobile units within a predetermined coverage area (e.g., 120°) as conventional antennas typically do. Smart antennas increase system capacity by decreasing the width of the beam directed at each mobile unit and thereby decreasing interference between mobile units. Such reductions in interference result in increases in signal-to-interference and signal-to-noise ratios that improve performance and/or capacity. In power controlled systems, directing narrow beam signals at each mobile unit also results in a reduction in the transmit power required to provide a given level of performance.

[0006] Wireless communication systems may use beamforming to provide system-wide gains. In beamforming, multiple antennas on the transmitter may steer the direction of transmissions towards multiple antennas on the receiver. Beamforming may reduce the signal-to-noise ratio (SNR). Beamforming may also decrease the amount of interference received by terminals in neighboring cells. Benefits may be realized by providing improved beamforming techniques.

SUMMARY

[0007] A method for signaling multiple-user multiple-input and multiple-output in a high speed packet access system is described. A multiple-user multiple-input and multiple-output parameter is determined. A message that includes the multiple-user multiple-input and multiple-output parameter is generated. The message is sent to a wireless device.

[0008] The method may be performed by a radio network controller. The wireless device may be a Node B that forwards the message to a user equipment. The multiple-user multiple-input and multiple-output parameter may include a user equipment multiple-user multiple-input and multiple-output configuration required of the user equipment to support multiple-user multiple-input and multiple-output operations. The message may be a radio resource control message.

[0009] The multiple-user multiple-input and multiple-output parameter may also include a channel quality indicator report configuration. The multiple-user multiple-input and multiple-output parameter may further include a high-speed shared control channel fields reinterpretation. The method may be performed by a user equipment. The wireless device may then be a Node B that forwards the message to a radio network controller.

[0010] The multiple-user multiple-input and multiple-output parameter may include a multiple-user multiple-input and multiple-output operation capability of the user equipment. The message may be a radio resource control message. The multiple-user multiple-input and multiple-output parameter may include a multiple-user multiple-input and multiple-output capable user equipment category.

[0011] The method may be performed by a Node B. The wireless device may be a radio network controller. The multiple-user multiple-input and multiple-output parameter may include a Node B multiple-user multiple-input and multiple-output scheduling capability.

[0012] The multiple-user multiple-input and multiple-output parameter may include a multiple-user multiple-input and multiple-output capability and configuration of a user equipment being served by the Node B. The multiple-user multiple-input and multiple-output parameter may also include a new high-speed shared control channel fields encoding.

[0013] The wireless device may be a user equipment. The multiple-user multiple-input and multiple-output parameter may include multiple-user multiple-input and multiple-output scheduling information that is sent for each transmission time interval. The multiple-user multiple-input and multiple-output scheduling information may be sent via a high-speed shared control channel on a common high speed downlink shared channel—radio network temporary identifier, via certain bits of a channelization code set of a high-speed shared control channel or via a Type-3 dual stream high-speed shared control channel with a secondary transport block size set to 111111 and a corresponding redundancy version set to 0.

[0014] The user equipment may be transmit antenna array capable. The multiple-user multiple-input and multiple-output scheduling information may be sent via a combination of a modulation scheme and a number of transport blocks in a high-speed shared control channel. The multiple-user multiple-input and multiple-output scheduling information may also be sent via a hybrid automatic repeat request processing identification in a high-speed shared control channel.

[0015] The multiple-user multiple-input and multiple-output parameter may include a command to activate/deactivate multiple-user multiple-input and multiple-output operations on the user equipment. The message may be a high-speed shared control channel order. The high-speed shared control channel order may include a channel quality indicator reporting change for the user equipment or a high-speed shared control channel fields interpretation change for the user equipment.

[0016] A wireless device configured for signaling multiple-user multiple-input and multiple-output in a high speed packet access system is also described. The wireless device includes a processor, memory in electronic communication with the processor and instructions stored in the memory. The instructions are executable by the processor to determine a multiple-user multiple-input and multiple-output parameter. The instructions are also executable by the processor to generate a message that includes the multiple-user multiple-input and multiple-output parameter. The instructions are further executable by the processor to send the message to a second wireless device.

[0017] A wireless device configured for signaling multiple-user multiple-input and multiple-output in a high speed packet access system is described. The wireless device includes means for determining a multiple-user multiple-input and multiple-output parameter. The wireless device also includes means for generating a message that includes the multiple-user multiple-input and multiple-output parameter. The wireless device further includes means for sending the message to a wireless device.

[0018] A computer-program product for signaling multiple-user multiple-input and multiple-output in a high-speed packet access system is also described. The computer-program product includes a non-transitory computer-readable medium having instructions thereon. The instructions include code for causing a first wireless device to determine a multiple-user multiple-input and multiple-output parameter. The instructions also include code for causing a first wireless device to generate a message that comprises the multiple-user multiple-input and multiple-output parameter. The instructions further include code for causing the first wireless device to send the message to a second wireless device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. **1** shows a wireless communication system with multiple wireless devices;

[0020] FIG. **2** shows another wireless communication system with multiple wireless devices;

[0021] FIG. **3** is a flow diagram of a method for adjusting a data rate to account for inter-stream interference (ISI) in both single-user multiple-input and multiple-output (SU-MIMO) transmissions and multiple-user multiple-input and multiple-output (MU-MIMO) transmissions;

[0022] FIG. **4** is a block diagram illustrating a comparison table for pairing user equipments (UEs);

[0023] FIG. **5** is a block diagram illustrating a timeline with multiple transmission time intervals (TTIs);

[0024] FIG. **6** is a flow diagram of a method for sending channel quality indicator (CQI) feedback that accounts for inter-stream interference (ISI);

[0025] FIG. **7** is a timing diagram illustrating channel quality indicator (CQI) feedback cycles for user equipments (UEs);

[0026] FIG. **8** is a block diagram of a base station for use in the present systems and methods;

[0027] FIG. **9** is a block diagram of a wireless communication device for use in the present systems and methods;

[0028] FIG. **10** is a block diagram of a transmitter and receiver in a multiple-input and multiple-output (MIMO) system;

[0029] FIG. **11** is a block diagram illustrating a radio network operating according to Universal Mobile Telecommunications System (UMTS) standards;

[0030] FIG. **12** is a block diagram illustrating communications between a user equipment (UE), a Node B and a radio network controller (RNC) in a wireless communications network;

[0031] FIG. **13** is a flow diagram of a method for signaling a user equipment's (UE's) multiple-user multiple-input and multiple-output (MU-MIMO) operation capability from a user equipment (UE) to a radio network controller (RNC);

[0032] FIG. **14** is a flow diagram of a method for signaling a user equipment (UE) multiple-user multiple-input and multiple-output (MU-MIMO) configuration required to support multiple-user multiple-input and multiple-output (MU-MIMO) operations from a network to a user equipment (UE);

[0033] FIG. **15** is a block diagram illustrating communications between a Node B and a radio network controller (RNC) in a wireless communications network;

[0034] FIG. **16** is a flow diagram of a method for signaling the multiple-user multiple-input and multiple-output (MU-MIMO) capability and configuration of a user equipment (UE) from a radio network controller (RNC) to a Node B;

[0035] FIG. **17** is a flow diagram of a method for signaling a Node B multiple-user multiple-input and multiple-output (MU-MIMO) scheduling capability to a radio network controller (RNC);

[0036] FIG. **18** is a block diagram illustrating the transmission of a high-speed shared control channel (HS-SCCH) order from a Node B to a user equipment (UE) in a wireless communications network;

[0037] FIG. **19** is a flow diagram of a method for sending a high-speed shared control channel (HS-SCCH) order to a user equipment (UE);

[0038] FIG. **20** is a block diagram illustrating multiple-user multiple-input and multiple-output (MU-MIMO) scheduling transmitted from a Node B to a user equipment (UE) for every transmission time interval (TTI) in a wireless communications network;

[0039] FIG. **21** illustrates certain components that may be included within a base station;

[0040] FIG. **22** illustrates certain components that may be included within a wireless communication device; and

[0041] FIG. **23** illustrates certain components that may be included within a radio network controller (RNC).

DETAILED DESCRIPTION

[0042] The 3rd Generation Partnership Project (3GPP) is a collaboration between groups of telecommunications associations that aims to define a globally applicable 3rd generation (3G) mobile phone specification. 3GPP Long Term Evolution (LTE) is a 3GPP project aimed at improving the Universal Mobile Telecommunications System (UMTS) mobile phone standard. The 3GPP may define specifications for the next generation of mobile networks, mobile systems and mobile devices. In 3GPP LTE, a mobile station or device may be referred to as a "user equipment" (UE).

[0043] FIG. **1** shows a wireless communication system **100** with multiple wireless devices. Wireless communication systems **100** are widely deployed to provide various types of communication content such as voice, data, and so on. A wireless device may be a base station **102** or a wireless communication device **104**.

[0044] A base station **102** is a station that communicates with one or more wireless communication devices **104**. A base station **102** may also be referred to as, and may include some or all of the functionality of, an access point, a broadcast transmitter, a NodeB, an evolved NodeB, etc. The term "Base Station" will be used herein. Each base station **102** provides communication coverage for a particular geographic area. A base station **102** may provide communication coverage for one or more wireless communication devices **104**. The term "cell" can refer to a base station **102** and/or its coverage area depending on the context in which the term is used.

[0045] Communications in a wireless system (e.g., a multiple-access system) may be achieved through transmissions over a wireless link. Such a communication link may be established via a single-input and single-output (SISO), multiple-input and single-output (MISO) or a multiple-input and multiple-output (MIMO) system. A MIMO system includes transmitter(s) and receiver(s) equipped, respectively, with multiple (NT) transmit antennas and multiple (NR) receive antennas for data transmission. SISO and MISO systems are particular instances of a MIMO system. The MIMO system can provide improved performance (e.g., higher throughput, greater capacity or improved reliability) if the additional dimensionalities created by the multiple transmit and receive antennas are utilized.

[0046] The wireless communication system **100** may utilize MIMO. A MIMO system may support both time division duplex (TDD) and frequency division duplex (FDD) systems. In a TDD system, uplink **108***a-b* and downlink **106***a-b* transmissions are on the same frequency region so that the reciprocity principle allows the estimation of the downlink **106** channel from the uplink **108** channel. This enables a transmitting wireless device to extract transmit beamforming gain from communications received by the transmitting wireless device.

[0047] The wireless communication system **100** may be a multiple-access system capable of supporting communication with multiple wireless communication devices **104** by sharing the available system resources (e.g., bandwidth and transmit power). Examples of such multiple-access systems include code division multiple access (CDMA) systems, wideband code division multiple access (W-CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, single-carrier frequency division multiple access (SC-FDMA) systems, 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE) systems and spatial division multiple access (SDMA) systems.

[0048] The terms "networks" and "systems" are often used interchangeably. A CDMA network may implement a radio technology such as Universal Terrestrial Radio Access (UTRA), cdma2000, etc. UTRA includes W-CDMA and Low Chip Rate (LCR) while cdma2000 covers IS-2000, IS-95 and IS-856 standards. A TDMA network may implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA network may implement a radio technology such as Evolved UTRA (E-UTRA), IEEE 802.11, IEEE 802.16, IEEE 802.20, Flash-OFDMA, etc. UTRA, E-UTRA, and GSM are part of Universal Mobile Telecommunication System (UMTS). Long Term Evolution (LTE) is a release of UMTS that uses E-UTRA. UTRA, E-UTRA, GSM, UMTS and LTE are described in documents from an organization named "3rd Generation Partnership Project" (3GPP). cdma2000 is described in documents from an organization named "3rd Generation Partnership Project 2" (3GPP2). For clarity, certain aspects of the techniques are described below for LTE, and LTE terminology is used in much of the description below.

[0049] A base station **102** may communicate with one or more wireless communication devices **104**. For example, the base station **102** may communicate with a first wireless communication device **104***a* and a second wireless communication device **104***b*. A wireless communication device **104** may also be referred to as, and may include some or all of the functionality of, a terminal, an access terminal, a user equipment (UE), a subscriber unit, a station, etc. A wireless communication device **104** may be a cellular phone, a personal digital assistant (PDA), a wireless device, a wireless modem, a handheld device, a laptop computer, etc.

[0050] A wireless communication device **104** may communicate with zero, one, or multiple base stations **102** on the downlink **106** and/or uplink **108** at any given moment. The downlink **106** (or forward link) refers to the communication link from a base station **102** to a wireless communication device **104**, and the uplink **108** (or reverse link) refers to the communication link from a wireless communication device **104** to a base station **102**.

[0051] 3GPP Release 5 and later supports High-Speed Downlink Packet Access (HSDPA). 3GPP Release 6 and later supports High-Speed Uplink Packet Access (HSUPA). HSDPA and HSUPA are sets of channels and procedures that enable high-speed packet data transmission on the downlink and uplink. HSDPA and HSUPA are thus parts of the family of mobile telephony protocols named High-Speed Packet Access (HSPA). Release 7 HSPA+ uses three enhancements to improve data rate. First, support was introduced for 2×2 multiple-input and multiple-output (MIMO) on the downlink **106**. With MIMO, the peak data rate supported on the downlink **106** is 28 megabits per second (Mbps). Second, higher order modulation was introduced on the downlink **106**. The use of 64 quadrature amplitude modulation (QAM) on the downlink **106** allows peak data rates of 21 Mbps. Third, higher order modulation was introduced on the uplink **108**. The use of 16 QAM on the uplink **108** allows peak data rates of 11 Mbps.

[0052] In HSUPA, the base station **102** may allow several wireless communication devices **104** to transmit at a certain power level at the same time (using grants). These grants are assigned to wireless communication devices **104** by using a fast scheduling algorithm that allocates the resources on a short-term basis (i.e., on the order of tens of milliseconds (ms)). The rapid scheduling of HSUPA is well suited to the bursty nature of packet data. During periods of high activity, a wireless communication device **104** may get a larger percentage of the available resources, while getting little or no bandwidth during periods of low activity.

[0053] In 3GPP Release 5 HSDPA, a base station **102** may send downlink payload data to wireless communication devices on the High-Speed Downlink Shared Channel (HS-DSCH). A base station **102** may also send the control information associated with the downlink data on the High-Speed

Shared Control Channel (HS-SCCH). There are 256 Orthogonal Variable Spreading Factor (OVSF) codes (or Walsh codes) used for data transmission. In HSDPA systems, these codes are partitioned into Release 1999 (legacy system) codes that are typically used for cellular telephony (voice) and HSDPA codes that are used for data services. For each transmission time interval (TTI), the dedicated control information sent to an HSDPA-enabled wireless communication device **104** may indicate to the wireless communication device **104** which codes within the code space will be used to send downlink payload data to the wireless communication device **104** and the modulation that will be used for transmission of the downlink payload data.

[0054] With HSDPA operations, downlink transmissions to the wireless communication devices **104***a-b* may be scheduled for different transmission time intervals (TTIs) using the 15 available HSDPA Orthogonal Variable Spreading Factor (OVSF) codes. For a given transmission time interval (TTI), each wireless communication device **104** may be using one or more of the 15 HSDPA codes, depending on the downlink bandwidth allocated to the wireless communication device **104** during the transmission time interval (TTI). As discussed above, for each transmission time interval (TTI), the control information indicates to the wireless communication device **104** which codes within the code space will be used to send downlink payload data (data other than control data of the wireless communications system **100**) to the wireless communication device **104**, along with the modulation that will be used for the transmission of the downlink payload data.

[0055] Based on communications received from a base station **102**, a wireless communication device **104** may generate one or more channel quality indicators (CQIs) **112***a-b*. Each channel quality indicator (CQI) **112** may be a channel measurement for the downlink **106** channel between the base station **102** and the wireless communication device **104**. A channel quality indicator (CQI) **112** may be dependent on the transmission scheme used in the wireless communications system **100**. Because multiple-input and multiple-output (MIMO) communication is used between the base station **102** and the wireless communication device **104**, each channel quality indicator (CQI) **112** may correspond to a different downlink **106** channel (i.e., a different transmit antenna and receive antenna pair) between the base station **102** and the wireless communication device **104**.

[0056] A wireless communication device **104** may use the channel quality indicators (CQIs) **112** to determine a preferred beam **110***a-b*. A preferred beam **110** may refer to the antenna structure, weight, transmission direction and phase of a signal transmitted by the base station **102** to the wireless communication device **104**. The terms "beam" and "precoding vector" may refer to the direction in which data is streamed wirelessly from an antenna. In multiple-input and multiple-output (MIMO), multiple beams may be used to transmit information between a base station **102** and a wireless communication device **104**. A preferred beam may thus refer to a beam that produces the best (i.e., the optimal) data stream between the base station **102** and the wireless communication device **104**.

[0057] In Release 7 of HSPA, single-user MIMO (SU-MIMO) is used. When a wireless communication device **104** has good geometry (i.e., the wireless communication device **104** is in a good position relative to the base station **102**), the wireless communication device **104** may request dual-stream transmissions from the base station **102**. In dual-stream transmissions, the base station **102** may transmit a first data stream and a second data stream to a wireless communication device **104** during a transmission time interval (TTI). The first data stream and the second data stream may be transmitted on orthogonal antenna beams. It is inherent that one of the data streams (i.e., a preferred data stream) will have a higher throughput than the other. When a MIMO-capable wireless communication device **104** requests dual-stream transmission, the channel quality indicator (CQI) **112** of the preferred beam may be higher than that of an orthogonal beam used in addition to the preferred beam. Hence, transmitting on both data streams to a wireless communication device **104** may not result in the most efficient resource usage.

[0058] In contrast, multiple-user MIMO (MU-MIMO) may increase user throughputs on the downlink **106** over traditional SU-MIMO by making more intelligent use of the base station **102** resources. MU-MIMO may enable an increase in throughput for a particular transmission time interval (TTI) compared to dual-stream transmission to a single wireless communication device **104**. The downlink data stream selection module **114** may thus determine whether to use dual downlink data streams for a single wireless communication device **104** (i.e., SU-MIMO) or to use a first data stream for a first wireless communication device **104***a* and a second data stream that is orthogonal to the first data stream for a second wireless communication device **104***b* (i.e., MU-MIMO).

[0059] A channel quality indicator (CQI) **112** may correspond to a request for a single-stream transmission or a dual-stream transmission. As discussed above, a wireless communication device **104** may include multiple channel quality indicators (CQIs) **112**. The wireless communication device **104** may generate multiple channel quality indicators (CQIs) **112** for each transmission time interval (TTI). A wireless communication device **104** may not send every channel quality indicator (CQI) **112** to the base station **102** for every transmission time interval (TTI). In the current standard, a wireless communication device **104** may send only the optimal channel quality indicator (CQI) **112** to the base station **102** for each transmission time interval (TTI).

[0060] If the wireless communication device **104** determines that it has good geometry with respect to the base station **102** (i.e., the channel quality between the base station **102** and the wireless communication device **104** is above a threshold), the wireless communication device **104** may send an optimal dual-stream multiple-input and multiple-output (MIMO) channel quality indicator (CQI) **112** to the base station **102**. If the wireless communication device **104** determines that it has bad geometry with respect to the base station **102** (i.e., the channel quality between the base station **102** and the wireless communication device **104** is below the threshold), the wireless communication device **104** may send an optimal single-stream multiple-input and multiple-output (MIM) channel quality indicator (CQI) **112** to the base station **102**.

[0061] However, these channel quality indicators (CQIs) **112** do not take into account inter-stream interference (ISI). Inter-stream interference (ISI) refers to the interference that may occur when the base station **102** transmits multiple data streams simultaneously. If inter-stream interference (ISI) is not taken into account, a base station **102** may use a bit rate that the wireless communication device **104** is unable to decode.

[0062] Each wireless communication device **104** may include a channel quality indicator (CQI) feedback module

119*a-b*. A channel quality indicator (CQI) feedback module **119** may be used by the wireless communication device **104** to determine what channel quality indicator (CQI) **112** to send to the base station **102**. The channel quality indicator (CQI) feedback module **119** may generate some single-stream channel quality indicators (CQIs) **112** that are adjusted to account for inter-stream interference (ISI). In one configuration, the channel quality indicator (CQI) feedback module **119** may alternate between sending a channel quality indicator (CQI) **112** generated using Release 7 and a channel quality indicator (CQI) **112** adjusted for inter-stream interference (ISI) for each transmission time interval (TTI).

[0063] A wireless communication device **104** may transmit the channel quality indicators (CQIs) **112** to the base station **102** via the uplink **108** channel. The base station **102** may thus receive channel quality indicators (CQI) **116** from many wireless communication devices **104** corresponding to many downlink **106** channels. The base station **102** may include a downlink data stream selection module **114**. The downlink data stream selection module **114** may include the received channel quality indicators (CQIs) **116**. The downlink data stream selection module **114** may use the received channel quality indicators (CQIs) **116** to determine scheduling for each wireless communication device **104**. The downlink data stream selection module **114** is discussed in further detail below in relation to FIG. **2**.

[0064] The downlink data stream selection module **114** may include a data rate **121**. The data rate **121** may refer to the bit rate of a downlink **106** data stream. The downlink data stream selection module **114** may also include a multiple-user multiple-input and multiple output (MU-MIMO) adaptive outer loop margin **115**. The multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** may be an adjustment that the base station **102** applies to the data rate **121** for each channel quality indicator (CQI) **112** feedback cycle. If the channel quality indicator (CQI) **112** feedback cycle is 1, a wireless communication device **104** may report a channel quality indicator (CQI) **112** for each transmission time interval (TTI).

[0065] The multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** may be used by the base station **102** to increase or decrease the data rate **121** when a wireless communication device **104** sends a single-stream channel quality indicator (CQI) **112** and the base station **102** has determined to use a multiple-user multiple-input and multiple-output (MU-MIMO) transmissions.

[0066] The downlink data stream selection module **114** may also include a single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117**. The single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** may be used by the base station **102** to increase or decrease the data rate **121** when a wireless communication device **104** has requested either a single-stream or a dual-stream transmission and the base station **102** determines to use a single-user multiple-input and multiple-output (SU-MIMO) transmission or when the wireless communication device **104** has requested a dual-stream transmission and the base station **102** determines to use a multiple-user multiple-input and multiple-output (MU-MIMO) transmission. Both the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** and the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** may be adjusted/updated based upon the reception of a positive-acknowledgement/negative-acknowledgement (ACK/NACK) from a wireless communication device **104**. Single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margins **117** and multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margins **115** are discussed in additional detail below in relation to FIG. **3**.

[0067] FIG. **2** shows another wireless communication system **200** with multiple wireless devices. The wireless communication system **200** may include a Node B **202**. The Node B **202** of FIG. **2** may be one configuration of the base station **102** of FIG. **1**. The wireless communication system **200** may also include a first user equipment (UE) **204***a* and a second user equipment (UE) **204***b*. The first user equipment (UE) **204***a* and the second user equipment (UE) **204***b* of FIG. **2** may be one configuration of the wireless communication devices **104***a-b* of FIG. **1**.

[0068] The Node B **202** may include a downlink data stream selection module **214**. The downlink data stream selection module **214** of FIG. **2** may be one configuration of the downlink data stream selection module **114** of FIG. **1**. The downlink data stream selection module **214** may include a user equipment (UE) pairing module **222**. The user equipment (UE) pairing module **222** may determine one or more user equipment (UE) pairs **224**. A user equipment (UE) pair **224** may refer to two user equipments (UEs) **204** with preferred data streams **218** that are orthogonal to each other. User equipment (UE) pairs **224** are discussed in additional detail below in relation to FIG. **4**. The Node B **202** may also include a selected user equipment (UE) pair **225**. Since the Node B **202** can only transmit two orthogonal data streams at a time, only one user equipment (UE) pair **224** may be selected as the user equipment (UE) pair **225**. Optimization procedures may be used to determine the selected user equipment (UE) pair **225**.

[0069] The Node B **202** may select a user equipment (UE) pair **224** as the selected user equipment (UE) pair **225**. In one configuration, the Node B **202** may select a user equipment (UE) pair **224** if the sum rate of data streams for two different user equipments (UEs) **204** is larger than the UE-specific sum rate of the two data streams. For example, if the first user equipment (UE) **204***a* requests two data streams, the first user equipment (UE) **204***a* may report a preferred primary precoding vector b**1** and the two channel quality indicators (CQIs) **112** CQI**1** and CQI**2** that correspond to the preferred (strong) data stream **218***a* and the secondary (weak) data stream **220**, respectively. Similarly, if the second user equipment (UE) **204***b* requests two streams of data, the second user equipment (UE) **204***b* may report a preferred primary precoding vector b**2** and channel quality indicators (CQIs) **112** CQI**1'** and CQI**2'** for both data streams.

[0070] The preferred secondary precoding vector (that is orthogonal to b**1**) is b**2** and may be known by the base station **102** based on the preferred primary precoding vector b**1**. If CQI**1**>CQI**1'** and CQI**2**>CQI**2'**, the first user equipment (UE) preferred data stream **218***a* may be mapped to precoding vector b**1** and the second user equipment (UE) preferred data stream **218***b* may be mapped to precoding vector b**2**. The base station **102** may only be capable of sending a maximum of two data streams in a given transmission time interval (TTI) on orthogonal beams. Therefore, only user equipments (UEs) **204** that have orthogonal preferred beams **228** may be paired.

[0071] If both the first user equipment (UE) **204***a* and the second user equipment (UE) **204***b* request beams b**1** and b**2**, the Node B **202** may pair the two user equipments (UEs) **204**

on beams b1 and b2. If the Node B **202** finds this pairing to be maximizing a certain metric during the transmission time interval (TTI), the Node B **202** may schedule data streams to the selected user equipment (UE) pair **225** in the same transmission time interval (TTI) using the same orthogonal variable spreading factor (OVSF) codes **226**. An orthogonal variable spreading factor (OVSF) code **226** is an orthogonal code that facilitates uniquely identifying individual communication channels. One example of a metric that may be maximized is the sum proportional fair metric. In the sum proportional fair metric, the proportional fair metrics per stream are summed whenever MU-MIMO transmission is considered. Other metrics may also be used.

[0072] The Node B **202** may communicate with the first user equipment (UE) **204***a* during a first transmission time interval (TTI) using SU-MIMO. For example, the Node B **202** may transmit a first user equipment (UE) preferred data stream **218***a* to the first user equipment (UE) **204***a* using a first preferred beam **228***a*. The Node B **202** may also transmit a first user equipment (UE) secondary data stream **220***a* to the first user equipment (UE) **204***a* using a first secondary beam **230***a*. The first preferred beam **228***a* and the first secondary beam **230***a* may be orthogonal to each other.

[0073] During a second transmission time interval (TTI), the Node B **202** may communicate with the second user equipment (UE) **204***b*. For example, the Node B **202** may transmit a second user equipment (UE) preferred data stream **218***b* to the second user equipment (UE) **204***b* using a second preferred beam **228***b*. The Node B **202** may also transmit a second user equipment (UE) secondary data stream **220***b* to the second user equipment (UE) **204***b* using a second secondary beam **230***b*. The second preferred beam **228***b* and the second secondary beam **230***b* may be orthogonal to each other.

[0074] Sending two data streams on orthogonal beams to the same user equipment (UE) **204** may not result in the best resource usage for the wireless communication system **200**. In other words, sending two data streams on orthogonal beams to the same user equipment (UE) **204** may not allocate power in the Node B **202** in the most efficient way because the preferred data stream **218** has a stronger channel quality indicator (CQI) **112** than a secondary data stream **220**. If the same amount of power is used to transmit each data stream, throughput for the secondary data stream **220** will be lower than throughput for the preferred data stream **218** (due to the secondary data stream **220** having a lower channel quality indicator (CQI)) **112**.

[0075] By using MU-MIMO instead of SU-MIMO, user throughputs on the downlink **106** may be increased by more intelligently using the resources of the Node B **202**. In MU-MIMO, the Node B **202** may find a first user equipment (UE) **204***a* and a second user equipment (UE) **204***b* with preferred beams **228** that are orthogonal to each other. The first user equipment (UE) **204***a* and the second user equipment (UE) **204***b* may be referred to as a user equipment (UE) pair **224**.

[0076] Instead of transmitting a dual stream (i.e., a preferred data stream **218** and a secondary data stream **220**) during one transmission time interval (TTI) to a user equipment (UE) **204**, the Node B **202** may transmit a first user equipment (UE) preferred data stream **218***a* to the first user equipment (UE) **204***a* while simultaneously transmitting a second user equipment (UE) preferred data stream **218***b* to the second user equipment (UE) **204***b*. Thus, the Node B **202** may refrain from transmitting a first user equipment (UE) secondary data stream **220***a* and a second user equipment (UE) secondary data stream **220***b*. The Node B **202** may transmit the first user equipment (UE) preferred data stream **218***a* and the second user equipment (UE) preferred data stream **218***b* using the same codes (e.g., an orthogonal variable spreading factor (OVSF) code **226** with a spreading factor of sixteen). Because the Node B **202** does not have to allocate power to a data stream with lower throughput, the throughput for the wireless communication system **200** may be improved.

[0077] The Node B **202** may transmit the first user equipment (UE) preferred data stream **218***a* using a first preferred beam **228***a*. The Node B **202** may transmit the first user equipment (UE) secondary data stream **220***a* using a first secondary beam **230***a*. The Node B **202** may transmit the second user equipment (UE) preferred data stream **218***b* using a second preferred beam **228***b*. The Node B **202** may also transmit the second user equipment (UE) secondary data stream **220***b* using a second secondary beam **230***b*. If the first user equipment (UE) **204***a* and the second user equipment (UE) **204***b* are a user equipment (UE) pair **224**, then the first preferred beam **228***a* and the second preferred beam **228***b* are orthogonal.

[0078] FIG. **3** is a flow diagram of a method **300** for adjusting a data rate **121** to account for inter-stream interference (ISI) in both single-user multiple-input and multiple-output (SU-MIMO) transmissions and multiple-user multiple-input and multiple-output (MU-MIMO) transmissions. The method **300** may be performed by a base station **102**. In one configuration, the base station **102** may be a Node B **202**. The method **300** of FIG. **3** requires no channel quality indicator (CQI) **112** reporting changes to the user equipments (UEs) **204** in communication with the base station **102**.

[0079] The base station **102** may receive **302** a channel quality indicator (CQI) **112** from a user equipment (UE) **204** requesting a single-stream transmission at a first data rate **121**. This channel quality indicator (CQI) **112** may not take into account the inter-stream interference (ISI) that may occur if the base station **102** uses a dual-stream transmission. If the channel quality indicator (CQI) **112** received is requesting a dual-stream transmission, the method **300** does not apply. This is because a user equipment (UE) **204** requesting dual-stream transmission requests a particular bit rate from the base station **102** on each stream that takes the inter-stream interference (ISI) into account.

[0080] After receiving a channel quality indicator (CQI) **112**, the base station **102** may determine **304** whether to use single-user multiple-input and multiple-output (SU-MIMO) or multiple-user multiple-input and multiple-output (MU-MIMO) for the data transmission. The base station **102** may use a ranking algorithm to determine whether to use single-user multiple-input and multiple-output (SU-MIMO) or multiple-user multiple-input and multiple-output (MU-MIMO) for the data transmission. The ranking algorithm is discussed in additional detail below.

[0081] If the base station **102** determines to use multiple-user multiple-input and multiple-output (MU-MIMO) for the data transmission, the base station **102** may adjust **306** the first data rate **121** by a multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** to obtain a second data rate **121**. The multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** may be positive or negative in the dB (logarithmic) domain. The multiple-user multiple-input and multiple-

output (MU-MIMO) adaptive outer loop margin **115** may be additive in the logarithm domain and multiplicative in the linear domain. In one configuration, the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** may not be constant; instead the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** may be updated whenever an ACK/NACK is received. In another configuration, the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** may be a constant. The base station **102** may then transmit **308** a data stream using multiple-user multiple-input and multiple-output (MU-MIMO) with the second data rate **121** to the user equipment (UE) **204**.

[0082] The base station **102** may receive **310** an ACK/NACK from the user equipment (UE) **204**. The base station **102** may then determine **312** whether an ACK or a NACK was received for the corresponding data transmission. If an ACK was received (i.e., the user equipment (UE) **204** was able to successfully decode the data transmission), the base station **102** may decrease **314** the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115**. In one configuration, the base station **102** may incrementally decrease **314** the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115**. In yet another configuration, the base station **102** may decrease **314** the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** using a function. The base station **102** may then wait to receive **302** another channel quality indicator (CQI) **112** from a user equipment (UE) **204**.

[0083] If a NACK was received (i.e., the user equipment (UE) **204** was unable to successfully decode the data transmission), the base station **102** may increase **316** the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115**. In one configuration, the base station **102** may incrementally increase **316** the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115**. In yet another configuration, the base station **102** may increase **316** the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** using a function. The base station **102** may then wait to receive **302** another channel quality indicator (CQI) **112** from a user equipment (UE) **204**.

[0084] If the base station **102** determines to use single-user multiple-input and multiple-output (SU-MIMO) for the data transmission, the base station **102** may adjust **318** the first data rate **121** by a single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** to obtain a third data rate **121**. The single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** may be positive or negative in the dB (logarithmic) domain. The single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** may be additive in the logarithm domain and multiplicative in the linear domain. In one configuration, the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** may not be constant; instead the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** may be updated whenever an ACK/NACK is received. In another configuration, the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** may be a constant. The base station **102** may then transmit **320** a data stream using single-user multiple-input and multiple-output (SU-MIMO) with the third data rate **121** to the user equipment (UE) **204**.

[0085] The base station **102** may receive **322** an ACK/NACK from the user equipment (UE) **204**. The base station **102** may then determine **324** whether an ACK or a NACK was received for the corresponding data transmission. If an ACK was received (i.e., the user equipment (UE) **204** was able to successfully decode the data transmission), the base station **102** may decrease **326** the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117**. In one configuration, the base station **102** may incrementally decrease **326** the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117**. In yet another configuration, the base station **102** may decrease **326** the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** using a function. The base station **102** may then wait to receive **302** another channel quality indicator (CQI) **112** from a user equipment (UE) **204**.

[0086] If a NACK was received (i.e., the user equipment (UE) **204** was unable to successfully decode the data transmission), the base station **102** may increase **328** the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117**. In one configuration, the base station **102** may incrementally increase **328** the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117**. In yet another configuration, the base station **102** may increase **328** the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** using a function. The base station **102** may then wait to receive **302** another channel quality indicator (CQI) **112** from a user equipment (UE) **204**.

[0087] Because the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** and the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** are dynamic, the method **300** of FIG. **3** may be referred to as the dual outer loop algorithm. One advantage of the dual outer loop algorithm is that no change to the channel quality indicator (CQI) **112** reporting protocol (e.g., the High-Speed Packet Access (HSPA) standards established by 3GPP) is required. One possible disadvantage may be that the single-user multiple-input and multiple-output (SU-MIMO) adaptive outer loop margin **117** and the multiple-user multiple-input and multiple-output (MU-MIMO) adaptive outer loop margin **115** may change relatively slowly, inhibiting optimal performance.

[0088] FIG. **4** is a block diagram illustrating a comparison table for pairing user equipments (UEs) **404**. In the table, five user equipments (UEs) **404***a-e* are compared to determine user equipment (UE) pairs **432**. Each of the user equipments (UEs) **404** is dual-stream capable. However, only the preferred beam **228** for each user equipment (UE) **404** is compared with the preferred beam **228** for each other user equipment (UE) **404**.

[0089] A user equipment (UE) pair **432** occurs when the preferred beam **228** for one user equipment (UE) **404** is orthogonal to the preferred beam **228** for another user equipment (UE) **404**. For example, the preferred beam **228** for UE**1** **404***a* may be orthogonal to the preferred beam **228** for UE**4** **404***d*. Thus, UE**1** **404***a* and UE**4** **404***d* are a user equipment (UE) pair **432***a*. As another example, the preferred beam **228** for UE**2** **404***b* may be orthogonal to the preferred beam **228** for UE**3** **404***c*. Thus, UE**2** **404***b* and UE**3** **404***c* are a user

equipment (UE) pair **432***b*. If the preferred beams **228** for user equipments (UEs) **404** are not orthogonal, the matchup may be listed as non-orthogonal. A user equipment (UE) **404** may have a preferred beam **228** that is orthogonal to the preferred beams **228** of multiple user equipments (UEs) **404**. A user equipment (UE) **404** may also have a preferred beam **228** that is orthogonal to none of the preferred beams **228** of the user equipments (UEs) **404** available for pairing. For example, UE**5** **404***e* is shown as having a preferred beam **228** that is non-orthogonal to the preferred beams **228** of the other user equipments (UEs) **404**.

[0090] In case of multiple user equipment (UE) pairs **432**, a base station **102** may select one of the user equipment (UE) pairs **432**. Many different methods may be used for selecting one of the user equipment (UE) pairs **432**. For example, a sum proportional fair metric may be used.

[0091] Usually scheduling aims to maximize a utility function $U(R_1(t), \ldots, R_N(t))$ by allocating resources per transmission time interval (TTI) to certain users. The utility function for proportional fairness is given in Equation (1):

$$U(R_1(t), \ldots, R_N(t)) = \sum_{i=1}^{N} \log(R_i(t)) \longrightarrow \max. \quad (1)$$

[0092] In Equation (1) $R_i(t)$ denotes the average throughput of user i at time t. Assuming one stream, Equation (1) is equivalent to the resource allocation rule per transmission time interval (TTI) in Equation (2):

$$\max_{\delta_i} \sum_{i=1}^{N} \frac{\delta_i \cdot r_i(t)}{R_i(t)}, \delta_i \in \{0, 1\}. \quad (2)$$

[0093] In Equation (2), $r_i(t)$ denotes the instantaneous rate the offers to user i at time t and $\delta_i \epsilon \{0,1\}$ indicates the resource allocation to user i. The task of the scheduler is to allocate resources per transmission time interval (TTI) (i.e., to choose the indices δ_i in order to maximize the utility function). The resource allocation rule can be generalized for SU-MIMO in Equation (3):

$$\max_{\delta_i} \sum_{i=1}^{N} \frac{\delta_i \sum_{j=1}^{M} r_{ij}(t)}{R_i(t)}, \delta_i \in \{0, 1\}. \quad (3)$$

[0094] For a 2×2 MU-MIMO, the rule to pair the users i_1 and i_2 is given in Equation (4):

$$\max_{\substack{i_1, i_2 \in [1 \ldots \ldots N] \\ i_1 \neq i_2}} \left(\max \left(\frac{r_{i_1 1}(t)}{R_{i_1}(t)} + \frac{r_{i_2 2}(t)}{R_{i_2}(t)}; \frac{r_{i_1 2}(t)}{R_{i_1}(t)} + \frac{r_{i_2 1}(t)}{R_{i_2}(t)} \right) \right). \quad (4)$$

[0095] The pairing algorithm decides which users and streams are paired per transmission time interval (TTI) according to the MU-MIMO proportional fair rule. The pairing algorithm then determines V precoding vectors b_k, k=1 . . . 4 and all candidate users u_j per transmission time interval (TTI). The candidate sets are $U(b_k)=\{(u_j, CQI(b_k)\}$, where b_k is a preferred primary precoding vector for u_j. Candidate users do not require a rank-2 CQI report. Precoding vectors b_k and b_{5-k} are assumed to be orthogonal. The user pairs for MU-MIMO transmission may then be determined using one or more approaches. In a first approach, the user pairs $(u_i, u_j) \epsilon (U(b_k), U(b_{5-k}))$ can be scheduled. For linear receivers, the preferred precoding vector offers a better CQI. This approach works irrespective of the receiver architecture.

[0096] A ranking algorithm may then be used. The ranking algorithm may identify per transmission time interval (TTI) the highest prioritized MU-MIMO pairs and the highest prioritized SU-MIMO users. A user is called eligible if it has a free HARQ process and data in its MAC priority queue(s). The reported CQI (quantized signal to noise ratio (SNR) in decibels (dB)) may be mapped to a spectral efficiency (in bits/symbol) for each eligible user.

[0097] An SU-MIMO user ranking list may then be calculated for all eligible users according to the proportional fair rule. Single or dual stream SU-MIMO may be assumed for each eligible user depending on the reported channel rank. The highest prioritized MU-MIMO eligible pair according to the user pairing approach may be determined according to the proportional fair rule. If needed, the spectral efficiencies may be rescaled to account for the power split between the paired users. Based on a priority comparison, either the highest prioritized user from the SU-MIMO ranking list or the highest prioritized MU-MIMO user pair may be scheduled in the instantaneous transmission time interval (TTI) (assuming that only one user for SU-MIMO or one user pair for MU-MIMO is scheduled per transmission time interval (TTI)). A CQI mapping table may then be used.

[0098] FIG. **5** is a block diagram illustrating a timeline **500** with multiple transmission time intervals (TTIs) **538**. A Node B **502** may communicate with a first user equipment (UE) **504***a*, a second user equipment (UE) **504***b* and a third user equipment (UE) **504***c*. During a first transmission time interval (TTI) **538***a*, the first user equipment (UE) **504***a* and the second user equipment (UE) **504***b* may be part of a first user equipment (UE) pair **534***a*. The Node B **502** may transmit **536** on orthogonal preferred data streams **218** to the first user equipment (UEs) pair **534** (i.e., to the first user equipment (UE) **504***a* using a first user equipment (UE) preferred data stream **218***a* and to the second user equipment (UE) **504***b* using a second user equipment (UE) preferred data stream **218***b*) during the first transmission time interval (TTI) **538***a*.

[0099] After the first transmission time interval (TTI) **538***a*, the Node B **502** may evaluate **540** received channel quality indicators (CQIs) **112** and reselect the user equipment (UE) pair **534**. For example, the Node B **502** may select a second user equipment (UE) pair **534***b* for a second transmission time interval (TTI) **538***b*. The second user equipment (UE) pair **534***b* may include the second user equipment (UE) **504***b* and the third user equipment (UE) **504***c*. The Node B **502** may then transmit **542** on the orthogonal preferred data streams **218** to the selected user equipment (UE) pair **534***b* (i.e., to the second user equipment (UE) **504***b* using a second user equipment (UE) preferred data stream **218***b* and to the third user equipment (UE) **504***c* using a third user equipment (UE) preferred data stream (not shown)) during the second transmission time interval (TTI) **538***b*.

[0100] FIG. **6** is a flow diagram of a method **600** for sending channel quality indicator (CQI) **112** feedback that accounts for inter-stream interference (ISI). The method **600** may be

performed by a user equipment (UE) **204**. The user equipment (UE) **204** may be operating in a High-Speed Packet Access (HSPA) system. In the method **600** of FIG. **6**, no standards changes are necessary for the base station **102** receiving the channel quality indicators (CQIs) **112**.

[0101] The user equipment (UE) **204** may determine **602** an optimal single-stream multiple-input and multiple-output (MIMO) channel quality indicator (CQI) **112** that is adjusted for inter-stream interference (ISI). Whenever the user equipment (UE) **204** computes a channel quality indicator (CQI) **112** along a beam for multiple-user multiple-input and multiple-output (MU-MIMO), the user equipment (UE) **204** may assume 50% of the power on the beam that is orthogonal to it. This is enough to obtain a channel quality indicator (CQI) **112** that is adjusted for inter-stream interference (ISI).

[0102] There may be four possible single-stream channel quality indicators (CQIs) **112** to choose from. In some configurations of High-Speed Packet Access (HSPA), single-stream multiple-input and multiple-output (MIMO) channel quality indicators (CQIs) **112** may not account for inter-stream interference (ISI), leading to a base station **102** transmitting at an overly optimistic data rate **121** (i.e., a large transmit block size (TBS)) to the user equipment (UE) **204** if the base station **102** is using multiple-user multiple-input and multiple-output (MU-MIMO). The user equipment (UE) **204** may send **604** the optimal adjusted MIMO channel quality indicator (CQI) **112** to a Node B **202**.

[0103] The user equipment (UE) **204** may then determine **606** an optimal multiple-input and multiple-output (MIMO) channel quality indicator (CQI) **112**. The optimal multiple-input and multiple-output (MIMO) channel quality indicator (CQI) **112** may request either a single-stream or a dual-stream data transmission. The optimal multiple-input and multiple-output (MIMO) channel quality indicator (CQI) **112** may be a channel quality indicator (CQI) **112** that is generated according to Release 7. The decision between an optimal single-stream channel quality indicator (CQI) **112** and an optimal dual-stream channel quality indicator (CQI) **112** within a transmission time interval (TTI) **538** may be performed according to the High-Speed Packet Access protocol (e.g., Release 7).

[0104] There may be four possible single-stream channel quality indicators (CQIs) **112** and two possible dual-stream channel quality indicators (CQIs) **112**. The user equipment (UE) **204** may calculate the optimal multiple-input and multiple-output (MIMO) channel quality indicator (CQI) **112** as the best of the six possible channel quality indicators (CQIs) **112**. The optimal multiple-input and multiple-output (MIMO) channel quality indicator (CQI) **112** may refer to a regular channel quality indicator (CQI) **112** as it is fed back by the user equipment (UE) **204** to a Node B **202** according to Release 7. The user equipment (UE) **204** may send **608** the optimal multiple-input and multiple-output (MIMO) channel quality indicator (CQI) **112** to the Node B **202**. The user equipment (UE) **204** may then return to determining **602** an optimal single-stream multiple-input and multiple-output (MIMO) channel quality indicator (CQI) **112** that is adjusted for inter-stream interference (ISI).

[0105] In general, user equipments (UEs) **204** with good geometry may report dual-stream channel quality indicators (CQIs) **112** more often than single-stream channel quality indicators (CQIs) **112**. User equipments (UEs) **204** at the edge of a cell may report single-stream channel quality indicators (CQIs) **112** more often than dual-stream channel quality indicators (CQIs) **112**.

[0106] Thus, the user equipment (UE) **204** may alternate between sending a channel quality indicator (CQI) **112** that is generated as in Release 7 and a channel quality indicator (CQI) **112** that is adjusted for inter-stream interference (ISI). In other words, the user equipment (UE) **204** may interlace optimal single-stream channel quality indicators (CQIs) **112** that are adjusted for inter-stream interference (ISI) in between the optimal multiple-input and multiple-output (MIMO) channel quality indicators (CQIs) **112** (that are generated as in Release 7). Depending on a feedback cycle used by the user equipment (UE) **204**, the user equipment (UE) **204** may send one channel quality indicator (CQI) **112** for each transmission time interval (TTI) **538**.

[0107] One advantage of using the user equipment (UE) **204** solution (i.e., the method **600** of FIG. **6**) instead of the base station **102** solution (i.e., the method **300** of FIG. **3**) is that better performance may be obtained. In every transmission time interval (TTI) **538**, the base station **102** has access to a channel quality indicator (CQI) **112** for scheduling single-user multiple-input and multiple-output (SU-MIMO) transmissions and a channel quality indicator (CQI) **112** for scheduling multiple-user multiple-input and multiple-output (MU-MIMO) transmissions. The base station **102** may also use the best multiple-input and multiple-output (MIMO) channel quality indicator (CQI) **112** when scheduling single-user multiple-input and multiple-output (SU-MIMO) data transmissions. Each of these channel quality indicators (CQIs) **112** is outdated by at most one extra transmission time interval (TTI) **538** more than usual.

[0108] One consequence of using the user equipment (UE) **204** solution is that it may require changes to the channel quality indicator (CQI) **112** reporting protocol (e.g., the High-Speed Packet Access standards established by 3GPP). These changes may include implementing higher-layer messaging to configure the channel quality indicator (CQI) **112** feedback algorithm of the user equipment (UE) **204**.

[0109] FIG. **7** is a timing diagram illustrating channel quality indicator (CQI) **112** feedback cycles for user equipments (UEs) **772***a-b*. FIG. **7** is a timing diagram for the method **600** illustrated in FIG. **6**. Each box represents a channel quality indicator (CQI) **112** report for a given transmission time interval (TTI). As discussed above, a user equipment (UE) **772** may interlace optimal single-stream channel quality indicators (CQIs) **112** that are adjusted for inter-stream interference (ISI) in between the optimal multiple-input and multiple-output (MIMO) channel quality indicators (CQIs) **112** (referred to as an optimal Rel-7 channel quality indicator (CQI) **112**).

[0110] The optimal Rel-7 channel quality indicator (CQI) **112** for a bad geometry user equipment (UE) **772***a* may often be a single-stream channel quality indicator (CQI) **112** such as that used in the transmission time interval (TTI) n **773***a* and in the transmission time interval (TTI) n+2 **773***c*. In contrast, the optimal channel quality indicator (CQI) **112** for a good geometry user equipment (UE) **772***b* may often be a dual-stream channel quality indicator (CQI) **112** such as that used in the transmission time interval (TTI) n **774***a* and in the transmission time interval (TTI) n+2 **774***c*. In one configuration (i.e., in the channel quality indicator (CQI) **112** of transmission time interval (TTI) n+6 **774***d*), the optimal channel

quality indicator (CQI) **112** for a good geometry user equipment (UE) **772***b* may instead be a single-stream channel quality indicator (CQI) **112**.

[0111] The channel quality indicator (CQI) **112** reporting for either a bad geometry user equipment (UE) **772***a* or a good geometry user equipment (UE) **772***b* may be unchanged for every other transmission time interval (TTI) (e.g., n, n+2, n+4, etc.). In between these transmission time intervals (TTIs), both a bad geometry user equipment (UE) **772***a* and a good geometry user equipment (UE) **772***b* may determine and send an optimal single-stream channel quality indicator (CQI) **112** that has been adjusted for inter-stream interference (ISI) such as the channel quality indicator (CQI) **112** for the transmission time interval (TTI) n+1 **773***b* for the bad geometry user equipment (UE) **772***a* and the channel quality indicator (CQI) **112** for the transmission time interval (TTI) n+1 **774***b* for the good geometry user equipment (UE) **772***b* (e.g., for transmission time intervals (TTIs) n+1, n+3, n+5, etc.). FIG. **7** as illustrated is for a feedback cycle equal to 1. FIG. **7** may change accordingly for a feedback cycle that is greater than 1.

[0112] FIG. **8** is a block diagram of a base station **802** for use in the present systems and methods. The base station **802** of FIG. **8** may be one configuration of the base station **102** of FIG. **1**. The base station **802** may include a first transmit chain **846***a* and a second transmit chain **846***b*. The first transmit chain **846***a* may be used for a first data stream **818***a* and the second transmit chain **846***b* may be used for a second data stream **818***b*.

[0113] The first transmit chain **846***a* may include a first baseband transmit signal **844***a*. The first baseband transmit signal **844***a* may be modulated using a modulator **847***a*, converted from a digital signal to an analog signal using a digital-to-analog converter (DAC) **848***a*, frequency converted using a mixer **849***a*, amplified using an amplifier **850***a* and finally transmitted by a first antenna **851***a* as the first data stream **818***a*. Likewise, the second transmit chain **846***b* may include a second baseband transmit signal **844***b*. The second baseband transmit signal **844***b* may be modulated using a modulator **847***b*, converted from a digital signal to an analog signal using a digital-to-analog converter (DAC) **848***b*, frequency converted using a mixer **849***b*, amplified using an amplifier **850***b* and finally transmitted by a second antenna **851***b* as the second data stream **818***b*. As discussed above, the first data stream **818***a* and the second data stream **818***b* may be transmitted during the same transmission time interval (TTI) **538** using the same orthogonal variable spreading factor (OVSF) codes **226** with orthogonal beams.

[0114] FIG. **9** is a block diagram of a wireless communication device **904** for use in the present systems and methods. The wireless communication device **904** of FIG. **9** may be one configuration of the wireless communication devices **104** of FIG. **1**. The wireless communication device **904** may include a transmit chain **946**. The transmit chain **946** may be used for a data stream **918**.

[0115] The transmit chain **946** may include a baseband transmit signal **944**. The baseband transmit signal **944** may be modulated using a modulator **947**, converted from a digital signal to an analog signal using a digital-to-analog converter (DAC) **948**, frequency converted using a mixer **949**, amplified using an amplifier **950** and finally transmitted by an antenna **951** as the data stream **918**. The data stream **918** may include one or more channel quality indicators (CQIs) sent by the wireless communication device **904** to a base station **102**.

[0116] FIG. **10** is a block diagram of a transmitter **1069** and receiver **1070** in a multiple-input and multiple-output (MIMO) system **1000**. In the transmitter **1069**, traffic data for a number of data streams is provided from a data source **1052** to a transmit (TX) data processor **1053**. Each data stream may then be transmitted over a respective transmit antenna **1056***a* through **1056***t*. The transmit (TX) data processor **1053** may format, code, and interleave the traffic data for each data stream based on a particular coding scheme selected for that data stream to provide coded data.

[0117] The coded data for each data stream may be multiplexed with pilot data using OFDM techniques. The pilot data may be a known data pattern that is processed in a known manner and used at the receiver **1070** to estimate the channel response. The multiplexed pilot and coded data for each stream is then modulated (i.e., symbol mapped) based on a particular modulation scheme (e.g., binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), multiple phase shift keying (M-PSK) or multi-level quadrature amplitude modulation (M-QAM)) selected for that data stream to provide modulation symbols. The data rate, coding and modulation for each data stream may be determined by instructions performed by a processor.

[0118] The modulation symbols for all data streams may be provided to a transmit (TX) multiple-input multiple-output (MIMO) processor **1054**, which may further process the modulation symbols (e.g., for OFDM). The transmit (TX) multiple-input multiple-output (MIMO) processor **1054** then provides NT modulation symbol streams to NT transmitters (TMTR) **1055***a* through **1055***t*. The TX transmit (TX) multiple-input multiple-output (MIMO) processor **1054** may apply beamforming weights to the symbols of the data streams and to the antenna **1056** from which the symbol is being transmitted.

[0119] Each transmitter **1055** may receive and process a respective symbol stream to provide one or more analog signals, and further condition (e.g., amplify, filter and upconvert) the analog signals to provide a modulated signal suitable for transmission over the MIMO channel. NT modulated signals from transmitters **1055***a* through **1055***t* are then transmitted from NT antennas **1056***a* through **1056***t*, respectively.

[0120] At the receiver **1070**, the transmitted modulated signals are received by NR antennas **1061***a* through **1061***r* and the received signal from each antenna **1061** is provided to a respective receiver (RCVR) **1062***a* through **1062***r*. Each receiver **1062** may condition (e.g., filter, amplify and downconvert) a respective received signal, digitize the conditioned signal to provide samples, and further process the samples to provide a corresponding "received" symbol stream.

[0121] An RX data processor **1063** then receives and processes the NR received symbol streams from NR receivers **1062** based on a particular receiver processing technique to provide NT "detected" symbol streams. The RX data processor **1063** then demodulates, deinterleaves and decodes each detected symbol stream to recover the traffic data for the data stream. The processing by RX data processor **1063** is complementary to that performed by TX MIMO processor **1054** and TX data processor **1053** at transmitter system **1069**.

[0122] A processor **1064** may periodically determine which pre-coding matrix to use. The processor **1064** may store information on and retrieve information from memory **1065**. The processor **1064** formulates a reverse link message comprising a matrix index portion and a rank value portion. The reverse link message may be referred to as channel state

information (CSI). The reverse link message may comprise various types of information regarding the communication link and/or the received data stream. The reverse link message is then processed by a TX data processor **1067**, which also receives traffic data for a number of data streams from a data source **1068**, modulated by a modulator **1066**, conditioned by transmitters **1062***a* through **1062***r*, and transmitted back to the transmitter **1069**.

[0123] At the transmitter **1069**, the modulated signals from the receiver are received by antennas **1056**, conditioned by receivers **1055**, demodulated by a demodulator **1058**, and processed by an RX data processor **1059** to extract the reverse link message transmitted by the receiver system **1070**. A processor **1060** may receive channel state information (CSI) from the RX data processor **1059**. The processor **1060** may store information on and retrieve information from memory **1057**. The processor **1060** then determines which pre-coding matrix to use for determining the beamforming weights and then processes the extracted message.

[0124] FIG. **11** is a block diagram illustrating a radio network **1100** operating according to Universal Mobile Telecommunications System (UMTS) standards. The radio network **1100** may be a UMTS Terrestrial Radio Access Network (UTRAN). A UMTS Terrestrial Radio Access Network (UTRAN) is a collective term for the Node Bs **1102***a-d* and the control equipment for the Node Bs **1102***a-d* (or radio network controllers (RNCs) **1175***a*) it contains which make up the UMTS radio access network (RAN) **1174**. This is a 3 G communications network which can carry both real-time circuit switched and IP based packet switched traffic types. The UTRAN provides an air interface access method for the user equipment (UE) **1104**. Connectivity is provided between the user equipment (UE) **1104** and the core network **1171** by the UTRAN. The radio access network (RAN) **1174** may transport data packets between multiple user equipments (UEs) **1104**.

[0125] The UTRAN is connected internally or externally to other functional entities by four interfaces: the Iu interface **1172***a-b*, the Uu interface **1178**, the Iub interface **1177***a-d* and the Iur interface **1176**. The UTRAN is attached to a Global Systems for Mobile (GSM) core network **1171** via an external interface called Iu interface **1172**. The radio network controllers (RNCs) **1175***a-b* support this interface. In addition, the radio network controllers (RNCs) **1175***a-b* manage a set of base stations called Node Bs **1102***a-d* through interfaces labeled Iub interface **1177***a-d*. A radio network controller (RNC) **1175** and the managed Node Bs **1102** form a radio network subsystem (RNS) **1173***a-b*. The Iur interface **1176** connects a first radio network controller (RNC) **1175***a* and a second radio network controller (RNC) **1175***b* with each other. The UTRAN is largely autonomous from the core network **1171** since the radio network controllers (RNCs) **1175***a-b* are interconnected by the Iur interface **1176**. FIG. **11** discloses a communication system which uses the radio network controller (RNC) **1175**, the Node Bs **1102***a-d*, the Iub interface **1172** and the Uu interface **1178**. The Uu interface **1178** is also external and connects the Node B **1102** with the user equipment (UE) **1104**, while the Iub interface **1177** is an internal interface connecting the radio network controller (RNC) **1175** with the Node B **1102**.

[0126] The radio network **1100** may be further connected to additional networks outside the radio network **1100**, such as a corporate intranet, the Internet, or a conventional public switched telephone network as stated above, and may transport data packets between each user equipment (UE) **1104** and such outside networks.

[0127] FIG. **12** is a block diagram illustrating communications between a user equipment (UE) **1204**, a Node B **1202** and a radio network controller (RNC) **1275** in a wireless communications network **1200**. The user equipment (UE) **1204** of FIG. **12** may be one configuration of the user equipment (UE) **204** of FIG. **2**. The Node B **1202** of FIG. **12** may be one configuration of the Node B **202** of FIG. **2**. The radio network controller (RNC) **1275** of FIG. **12** may be one configuration of the radio network controller (RNC) **1175** of FIG. **11**. The wireless communications network **1200** may operate using High-Speed Packet Access (HSPA). Both the Node B **1202** and the user equipment (UE) **1204** may be capable of multiple-user multiple-input and multiple-output (MU-MIMO) operations. The user equipment (UE) **1204** and the radio network controller (RNC) **1275** may communicate with each other via the Node B **1202** using Layer 3 messages. Layer 3 messages may also be referred to as radio resource control (RRC) messages. Layer 3 messages may be passed between the UTRAN and the user equipment (UE) **1204** and are used to configure and control the radio resource control (RRC) connection between a user equipment (UE) **1204** and the UTRAN. Layer 3 messages may deal with connection management, control, mobility and measurement messages.

[0128] As discussed above, the Node B **1202** may communicate with the user equipment (UE) **1204** via the Uu interface **1178**. The Node B **1202** may communicate with the radio network controller (RNC) **1275** via the Iub interface **1177**. The Node B **1202**, the radio network controller (RNC) **1275** and the user equipment (UE) **1204** may all operate in accordance with a standard. Small changes to the standard may be needed to accommodate some signaling possibilities associated with multiple-user multiple-input and multiple-output (MU-MIMO) operation. As standards changes may be involved, multiple-user multiple-input and multiple-output (MU-MIMO) operation may be automatically detectable.

[0129] The user equipment (UE) **1204** may indicate to the radio network controller (RNC) **1275** that it is multiple-user multiple-input and multiple-output (MU-MIMO) capable. In one configuration, the user equipment (UE) **1204** may send a Radio Resource Control (RRC) message **1279** to the radio network controller (RNC) **1275** via the Node B **1202**. The Radio Resource Control (RRC) message **1279** may indicate the multiple-user multiple-input and multiple-output (MU-MIMO) capabilities **1280** of the user equipment (UE) **1204**. In another configuration, the user equipment (UE) **1204** may send a message to the radio network controller (RNC) **1275** via the Node B **1202** indicating that the user equipment (UE) **1204** is within a designated multiple-user multiple-input and multiple-output (MU-MIMO) capable category **1281**. In other words, the user equipment (UE) **1204** may indicate that it is in a category that is defined as being multiple-user multiple-input and multiple-output (MU-MIMO) capable.

[0130] The radio network controller (RNC) **1275** may send configuration messages to the user equipment (UE) **1204** via the Node B **1202**. For example, the radio network controller (RNC) **1275** may send a Radio Resource Control (RRC) message **1282** to the user equipment (UE) **1204** via the Node B **1202**. The Radio Resource Control (RRC) message **1282** may include a user equipment (UE) multiple-user multiple-input and multiple-output (MU-MIMO) configuration **1283** for the user equipment (UE) **1204**. The user equipment (UE)

multiple-user multiple-input and multiple-output (MU-MIMO) configuration **1283** may be required for the user equipment (UE) **1204** to support multiple-user multiple-input and multiple-output (MU-MIMO) operation.

[0131] The user equipment (UE) multiple-user multiple-input and multiple-output (MU-MIMO) configuration **1283** may include a channel quality indicator (CQI) report configuration **1284**. The channel quality indicator (CQI) report configuration **1284** may make changes to channel quality indicator (CQI) reporting by the user equipment (UE) **1204** (such as those discussed above in relation to FIG. **6**). The user equipment (UE) multiple-user multiple-input and multiple-output (MU-MIMO) configuration **1283** may also include a high-speed shared control channel (HS-SCCH) fields reinterpretation **1285**. The high-speed shared control channel (HS-SCCH) fields reinterpretation **1285** may instruct the user equipment (UE) **1204** on how to interpret high-speed shared control channel (HS-SCCH) fields differently than they would be interpreted otherwise. The user equipment (UE) **1204** may use the information in the Radio Resource Control (RRC) message **1282** to adjust configurations for multiple-user multiple-input and multiple-output (MU-MIMO) operation.

[0132] FIG. **13** is a flow diagram of a method **1300** for signaling a user equipment's (UE's) multiple-user multiple-input and multiple-output (MU-MIMO) operation capability **1280** from a user equipment (UE) **1204** to a radio network controller (RNC) **1275**. The method **1300** may be performed by a user equipment (UE) **1204**. The user equipment (UE) **1204** may determine **1302** the multiple-user multiple-input and multiple-output (MU-MIMO) operation capability **1280** of the user equipment (UE) **1204**. Examples of multiple-user multiple-input and multiple-output (MU-MIMO) operation capabilities **1280** of the user equipment (UE) **1204** include the ability to configure multiple-user multiple-input and multiple-output (MU-MIMO) channel quality indicator (CQI) **112** feedback if asked to do so by the radio network controller (RNC) **1175** and the ability to reinterpret fields in the high-speed shared control channel (HS-SCCH) if asked to do so by the radio network controller (RNC) **1175**. These operations may be required of the multiple-user multiple-input and multiple-output (MU-MIMO) user equipment (UE) **1204**.

[0133] The user equipment (UE) **1204** may generate **1304** a Radio Resource Control (RRC) message **1279** that includes the multiple-user multiple-input and multiple-output (MU-MIMO) operation capability **1280** of the user equipment (UE) **1204**. The user equipment (UE) **1204** may then send **1306** the Radio Resource Control (RRC) message **1279** to a Node B **1202** that forwards it to a radio network controller (RNC) **1275**.

[0134] FIG. **14** is a flow diagram of a method **1400** for signaling a user equipment (UE) multiple-user multiple-input and multiple-output (MU-MIMO) configuration **1283** required to support multiple-user multiple-input and multiple-output (MU-MIMO) operations from a network to a user equipment (UE) **1204**. The method **1400** may be performed by a radio network controller (RNC) **1275**. The radio network controller (RNC) **1275** may determine **1402** a user equipment (UE) multiple-user multiple-input and multiple-output (MU-MIMO) configuration **1283** required to support multiple-user multiple-input and multiple-output (MU-MIMO) operations. The radio network controller (RNC) **1275** may then generate **1404** a Radio Resource Control (RRC) message **1282** that includes the user equipment (UE) multiple-user multiple-input and multiple-output (MU-MIMO) configuration **1283**. The radio network controller (RNC) **1275** may send **1406** the Radio Resource Control (RRC) message **1282** to a Node B **1202** that forwards it to the user equipment (UE) **1204**. As discussed above in relation to FIG. **12**, the Radio Resource Control (RRC) message **1282** may also include the channel quality indicator (CQI) report configuration **1284** changes for the user equipment (UE) and high-speed shared control channel (HS-SCCH) fields reinterpretation **1285** changes for the user equipment (UE) **1204**.

[0135] FIG. **15** is a block diagram illustrating communications between a Node B **1502** and a radio network controller (RNC) **1575** in a wireless communications network **1500**. The Node B **1502** of FIG. **15** may be one configuration of the Node B **202** of FIG. **2**. The radio network controller (RNC) **1575** of FIG. **15** may be one configuration of the radio network controller (RNC) **1175** of FIG. **11**. The wireless communications network **1500** may operate using High-Speed Packet Access (HSPA). The Node B **1502** may be capable of multiple-user multiple-input and multiple-output (MU-MIMO) operations. Communications between a Node B **1502** and a radio network controller (RNC) **1575** may take place over the Iub interface **1177** (i.e., layer).

[0136] The Node B **1502** may send a message to the radio network controller (RNC) **1575** that indicates the Node B multiple-user multiple-input and multiple-output (MU-MIMO) scheduling capabilities **1586**. For example, the message may indicate that the Node B **1502** is capable of scheduling a multiple-user multiple-input and multiple-output (MU-MIMO) packet.

[0137] The radio network controller (RNC) **1575** may have information regarding the user equipments (UEs) **1104** being served by the Node B **1502**. For example, the radio network controller (RNC) **1575** may know the multiple-user multiple-input and multiple-output (MU-MIMO) capability and configuration of each user equipment (UE) **1587** being served by the Node B **1502**. The radio network controller (RNC) **1575** may send the multiple-user multiple-input and multiple-output (MU-MIMO) capability and configuration of the user equipments (UEs) **1587** to the Node B **1502** in a message. In one configuration, the message may also indicate that the high-speed shared control channel (HS-SCCH) fields encoding **1588***a-b* will need to be changed at the Node B **1502** (since some of the fields in the high-speed shared control channel (HS-SCCH) may be interpreted differently by a user equipment (UE)) **1104**.

[0138] FIG. **16** is a flow diagram of a method **1600** for signaling the multiple-user multiple-input and multiple-output (MU-MIMO) capability and configuration of a user equipment (UE) **1587** from a radio network controller (RNC) **1575** to a Node B **1502**. The method **1600** may be performed by a radio network controller (RNC) **1575**. Communications between the radio network controller (RNC) **1575** and the Node B **1502** may be over the Iub interface **1177**.

[0139] The radio network controller (RNC) **1575** may determine **1602** a multiple-user multiple-input and multiple-output (MU-MIMO) capability and configuration of a user equipment (UE) **1587**. In one configuration, the radio network controller (RNC) **1575** may determine the multiple-user multiple-input and multiple-output (MU-MIMO) capabilities and configurations of multiple user equipments (UEs) **1587**. The radio network controller (RNC) **1575** may generate **1604** a message that includes the multiple-user multiple-input and multiple-output (MU-MIMO) capability and configuration of

the user equipment (UE) **1587**. The radio network controller (RNC) **1575** may then send **1606** the message to a Node B **1502** over the Iub interface **1177**.

[0140] FIG. **17** is a flow diagram of a method **1700** for signaling a Node B multiple-user multiple-input and multiple-output (MU-MIMO) scheduling capability **1586** to a radio network controller (RNC) **1575**. The method **1700** may be performed by a Node B **1502**. Communications between the Node B **1502** and the radio network controller (RNC) **1575** may be over the Iub interface **1177**.

[0141] The Node B **1502** may determine **1702** the Node B multiple-user multiple-input and multiple-output (MU-MIMO) scheduling capability **1586** for transmissions. For example, the Node B **1502** may determine how often multiple-user multiple-input and multiple-output (MU-MIMO) transmissions can be scheduled, the power available for multiple-user multiple-input and multiple-output (MU-MIMO) transmissions and the current load of the Node B **1502**. The Node B **1502** may then generate **1704** a message that includes the Node B multiple-user multiple-input and multiple-output (MU-MIMO) scheduling capability **1586** for transmissions. The Node B **1502** may send **1706** the message to a radio network controller (RNC) **1575** over the Iub interface **1177**.

[0142] FIG. **18** is a block diagram illustrating the transmission of a high-speed shared control channel (HS-SCCH) order **1889** from a Node B **1802** to a user equipment (UE) **1804** in a wireless communications network **1800**. The user equipment (UE) **1804** of FIG. **18** may be one configuration of the user equipment (UE) **204** of FIG. **2**. The Node B **1802** of FIG. **18** may be one configuration of the Node B **202** of FIG. **2**. The wireless communications network **1800** may operate using High-Speed Packet Access (HSPA). Both the Node B **1802** and the user equipment (UE) **1804** may be capable of multiple-user multiple-input and multiple-output (MU-MIMO) operations. The high-speed shared control channel (HS-SCCH) is a downlink physical channel used to carry downlink signaling information related to a high-speed downlink shared channel (HS-DSCH) transmission. A Node B **1802** may use a high-speed shared control channel (HS-SCCH) order **1889** to activate/deactivate the uplink discontinuous transmission (UL-DTX) and/or the downlink discontinuous receiving (DL-DRX) by sending them as L**1**/PHY signaling commands to the user equipment (UE) **1804**.

[0143] The high-speed shared control channel (HS-SCCH) order **1889** may include an activate/deactivate multiple-user multiple-input and multiple-output (MU-MIMO) command **1890**. The activate/deactivate multiple-user multiple-input and multiple-output (MU-MIMO) command **1890** may activate or deactivate multiple-user multiple-input and multiple-output (MU-MIMO) operations at the user equipment (UE) **1804**. There may be instances when multiple-user multiple-input and multiple-output (MU-MIMO) operation is not highly beneficial (e.g., only two user equipments (UEs) **1804** are being served). There may also be instances when multiple-user multiple-input and multiple-output (MU-MIMO) operation would be particularly beneficial (e.g., multiple user equipments (UEs) **1804** requesting large amounts of traffic).

[0144] The high-speed shared control channel (HS-SCCH) order **1889** may also include a channel quality indicator (CQI) reporting change **1891**. The user equipment (UE) **1804** may thus be instructed on changes to channel quality indicator (CQI) reporting. The high-speed shared control channel (HS-SCCH) order **1889** may further include a high-speed shared control channel (HS-SCCH) fields interpretation change **1892**. Upon receiving the high-speed shared control channel (HS-SCCH) order **1889**, the user equipment (UE) **1804** may activate/deactivate multiple-user multiple-input and multiple-output (MU-MIMO) operations, apply the channel quality indicator (CQI) reporting change **1891** and/or apply the high-speed shared control channel (HS-SCCH) fields interpretation change **1892**.

[0145] FIG. **19** is a flow diagram of a method **1900** for sending a high-speed shared control channel (HS-SCCH) order **1889** to a user equipment (UE) **1804**. The method **1900** may be performed by a Node B **1802**. The Node B **1802** may determine **1902** to activate/deactivate multiple-user multiple-input and multiple-output (MU-MIMO) operations on a user equipment (UE) **1804**. In one configuration, the Node B **1802** may further determine to change the channel quality indicator (CQI) reporting configurations of the user equipment (UE) **1804**. In yet another configuration, the Node B **1802** may determine to change the high-speed shared control channel (HS-SCCH) fields interpretation of the user equipment (UE) **1804**.

[0146] The Node B **1802** may then generate **1904** a high-speed shared control channel (HS-SCCH) order **1889**. As discussed above, the high-speed shared control channel (HS-SCCH) order **1889** may include an activation/deactivation of multiple-user multiple-input and multiple-output (MU-MIMO) operations command **1890**, a channel quality indicator (CQI) reporting change **1891** and/or a high-speed shared control channel (HS-SCCH) fields interpretation change **1892**. The Node B **1802** may then send **1906** the high-speed shared control channel (HS-SCCH) order **1889** to the user equipment (UE) **1804**.

[0147] FIG. **20** is a block diagram illustrating multiple-user multiple-input and multiple-output (MU-MIMO) scheduling **2094***a-n* transmitted from a Node B **2002** to a user equipment (UE) **2004** for every transmission time interval (TTI) **2093***a-n* in a wireless communications network **2000**. The user equipment (UE) **2004** of FIG. **20** may be one configuration of the user equipment (UE) **204** of FIG. **2**. The Node B **2002** of FIG. **20** may be one configuration of the Node B **202** of FIG. **2**. The wireless communications network **2000** may operate using High-Speed Packet Access (HSPA). Both the Node B **2002** and the user equipment (UE) **2004** may be capable of multiple-user multiple-input and multiple-output (MU-MIMO) operations. A Node B **2002** may signal a user equipment (UE) **2004** regarding multiple-user multiple-input and multiple-output (MU-MIMO) scheduling **2094**. This signaling may be "long-term," where the signaling does not occur every transmission time interval (TTI) **2093**. For example, certain user equipments (UEs) **2004** do not need such signaling for each transmission time interval (TTI) **2093**.

[0148] However, there may be cases where a user equipment (UE) **2004** needs multiple-user multiple-input and multiple-output (MU-MIMO) scheduling **2094** for each transmission time interval (TTI) **2093**. For example, a Node B **2002** may send multiple-user multiple-input and multiple-output (MU-MIMO) scheduling **2094** information (e.g., whether or not multiple-user multiple-input and multiple-output (MU-MIMO) transmissions are being used in a particular transmission time interval (TTI) **2093**) to a user equipment (UE) **2004** during each transmission time interval (TTI) **2093**. This may be accomplished in several ways. In a first option, a high-speed shared control channel (HS-SCCH) may be configured on a common High Speed Downlink Shared Channel—Radio Network Temporary Identifier (H-RNTI).

The common High Speed Downlink Shared Channel—Radio Network Temporary Identifier (H-RNTI) may be decoded by all of the user equipments (UEs) **2004** in a cell. Thus, the multiple-user multiple-input and multiple-output (MU-MIMO) scheduling **2094** information may be sent via a high-speed shared control channel (HS-SCCH) on a common High Speed Downlink Shared Channel—Radio Network Temporary Identifier (H-RNTI).

[0149] In a second option, the Node B **2002** may signal multiple-user multiple-input and multiple-output (MU-MIMO) transmission through certain fields of the high-speed shared control channel (HS-SCCH). For example, certain bits of the channelization code set could be used for this purpose. The user equipment (UE) **2004** may re-interpret the bits (which would otherwise be interpreted differently) to mean that multiple-user multiple-input and multiple-output (MU-MIMO) scheduling is happening for this particular transmission time interval (TTI) **2093**. On the other hand, the Node B **2002** could set the secondary transport block size field of the high-speed shared control channel (HS-SCCH) to 111111 and the corresponding redundancy version field could be set to 0. Again, the user equipment (UE) **2004** may re-interpret the bits (which would otherwise be interpreted differently) to mean an indication of multiple-user multiple-input and multiple-output (MU-MIMO) transmission in this particular transmission time interval (TTI) **2093**.

[0150] When a user equipment (UE) **2004** is Release-7 capable or Transmit Antenna Array (TxAA) capable, other options may be used for multiple-user multiple-input and multiple-output (MU-MIMO) scheduling **2094**. One option (when the user equipment (UE) **2004** is Release-7 or TxAA capable) is for the Node B **2002** to use a typically unused combination of a modulation scheme and a number of transport blocks in a high-speed shared control channel (HS-SCCH) to convey multiple-user multiple-input and multiple-output (MU-MIMO) scheduling **2094** to the user equipment (UE) **2004** for each transmission time interval (TTI) **2093**. For a user equipment (UE) **2004** that is Transmit Antenna Array (TxAA) capable, the Node B **2002** may use one bit of a Hybrid Automatic Repeat Request (HARD) processing identification (ID) in a high-speed shared control channel (HS-SCCH) to convey the multiple-user multiple-input and multiple-output (MU-MIMO) scheduling **2094** information to a user equipment (UE) **2004** for each transmission time interval (TTI) **2093**.

[0151] FIG. **21** illustrates certain components that may be included within a base station **2102**. A base station may also be referred to as, and may include some or all of the functionality of, an access point, a broadcast transmitter, a NodeB, an evolved NodeB, etc. The base station **2102** includes a processor **2103**. The processor **2103** may be a general purpose single- or multi-chip microprocessor (e.g., an ARM), a special purpose microprocessor (e.g., a digital signal processor (DSP)), a microcontroller, a programmable gate array, etc. The processor **2103** may be referred to as a central processing unit (CPU). Although just a single processor **2103** is shown in the base station **2102** of FIG. **21**, in an alternative configuration, a combination of processors (e.g., an ARM and DSP) could be used.

[0152] The base station **2102** also includes memory **2105**. The memory **2105** may be any electronic component capable of storing electronic information. The memory **2105** may be embodied as random access memory (RAM), read only memory (ROM), magnetic disk storage media, optical storage media, flash memory devices in RAM, on-board memory included with the processor, EPROM memory, EEPROM memory, registers, and so forth, including combinations thereof.

[0153] Data **2107***a* and instructions **2109***a* may be stored in the memory **2105**. The instructions **2109***a* may be executable by the processor **2103** to implement the methods disclosed herein. Executing the instructions **2109***a* may involve the use of the data **2107***a* that is stored in the memory **2105**. When the processor **2103** executes the instructions **2109***a*, various portions of the instructions **2109***b* may be loaded onto the processor **2103**, and various pieces of data **2107***b* may be loaded onto the processor **2103**.

[0154] The base station **2102** may also include a transmitter **2111** and a receiver **2113** to allow transmission and reception of signals to and from the base station **2102**. The transmitter **2111** and receiver **2113** may be collectively referred to as a transceiver **2115**. Multiple antennas **2117***a-b* may be electrically coupled to the transceiver **2115**. The base station **2102** may also include (not shown) multiple transmitters, multiple receivers, multiple transceivers and/or additional antennas.

[0155] The base station **2102** may include a digital signal processor (DSP) **2121**. The base station **2102** may also include a communications interface **2123**. The communications interface **2123** may allow a user to interact with the base station **2102**.

[0156] The various components of the base station **2102** may be coupled together by one or more buses, which may include a power bus, a control signal bus, a status signal bus, a data bus, etc. For the sake of clarity, the various buses are illustrated in FIG. **21** as a bus system **2119**.

[0157] FIG. **22** illustrates certain components that may be included within a wireless communication device **2204**. The wireless communication device **2204** may be an access terminal, a mobile station, a user equipment (UE), etc. The wireless communication device **2204** includes a processor **2203**. The processor **2203** may be a general purpose single- or multi-chip microprocessor (e.g., an ARM), a special purpose microprocessor (e.g., a digital signal processor (DSP)), a microcontroller, a programmable gate array, etc. The processor **2203** may be referred to as a central processing unit (CPU). Although just a single processor **2203** is shown in the wireless communication device **2204** of FIG. **22**, in an alternative configuration, a combination of processors (e.g., an ARM and DSP) could be used.

[0158] The wireless communication device **2204** also includes memory **2205**. The memory **2205** may be any electronic component capable of storing electronic information. The memory **2205** may be embodied as random access memory (RAM), read-only memory (ROM), magnetic disk storage media, optical storage media, flash memory devices in RAM, on-board memory included with the processor, EPROM memory, EEPROM memory, registers, and so forth, including combinations thereof.

[0159] Data **2207***a* and instructions **2209***a* may be stored in the memory **2205**. The instructions **2209***a* may be executable by the processor **2203** to implement the methods disclosed herein. Executing the instructions **2209***a* may involve the use of the data **2207***a* that is stored in the memory **2205**. When the processor **2203** executes the instructions **2209***a*, various portions of the instructions **2209***b* may be loaded onto the processor **2203**, and various pieces of data **2207***b* may be loaded onto the processor **2203**.

[0160] The wireless communication device **2204** may also include a transmitter **2211** and a receiver **2213** to allow transmission and reception of signals to and from the wireless communication device **2204**. The transmitter **2211** and receiver **2213** may be collectively referred to as a transceiver **2215**. Multiple antennas **2217***a-b* may be electrically coupled to the transceiver **2215**. The wireless communication device **2204** may also include (not shown) multiple transmitters, multiple receivers, multiple transceivers and/or additional antennas.

[0161] The wireless communication device **2204** may include a digital signal processor (DSP) **2221**. The wireless communication device **2204** may also include a communications interface **2223**. The communications interface **2223** may allow a user to interact with the wireless communication device **2204**.

[0162] The various components of the wireless communication device **2204** may be coupled together by one or more buses, which may include a power bus, a control signal bus, a status signal bus, a data bus, etc. For the sake of clarity, the various buses are illustrated in FIG. **22** as a bus system **2219**.

[0163] FIG. **23** illustrates certain components that may be included within a radio network controller (RNC) **2375**. A radio network controller (RNC) **2375** is a governing element in the UMTS radio access network (UTRAN) that is responsible for controlling the base stations **2102** (or Node Bs **1102**) that are connected to it. The radio network controller (RNC) **2375** may be connected to a circuit switched core network through a media gateway. The radio network controller (RNC) **2375** includes a processor **2303**. The processor **2303** may be a general purpose single- or multi-chip microprocessor (e.g., an ARM), a special purpose microprocessor (e.g., a digital signal processor (DSP)), a microcontroller, a programmable gate array, etc. The processor **2303** may be referred to as a central processing unit (CPU). Although just a single processor **2303** is shown in the radio network controller (RNC) **2375** of FIG. **23**, in an alternative configuration, a combination of processors (e.g., an ARM and DSP) could be used.

[0164] The radio network controller (RNC) **2375** also includes memory **2305**. The memory **2305** may be any electronic component capable of storing electronic information. The memory **2305** may be embodied as random access memory (RAM), read only memory (ROM), magnetic disk storage media, optical storage media, flash memory devices in RAM, on-board memory included with the processor, EPROM memory, EEPROM memory, registers, and so forth, including combinations thereof.

[0165] Data **2307***a* and instructions **2309***a* may be stored in the memory **2305**. The instructions **2309***a* may be executable by the processor **2303** to implement the methods disclosed herein. Executing the instructions **2309***a* may involve the use of the data **2307***a* that is stored in the memory **2305**. When the processor **2303** executes the instructions **2309***a*, various portions of the instructions **2309***b* may be loaded onto the processor **2303**, and various pieces of data **2307***b* may be loaded onto the processor **2303**.

[0166] The radio network controller (RNC) **2375** may also include a transmitter **2311** and a receiver **2313** to allow transmission and reception of signals to and from the radio network controller (RNC) **2375**. The transmitter **2311** and receiver **2313** may be collectively referred to as a transceiver **2315**. Multiple antennas **2317***a-b* may be electrically coupled to the transceiver **2315**. The radio network controller (RNC) **2375** may also include (not shown) multiple transmitters, multiple receivers, multiple transceivers and/or additional antennas.

[0167] The radio network controller (RNC) **2375** may include a digital signal processor (DSP) **2321**. The radio network controller (RNC) **2375** may also include a communications interface **2323**. The communications interface **2323** may allow a user to interact with the radio network controller (RNC) **2375**.

[0168] The various components of the radio network controller (RNC) **2375** may be coupled together by one or more buses, which may include a power bus, a control signal bus, a status signal bus, a data bus, etc. For the sake of clarity, the various buses are illustrated in FIG. **23** as a bus system **2319**.

[0169] The techniques described herein may be used for various communication systems, including communication systems that are based on an orthogonal multiplexing scheme. Examples of such communication systems include Orthogonal Frequency Division Multiple Access (OFDMA) systems, Single-Carrier Frequency Division Multiple Access (SC-FDMA) systems, and so forth. An OFDMA system utilizes orthogonal frequency division multiplexing (OFDM), which is a modulation technique that partitions the overall system bandwidth into multiple orthogonal sub-carriers. These sub-carriers may also be called tones, bins, etc. With OFDM, each sub-carrier may be independently modulated with data. An SC-FDMA system may utilize interleaved FDMA (IFDMA) to transmit on sub-carriers that are distributed across the system bandwidth, localized FDMA (LFDMA) to transmit on a block of adjacent sub-carriers, or enhanced FDMA (EFDMA) to transmit on multiple blocks of adjacent sub-carriers. In general, modulation symbols are sent in the frequency domain with OFDM and in the time domain with SC-FDMA.

[0170] The term "determining" encompasses a wide variety of actions and, therefore, "determining" can include calculating, computing, processing, deriving, investigating, looking up (e.g., looking up in a table, a database or another data structure), ascertaining and the like. Also, "determining" can include receiving (e.g., receiving information), accessing (e.g., accessing data in a memory) and the like. Also, "determining" can include resolving, selecting, choosing, establishing and the like.

[0171] The phrase "based on" does not mean "based only on," unless expressly specified otherwise. In other words, the phrase "based on" describes both "based only on" and "based at least on."

[0172] The term "processor" should be interpreted broadly to encompass a general purpose processor, a central processing unit (CPU), a microprocessor, a digital signal processor (DSP), a controller, a microcontroller, a state machine, and so forth. Under some circumstances, a "processor" may refer to an application specific integrated circuit (ASIC), a programmable logic device (PLD), a field programmable gate array (FPGA), etc. The term "processor" may refer to a combination of processing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0173] The term "memory" should be interpreted broadly to encompass any electronic component capable of storing electronic information. The term memory may refer to various types of processor-readable media such as random access memory (RAM), read-only memory (ROM), non-volatile

random access memory (NVRAM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable PROM (EEPROM), flash memory, magnetic or optical data storage, registers, etc. Memory is said to be in electronic communication with a processor if the processor can read information from and/or write information to the memory. Memory that is integral to a processor is in electronic communication with the processor.

[0174] The terms "instructions" and "code" should be interpreted broadly to include any type of computer-readable statement(s). For example, the terms "instructions" and "code" may refer to one or more programs, routines, sub-routines, functions, procedures, etc. "Instructions" and "code" may comprise a single computer-readable statement or many computer-readable statements.

[0175] The functions described herein may be implemented in software or firmware being executed by hardware. The functions may be stored as one or more instructions on a computer-readable medium. The terms "computer-readable medium" or "computer-program product" refers to any tangible storage medium that can be accessed by a computer or a processor. By way of example, and not limitation, a computer-readable medium may comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray® disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers.

[0176] The methods disclosed herein comprise one or more steps or actions for achieving the described method. The method steps and/or actions may be interchanged with one another without departing from the scope of the claims. In other words, unless a specific order of steps or actions is required for proper operation of the method that is being described, the order and/or use of specific steps and/or actions may be modified without departing from the scope of the claims.

[0177] Further, it should be appreciated that modules and/or other appropriate means for performing the methods and techniques described herein, such as those illustrated by FIGS. **3**, **6**, **13**, **14**, **16**, **17** and **19**, can be downloaded and/or otherwise obtained by a device. For example, a device may be coupled to a server to facilitate the transfer of means for performing the methods described herein. Alternatively, various methods described herein can be provided via a storage means (e.g., random access memory (RAM), read-only memory (ROM), a physical storage medium such as a compact disc (CD) or floppy disk, etc.), such that a device may obtain the various methods upon coupling or providing the storage means to the device.

[0178] It is to be understood that the claims are not limited to the precise configuration and components illustrated above. Various modifications, changes and variations may be made in the arrangement, operation and details of the systems, methods, and apparatus described herein without departing from the scope of the claims.

What is claimed is:

1. A method for signaling multiple-user multiple-input and multiple-output in a high speed packet access system, comprising:

determining a multiple-user multiple-input and multiple-output parameter;

generating a message that comprises the multiple-user multiple-input and multiple-output parameter; and

sending the message to a wireless device.

2. The method of claim **1**, wherein the method is performed by a radio network controller, wherein the wireless device is a Node B that forwards the message to a user equipment, wherein the multiple-user multiple-input and multiple-output parameter comprises a user equipment multiple-user multiple-input and multiple-output configuration required of the user equipment to support multiple-user multiple-input and multiple-output operations, and wherein the message is a radio resource control message.

3. The method of claim **2**, wherein the multiple-user multiple-input and multiple-output parameter further comprises a channel quality indicator report configuration.

4. The method of claim **2**, wherein the multiple-user multiple-input and multiple-output parameter further comprises a high-speed shared control channel fields reinterpretation.

5. The method of claim **1**, wherein the method is performed by a user equipment, and wherein the wireless device is a Node B that forwards the message to a radio network controller.

6. The method of claim **5**, wherein the multiple-user multiple-input and multiple-output parameter comprises a multiple-user multiple-input and multiple-output operation capability of the user equipment, and wherein the message is a radio resource control message.

7. The method of claim **5**, wherein the multiple-user multiple-input and multiple-output parameter comprises a multiple-user multiple-input and multiple-output capable user equipment category.

8. The method of claim **1**, wherein the method is performed by a Node B, wherein the wireless device is a radio network controller, and wherein the multiple-user multiple-input and multiple-output parameter comprises a Node B multiple-user multiple-input and multiple-output scheduling capability.

9. The method of claim **1**, wherein the method is performed by a radio network controller, wherein the wireless device is a Node B, and wherein the multiple-user multiple-input and multiple-output parameter comprises a multiple-user multiple-input and multiple-output capability and configuration of a user equipment being served by the Node B.

10. The method of claim **9**, wherein the multiple-user multiple-input and multiple-output parameter further comprises a new high-speed shared control channel fields encoding.

11. The method of claim **1**, wherein the method is performed by a Node B, wherein the wireless device is a user equipment, and wherein the multiple-user multiple-input and multiple-output parameter comprises multiple-user multiple-input and multiple-output scheduling information, wherein new multiple-user multiple-input and multiple-output scheduling information is sent for each transmission time interval.

12. The method of claim **11**, wherein the multiple-user multiple-input and multiple-output scheduling information is sent via a high-speed shared control channel on a common high speed downlink shared channel—radio network temporary identifier.

13. The method of claim 11, wherein the multiple-user multiple-input and multiple-output scheduling information is sent via fields of a Type-3 dual stream high-speed shared control channel, wherein the fields comprise certain bits of a channelization code.

14. The method of claim 11, wherein the multiple-user multiple-input and multiple-output scheduling information is sent via fields of a Type-3 dual stream high-speed shared control channel, wherein the fields comprise a combination of a secondary transport block size being set to 111111 and a corresponding redundancy version being set to 0.

15. The method of claim 11, wherein the user equipment is transmit antenna array capable, and wherein the multiple-user multiple-input and multiple-output scheduling information is sent via a combination of a modulation scheme and a number of transport blocks in a high-speed shared control channel.

16. The method of claim 11, wherein the user equipment is transmit antenna array capable, and wherein the multiple-user multiple-input and multiple-output scheduling information is sent via a hybrid automatic repeat request processing identification in a high-speed shared control channel.

17. The method of claim 1, wherein the method is performed by a Node B, wherein the wireless device is a user equipment, wherein the multiple-user multiple-input and multiple-output parameter comprises a command to activate/deactivate multiple-user multiple-input and multiple-output operations on the user equipment, and wherein the message comprises a high-speed shared control channel order.

18. The method of claim 17, wherein the high-speed shared control channel order further comprises a channel quality indicator reporting change for the user equipment.

19. The method of claim 17, wherein the high-speed shared control channel order further comprises a high-speed shared control channel fields interpretation change for the user equipment.

20. A wireless device configured for signaling multiple-user multiple-input and multiple-output in a high speed packet access system, comprising:

a processor;

memory in electronic communication with the processor;

instructions stored in the memory, the instructions being executable by the processor to:

determine a multiple-user multiple-input and multiple-output parameter;

generate a message that comprises the multiple-user multiple-input and multiple-output parameter; and

send the message to a second wireless device.

21. The wireless device of claim 20, wherein the wireless device is a radio network controller, wherein the second wireless device is a Node B that forwards the message to a user equipment, wherein the multiple-user multiple-input and multiple-output parameter comprises a user equipment multiple-user multiple-input and multiple-output configuration required of the user equipment to support multiple-user multiple-input and multiple-output operations, and wherein the message is a radio resource control message.

22. The wireless device of claim 21, wherein the multiple-user multiple-input and multiple-output parameter further comprises a channel quality indicator report configuration.

23. The wireless device of claim 21, wherein the multiple-user multiple-input and multiple-output parameter further comprises a high-speed shared control channel fields reinterpretation.

24. The wireless device of claim 20, wherein the wireless device is a user equipment, and wherein the second wireless device is a Node B that forwards the message to a radio network controller.

25. The wireless device of claim 24, wherein the multiple-user multiple-input and multiple-output parameter comprises a multiple-user multiple-input and multiple-output operation capability of the user equipment, and wherein the message is a radio resource control message.

26. The wireless device of claim 24, wherein the multiple-user multiple-input and multiple-output parameter comprises a multiple-user multiple-input and multiple-output capable user equipment category.

27. The wireless device of claim 20, wherein the wireless device is a Node B, wherein the second wireless device is a radio network controller, and wherein the multiple-user multiple-input and multiple-output parameter comprises a Node B multiple-user multiple-input and multiple-output scheduling capability.

28. The wireless device of claim 20, wherein the wireless device is a radio network controller, wherein the second wireless device is a Node B, and wherein the multiple-user multiple-input and multiple-output parameter comprises a multiple-user multiple-input and multiple-output capability and configuration of a user equipment being served by the Node B.

29. The wireless device of claim 28, wherein the multiple-user multiple-input and multiple-output parameter further comprises a new high-speed shared control channel fields encoding.

30. The wireless device of claim 20, wherein the wireless device is a Node B, wherein the second wireless device is a user equipment, and wherein the multiple-user multiple-input and multiple-output parameter comprises multiple-user multiple-input and multiple-output scheduling information, wherein new multiple-user multiple-input and multiple-output scheduling information is sent for each transmission time interval.

31. The wireless device of claim 30, wherein the multiple-user multiple-input and multiple-output scheduling information is sent via a high-speed shared control channel on a common high speed downlink shared channel—radio network temporary identifier.

32. The wireless device of claim 30, wherein the multiple-user multiple-input and multiple-output scheduling information is sent via fields of a Type-3 dual stream high-speed shared control channel, wherein the fields comprise certain bits of a channelization code.

33. The wireless device of claim 30, wherein the multiple-user multiple-input and multiple-output scheduling information is sent via fields of a Type-3 dual stream high-speed shared control channel, wherein the fields comprise a combination of a secondary transport block size being set to 111111 and a corresponding redundancy version being set to 0.

34. The wireless device of claim 30, wherein the wireless device is transmit antenna array capable, and wherein the multiple-user multiple-input and multiple-output scheduling information is sent via a combination of a modulation scheme and a number of transport blocks in a high-speed shared control channel.

35. The wireless device of claim 30, wherein the wireless device is transmit antenna array capable, and wherein the multiple-user multiple-input and multiple-output scheduling

information is sent via a hybrid automatic repeat request processing identification in a high-speed shared control channel.

36. The wireless device of claim **20**, wherein the wireless device is a Node B, wherein the second wireless device is a user equipment, wherein the multiple-user multiple-input and multiple-output parameter comprises a command to activate/deactivate multiple-user multiple-input and multiple-output operations on the user equipment, and wherein the message comprises a high-speed shared control channel order.

37. The wireless device of claim **36**, wherein the high-speed shared control channel order further comprises a channel quality indicator reporting change for the user equipment.

38. The wireless device of claim **36**, wherein the high-speed shared control channel order further comprises a high-speed shared control channel fields interpretation change for the user equipment.

39. A wireless device configured for signaling multiple-user multiple-input and multiple-output in a high speed packet access system, comprising:

means for determining a multiple-user multiple-input and multiple-output parameter;

means for generating a message that comprises the multiple-user multiple-input and multiple-output parameter; and

means for sending the message to a wireless device.

40. A computer-program product for signaling multiple-user multiple-input and multiple-output in a high-speed packet access system, the computer-program product comprising a non-transitory computer-readable medium having instructions thereon, the instructions comprising:

code for causing a first wireless device to determine a multiple-user multiple-input and multiple-output parameter;

code for causing a first wireless device to generate a message that comprises the multiple-user multiple-input and multiple-output parameter; and

code for causing the first wireless device to send the message to a second wireless device.

* * * * *

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Park et al.

(54) METHOD FOR REPORTING CHANNEL STATE INFORMATION IN WIRELESS COMMUNICATION SYSTEM AND APPARATUS THEREFOR

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(72) Inventors: **Jonghyun Park**, Seoul (KR); **Yoonsoo Kim**, Seoul (KR); **Wonji Sung**, Seoul (KR); **Hosik Kang**, Seoul (KR); **Jihoon Sung**, Seoul (KR)

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(2) Date: **Feb. 24, 2016**

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Publication Classification

(51) **Int. Cl.**

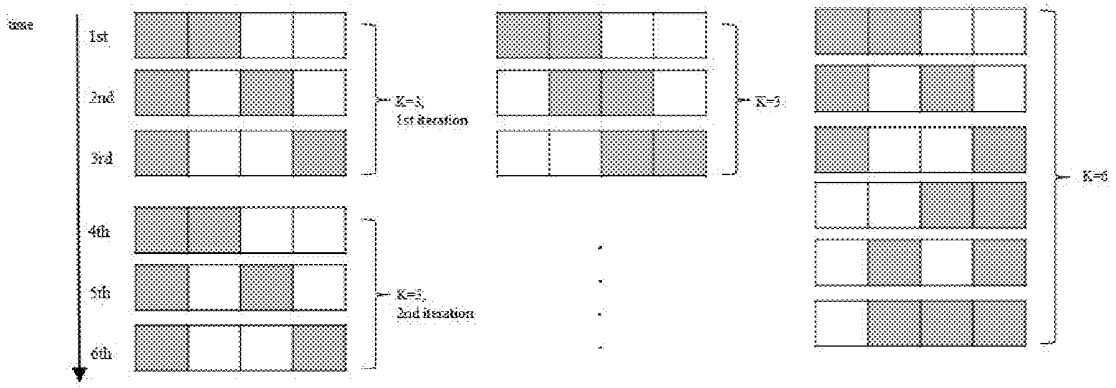
H04B 7/06	(2006.01)
H04B 7/04	(2006.01)
H04L 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***H04B 7/0626*** (2013.01); ***H04L 5/0048*** (2013.01); ***H04B 7/0456*** (2013.01)

(57) **ABSTRACT**

Disclosed are a method for reporting channel state information in a wireless communication system and an apparatus therefor. A method by which user equipment reports channel state information (CSI) in a wireless communication system, according to one embodiment of the present invention, comprises the steps of: receiving, from a base station, an RRC message including at least one CSI-reference signal (CSI-RS) configuration for a first direction domain; respectively receiving through different sub-frames, a first CSI-RS from a first subset and a second CSI-RS from a second subset among a plurality of physical antenna elements in the base station on the basis of the CSI-RS configuration; and performing a CSI report by using the first and second CSI-RSs, wherein when the CSI-RS configuration for the first direction domain is one, the first CSI-RS and the second CSI-RS are respectively received from the first subset and the second subset by virtualization-varying antenna ports related to one CSI-RS configuration in a predetermined period.



(a) K=3, L=2 (b) K=3, L=2 (c) K=6, L=2

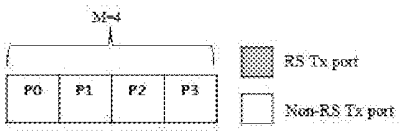


FIG. 1

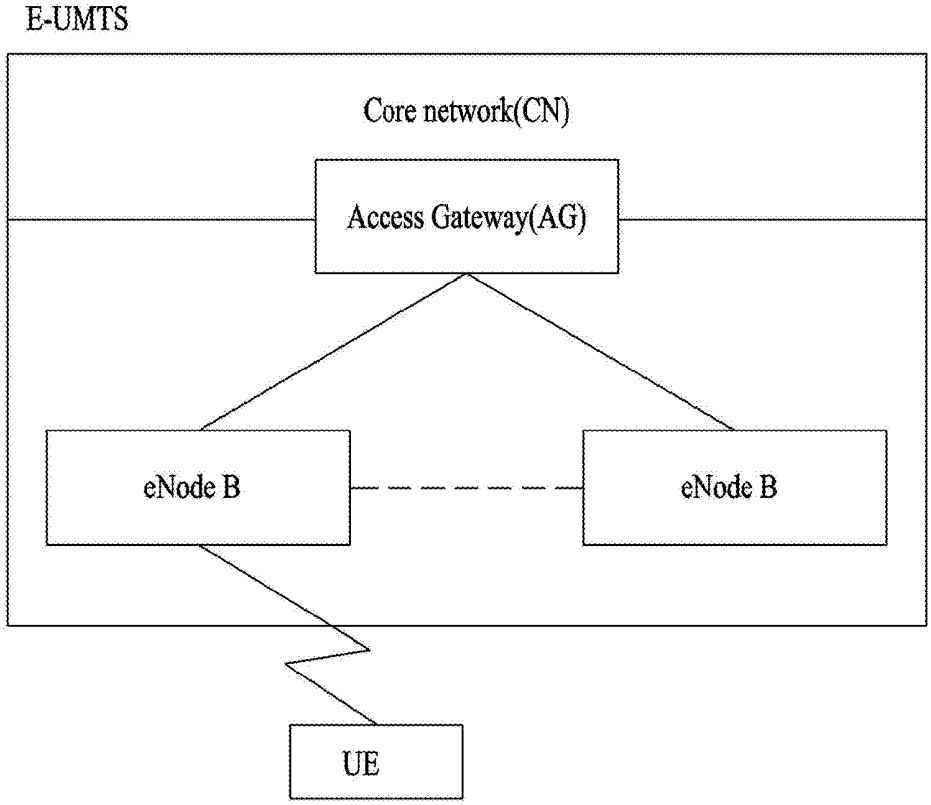
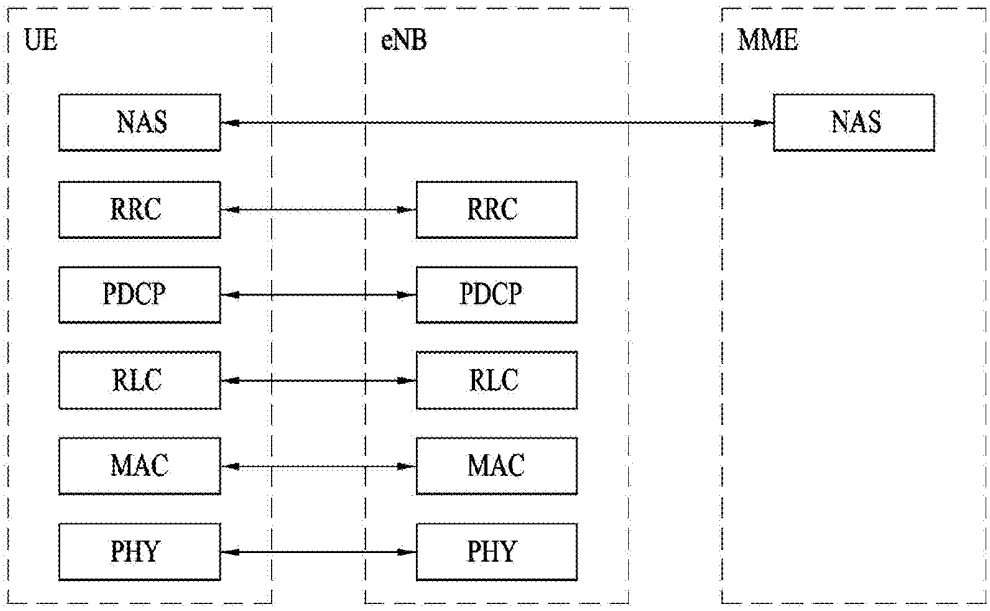
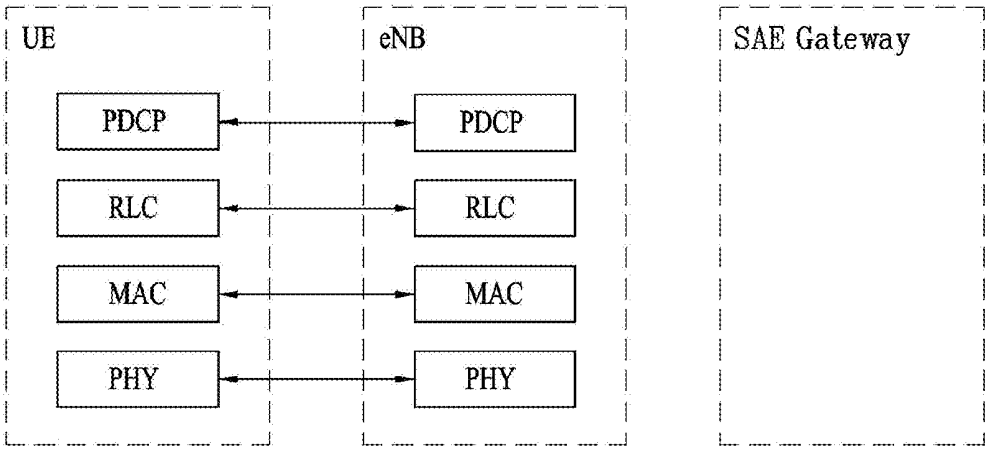


FIG. 2

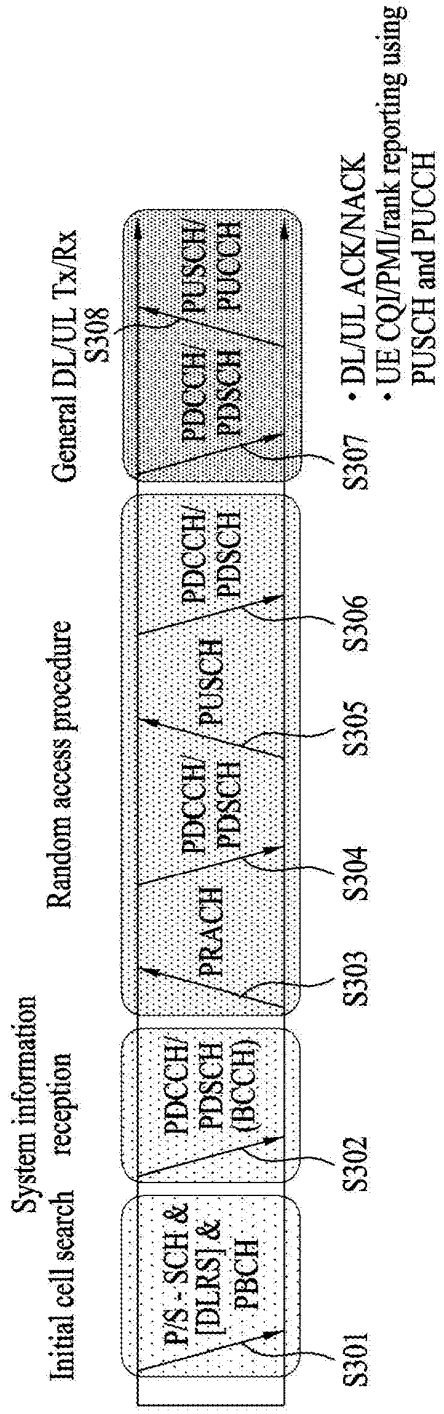


(a) control-plane protocol stack



(b) user-plane protocol stack

FIG. 3


Initial cell search
System information reception
Random access procedure
General DL/UL Tx/Rx
S308
P/S - SCH & [DLRS] & PBCH
PDCCH/ PDSCH (BCCH)
PRACH
PDCCH/ PDSCH
PUSCH
PDCCH/ PDSCH
PDCCH/ PDSCH
PUSCH/ PUCCH
S301
S302
S303
S304
S305
S306
S307
• DL/UL ACK/NACK
• UE CQI/PMI/rank reporting using PUSCH and PUCCH

591

FIG. 4

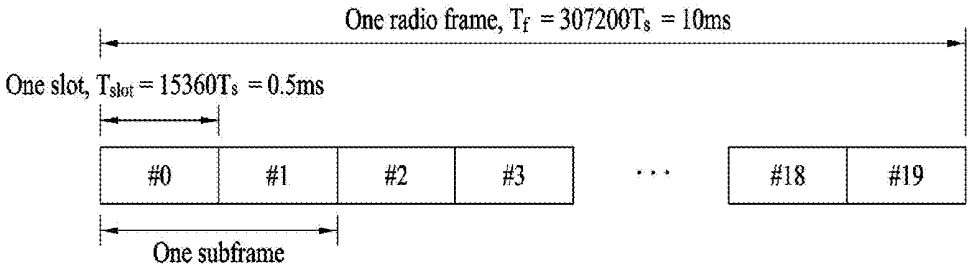

One radio frame, $T_f = 307200T_s = 10ms$
One slot, $T_{slot} = 15360T_s = 0.5ms$
#0
#1
#2
#3
· · ·
#18
#19
One subframe

FIG. 5

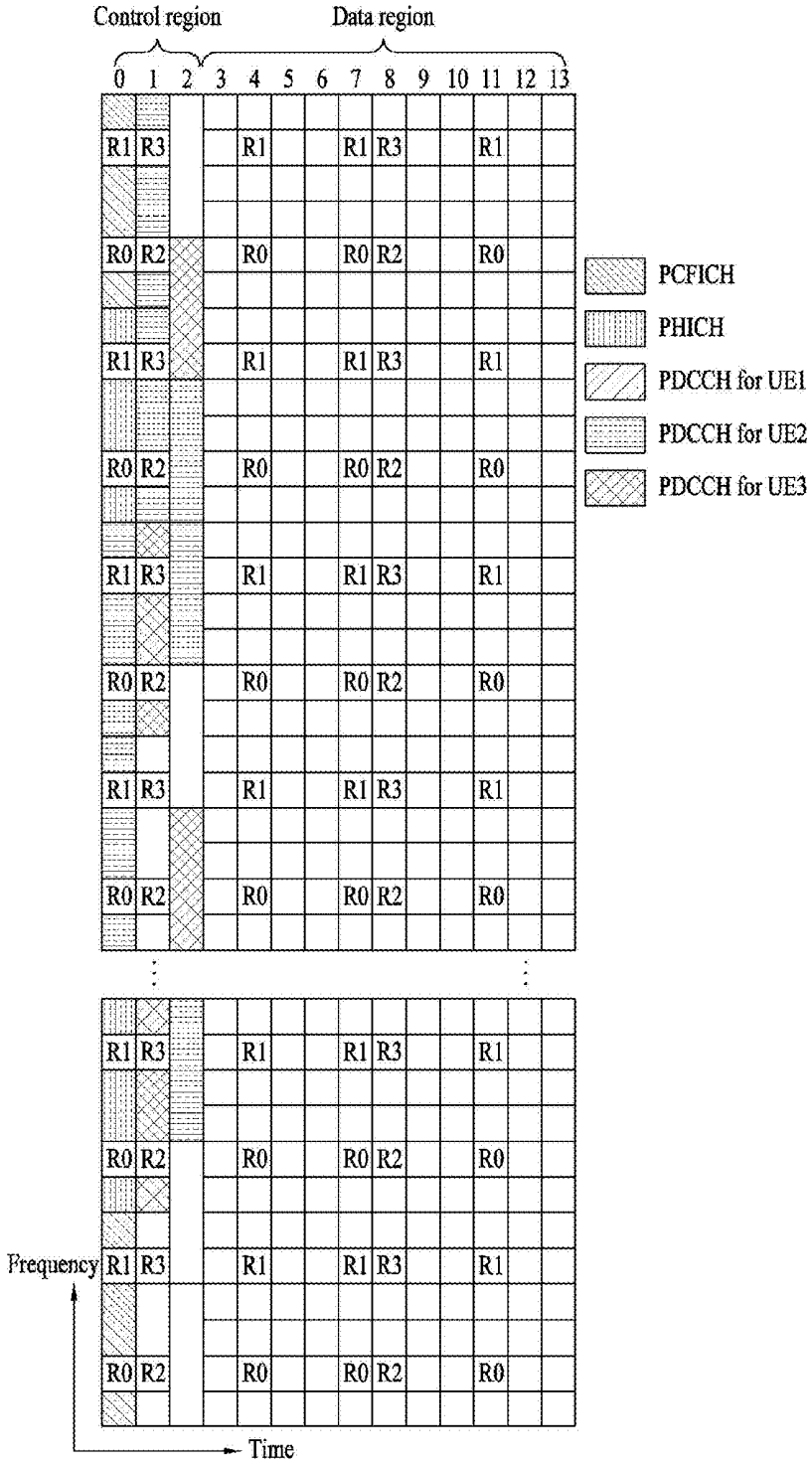

Control region
Data region
0 1 2 3 4 5 6 7 8 9 10 11 12 13
R1 R3
R0 R2
PCFICH
PHICH
PDCCH for UE1
PDCCH for UE2
PDCCH for UE3
Frequency
Time

FIG. 6

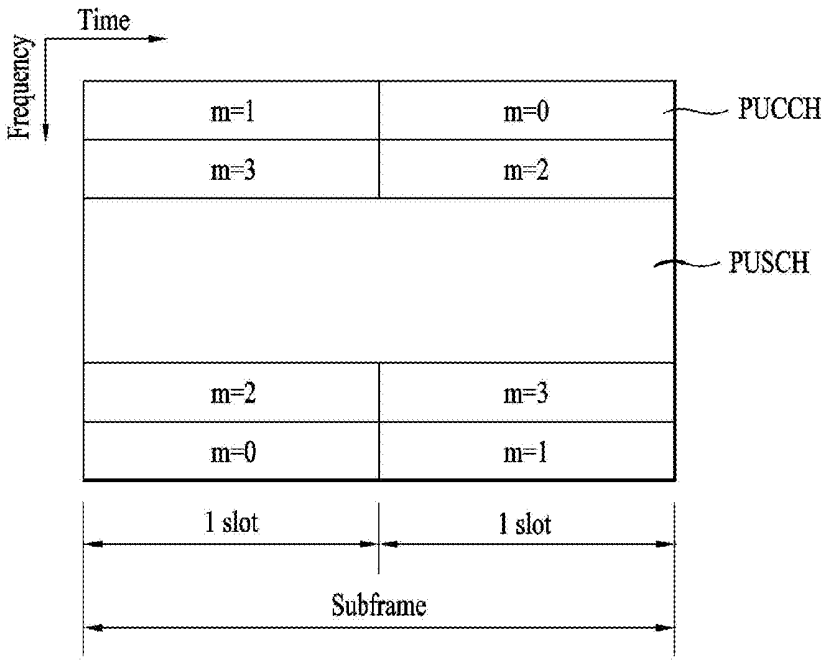

Time
Frequency
m=1
m=0
PUCCH
m=3
m=2
PUSCH
m=2
m=3
m=0
m=1
1 slot
1 slot
Subframe

FIG. 7

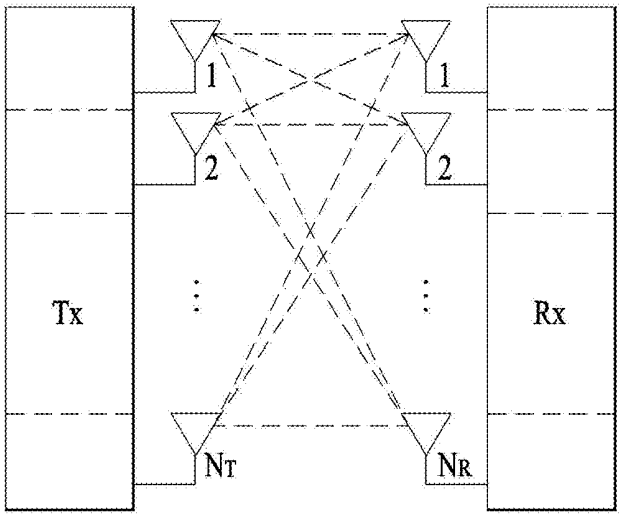


FIG. 8

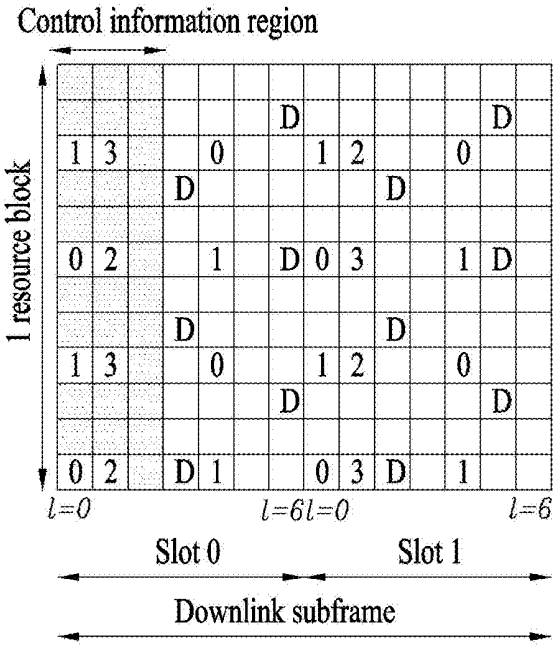

Control information region
1 resource block
l=0
l=6
l=0
l=6
Slot 0
Slot 1
Downlink subframe

FIG. 9

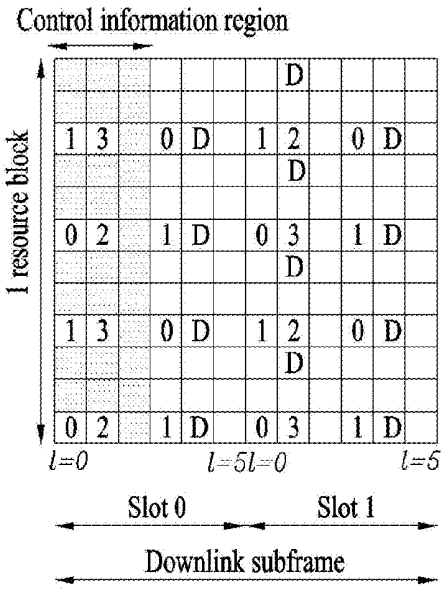
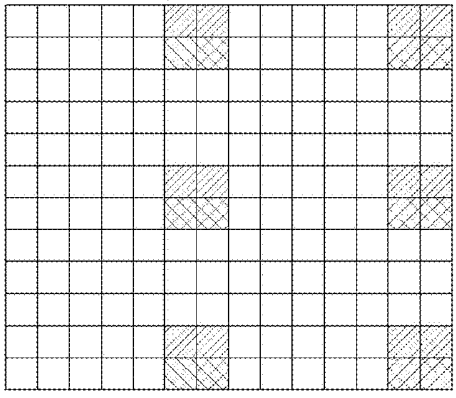


FIG. 10



: DMRS group 1

: DMRS group 2

FIG. 11

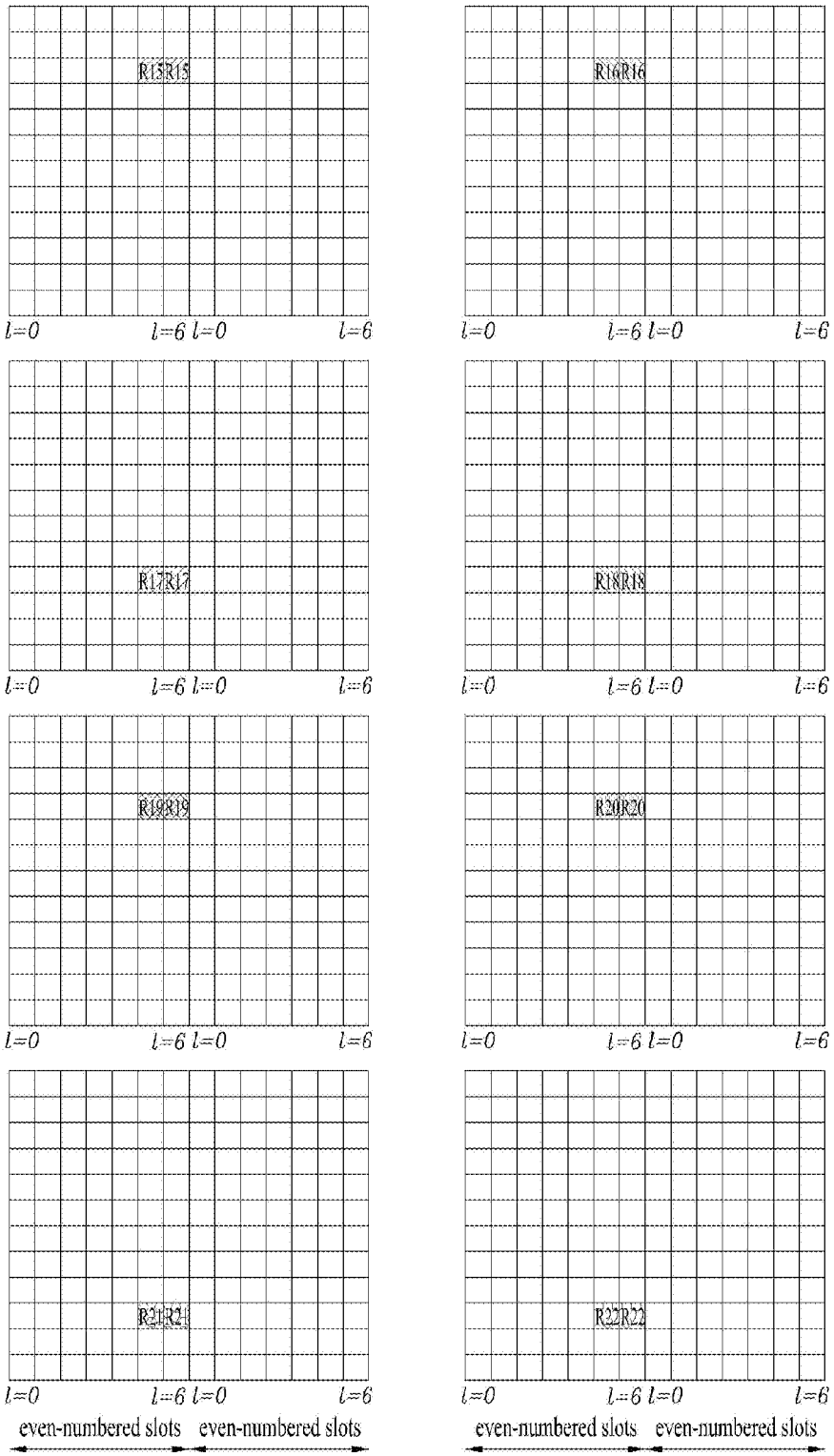

R15R15
R16R16
R17R17
R18R18
R19R19
R20R20
R21R21
R22R22
l=0
l=6
l=0
l=6
even-numbered slots
even-numbered slots

FIG. 12

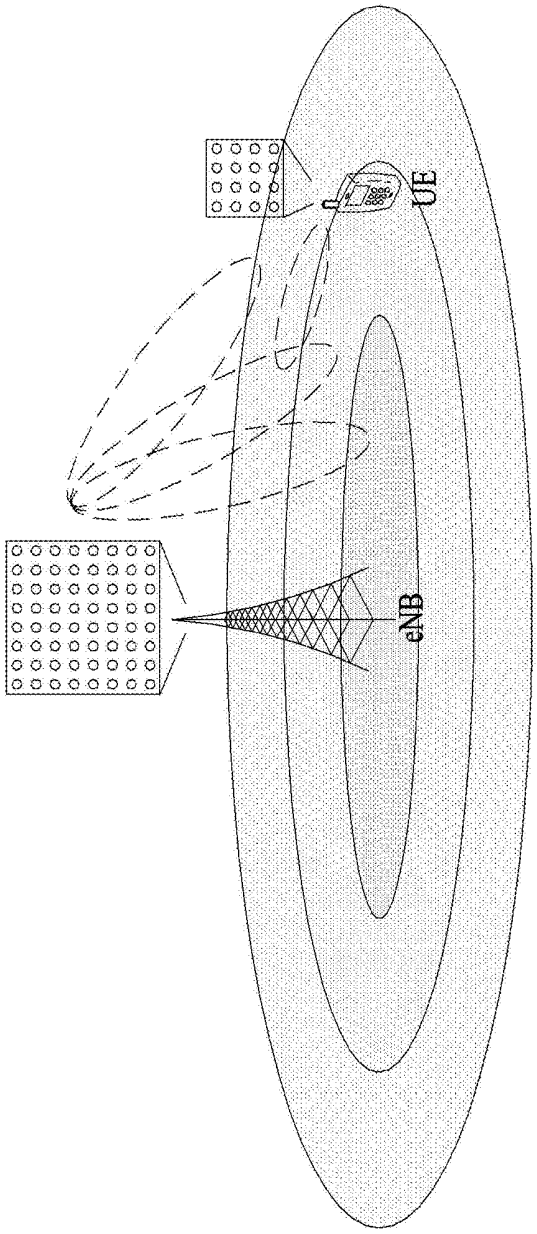


FIG. 13

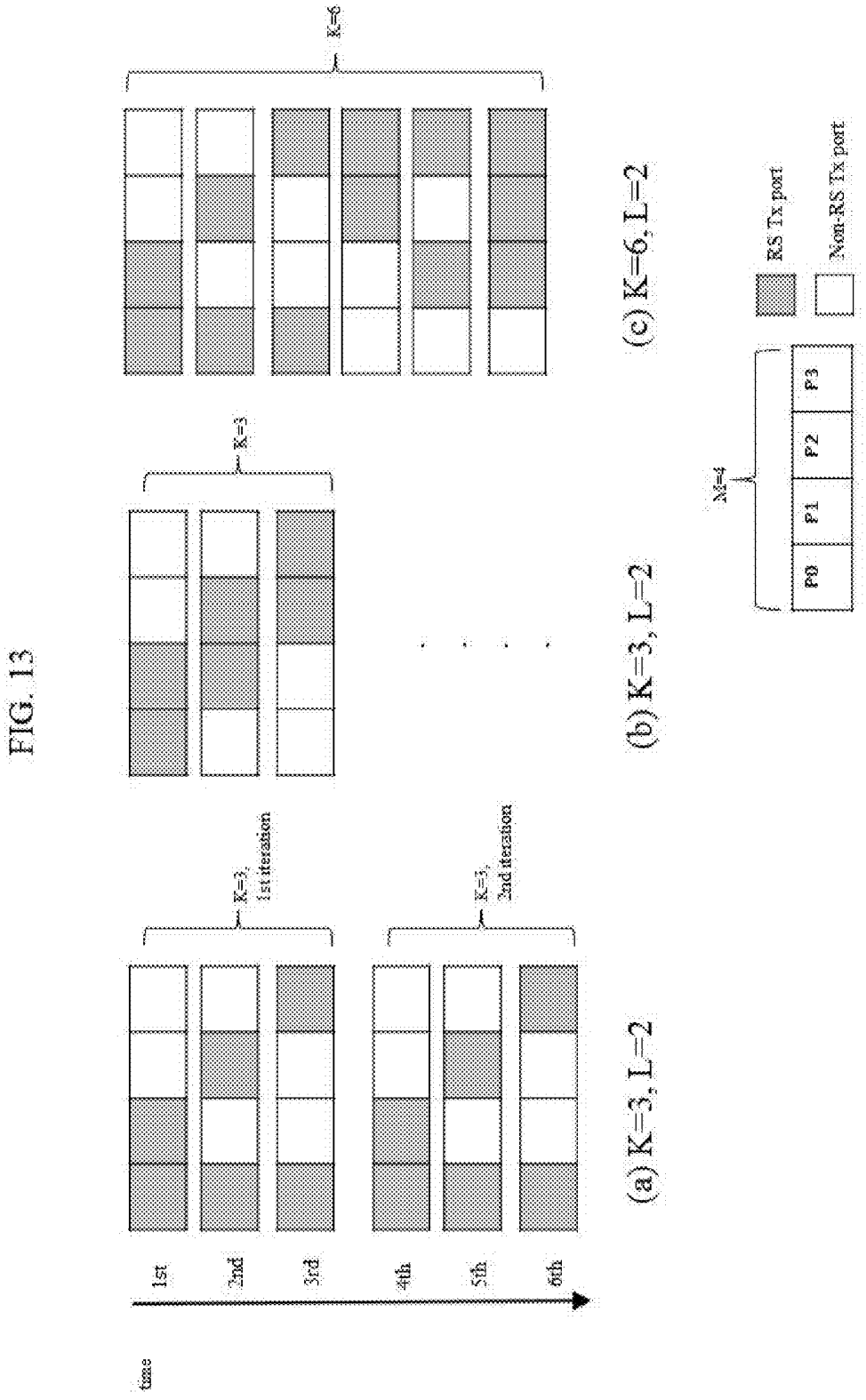

K=6
K=3
K=3, 1st iteration
K=3, 2nd iteration
1st
2nd
3rd
4th
5th
6th
time
(a) K=3, L=2
(b) K=3, L=2
(c) K=6, L=2
M=4
P0
P1
P2
P3
RS Tx port
Non-RS Tx port

FIG. 14

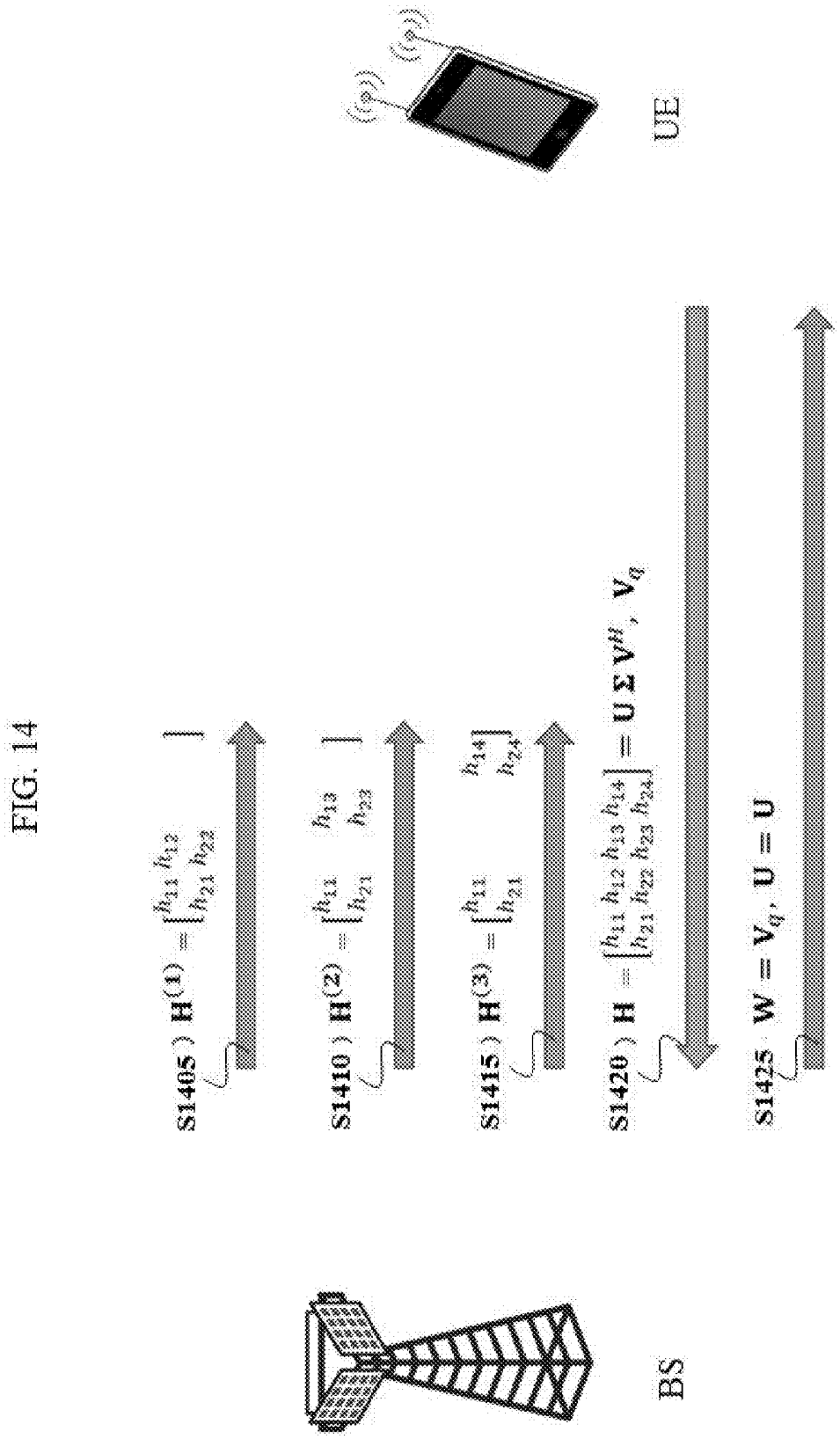

UE
BS
S1405) $\mathbf{H}^{(1)} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}$
S1410) $\mathbf{H}^{(2)} = \begin{bmatrix} h_{11} & h_{13} \\ h_{21} & h_{23} \end{bmatrix}$
S1415) $\mathbf{H}^{(3)} = \begin{bmatrix} h_{11} & h_{14} \\ h_{21} & h_{24} \end{bmatrix}$
S1420) $\mathbf{H} = \begin{bmatrix} h_{11} & h_{12} & h_{13} & h_{14} \\ h_{21} & h_{22} & h_{23} & h_{24} \end{bmatrix} = \mathbf{U}\,\mathbf{\Sigma}\,\mathbf{V}^{H}$, $\mathbf{V}_q$
S1425 $\mathbf{W} = \mathbf{V}_q$, $\mathbf{U} = \mathbf{U}$

FIG. 15

Beamforming	Code-book size		M = 2, L = 2	M = 4, L = 2	M = 6, L = 4	M = 16, L = 4
Perfect CSI-T	∞	μ	4.00	8.00	16.00	32.00
		Ratio	100%	100%	100%	100%
Quantized-V	4^{M-1}	μ	3.35	6.16	11.58	21.16
		Ratio	84.0%	77.1%	72.3%	66.0%

FIG. 16

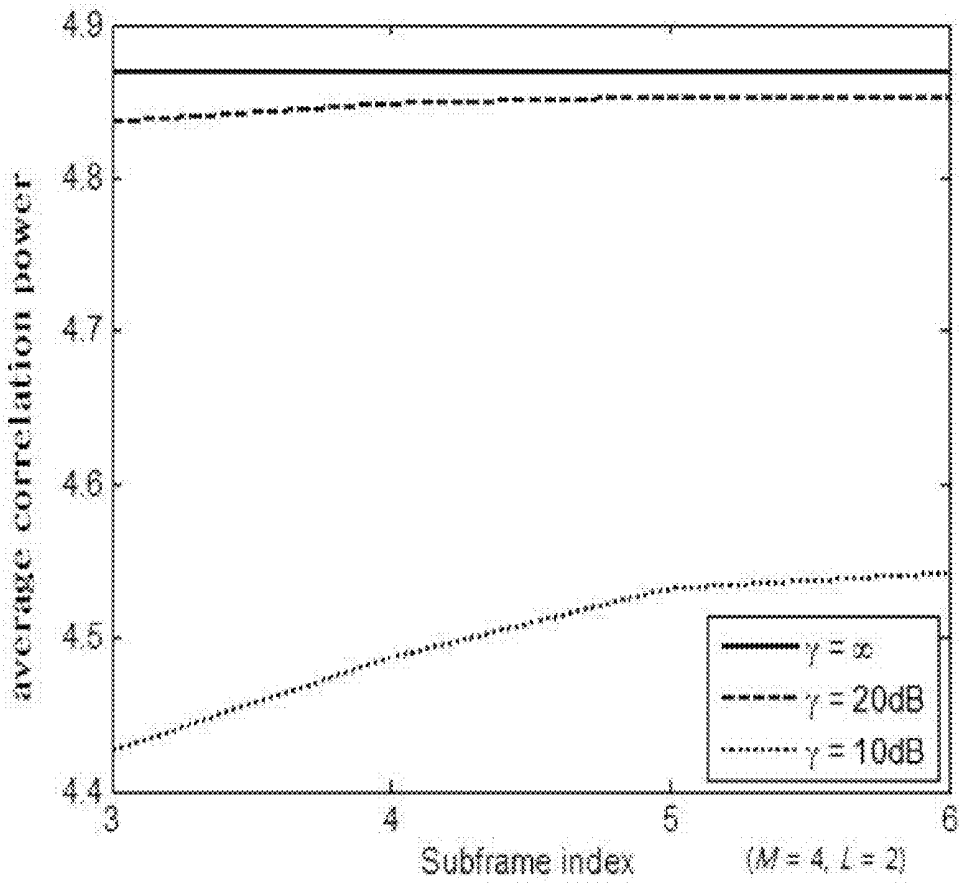

4.9
4.8
4.7
4.6
4.5
4.4
3
4
5
6
average correlation power
Subframe index
(M = 4, L = 2)
γ = ∞
γ = 20dB
γ = 10dB

FIG. 17

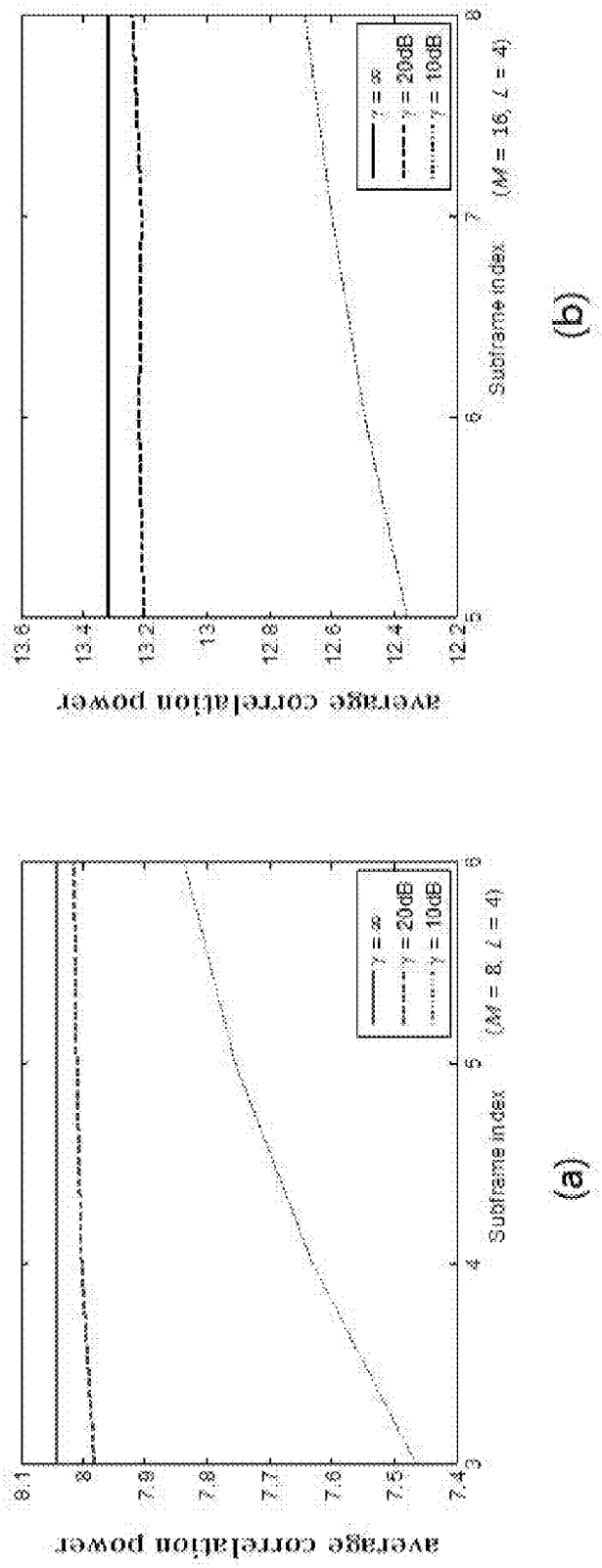
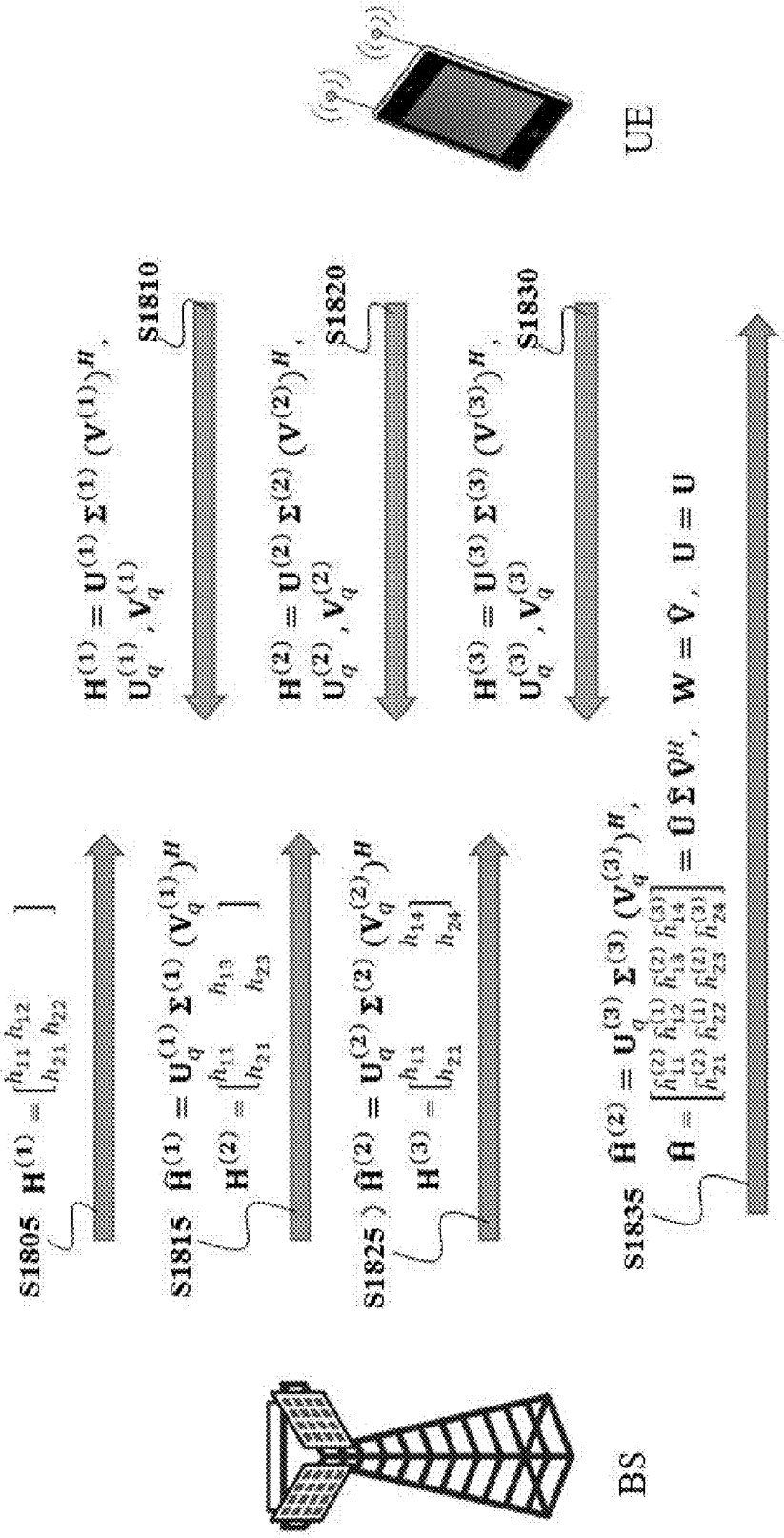

average correlation power
Subframe index
(M = 8, J = 4)
γ = ∞
γ = 20dB
γ = 10dB
(a)
average correlation power
Subframe index
(M = 16, J = 4)
γ = ∞
γ = 20dB
γ = 10dB
(b)

FIG. 18



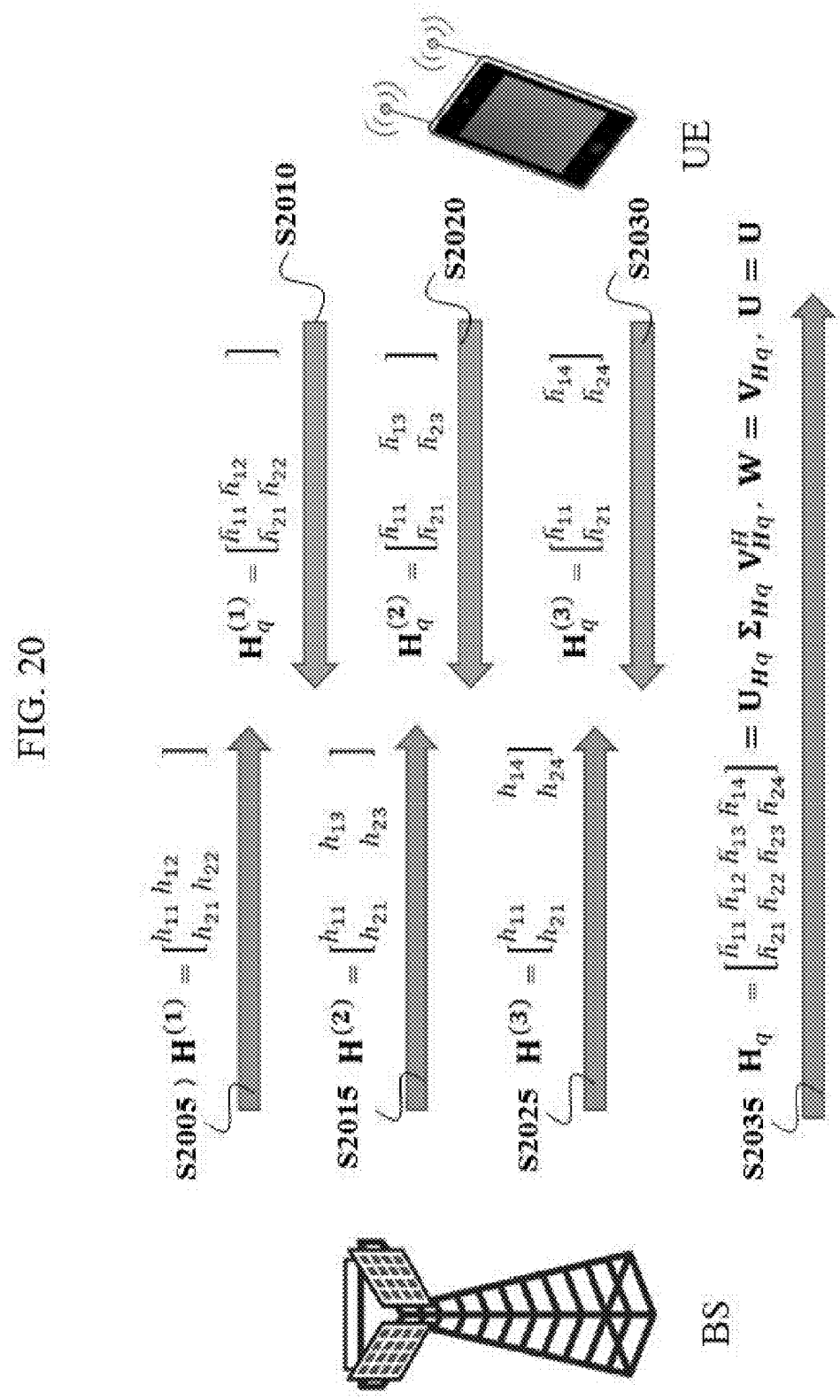
605

FIG. 19

Beamforming	Code-book size		M = 4, L = 2		M = 8, L = 4	
			R1	R2	R1	R2
Perfect CSI-T	∞	μ	8.22	8.00	11.03	16.00
		Ratio	100%	100%	100%	100%
Quantized-U/V (fixed U)	4M-1	μ	4.49	5.22	6.90	8.38
		Ratio	72.8%	65.3%	62.6%	52.4%
Quantized-U/V (quantized U)	4M-1	μ	4.49	5.22	6.90	8.38
		Ratio	72.8%	65.3%	62.6%	52.4%

606

FIG. 20


S2005
$\mathbf{H}^{(1)} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}$
S2010
$\mathbf{H}_q^{(1)} = \begin{bmatrix} \tilde{h}_{11} & \tilde{h}_{12} \\ \tilde{h}_{21} & \tilde{h}_{22} \end{bmatrix}$
S2015
$\mathbf{H}^{(2)} = \begin{bmatrix} h_{11} & h_{13} \\ h_{21} & h_{23} \end{bmatrix}$
S2020
$\mathbf{H}_q^{(2)} = \begin{bmatrix} \tilde{h}_{11} & \tilde{h}_{13} \\ \tilde{h}_{21} & \tilde{h}_{23} \end{bmatrix}$
S2025
$\mathbf{H}^{(3)} = \begin{bmatrix} h_{11} & h_{14} \\ h_{21} & h_{24} \end{bmatrix}$
S2030
$\mathbf{H}_q^{(3)} = \begin{bmatrix} \tilde{h}_{11} & \tilde{h}_{14} \\ \tilde{h}_{21} & \tilde{h}_{24} \end{bmatrix}$
S2035
$\mathbf{H}_q = \begin{bmatrix} \tilde{h}_{11} & \tilde{h}_{12} & \tilde{h}_{13} & \tilde{h}_{14} \\ \tilde{h}_{21} & \tilde{h}_{22} & \tilde{h}_{23} & \tilde{h}_{24} \end{bmatrix} = \mathbf{U}_{Hq} \, \mathbf{\Sigma}_{Hq} \, \mathbf{V}_{Hq}^{H}, \; \mathbf{W} = \mathbf{V}_{Hq}, \; \mathbf{U} = \mathbf{U}$
BS
UE

607

FIG. 21

Beamforming	Code-book size		M = 2, L = 2	M = 4, L = 2	M = 8, L = 4	M = 16, L = 4
Perfect CSI-T	∞	μ	4.00	8.00	16.00	32.00
		Ratio	100%	100%	100%	100%
Quantized-H	4M-1	μ	3.02	4.95	8.76	15.93
		Ratio	75.7%	62.0%	54.8%	49.7%

FIG. 22


$\mathbf{H} = \begin{bmatrix} h_{11} & h_{12} & h_{13} & h_{14} \\ h_{21} & h_{22} & h_{23} & h_{24} \end{bmatrix}$
1st feedback : V of $\mathbf{H}^{(1)} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}$
$\rightarrow \mathbf{V}^{(1)} = \begin{bmatrix} 1 & 1 \\ v_1^{(1)} & v_2^{(1)} \end{bmatrix}$
2nd feedback : V of $\mathbf{H}^{(2)} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \end{bmatrix}$
$\rightarrow \mathbf{V}^{(2)} = \begin{bmatrix} 1 & 1 \\ v_1^{(2)} & v_2^{(2)} \\ v_3^{(2)} & v_4^{(2)} \end{bmatrix}$
3rd feedback : V of $\mathbf{H}^{(3)} = \begin{bmatrix} h_{11} & h_{12} & h_{13} & h_{14} \\ h_{21} & h_{22} & h_{23} & h_{24} \end{bmatrix}$
$\rightarrow \mathbf{V}^{(2)} = \begin{bmatrix} 1 & 1 \\ v_1^{(3)} & v_2^{(3)} \\ v_3^{(3)} & v_4^{(3)} \\ v_5^{(3)} & v_6^{(3)} \end{bmatrix}$

FIG. 23

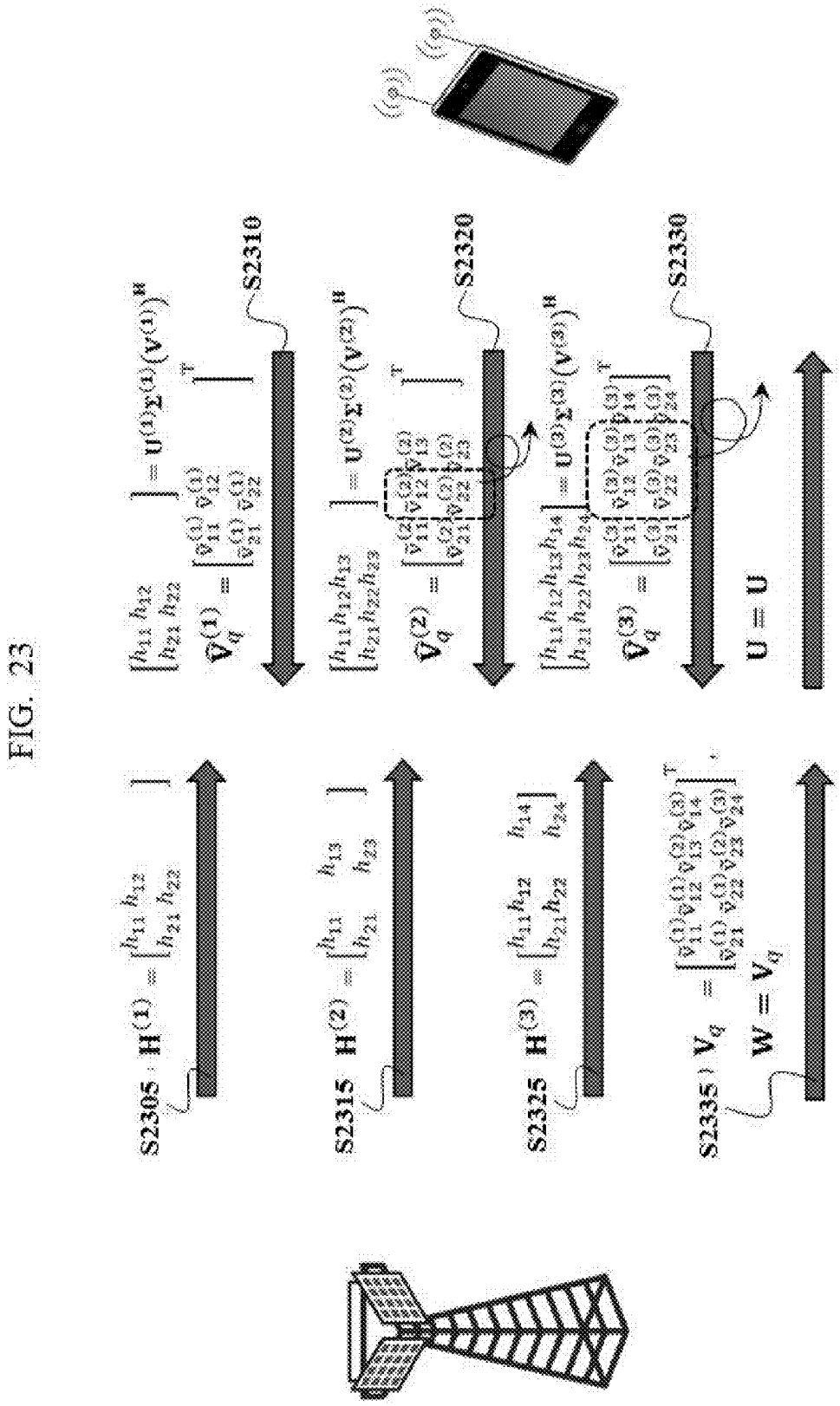


FIG. 24

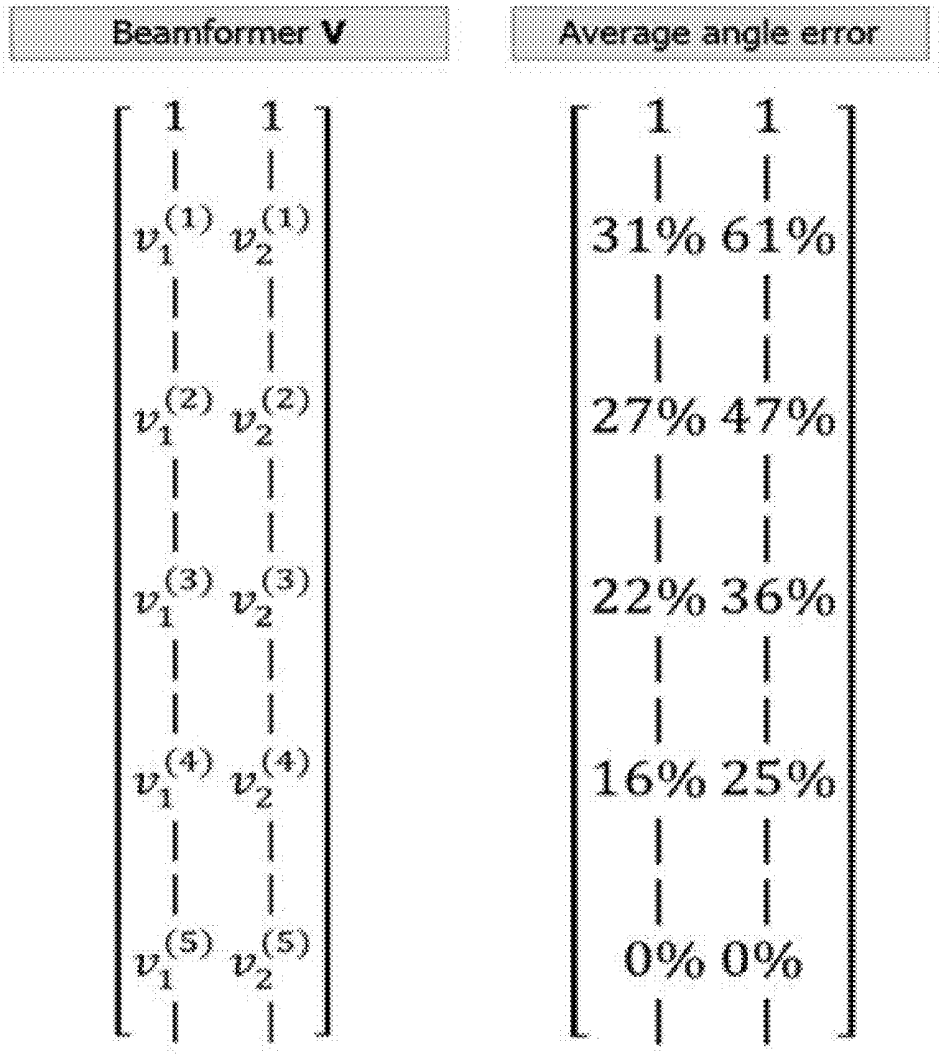
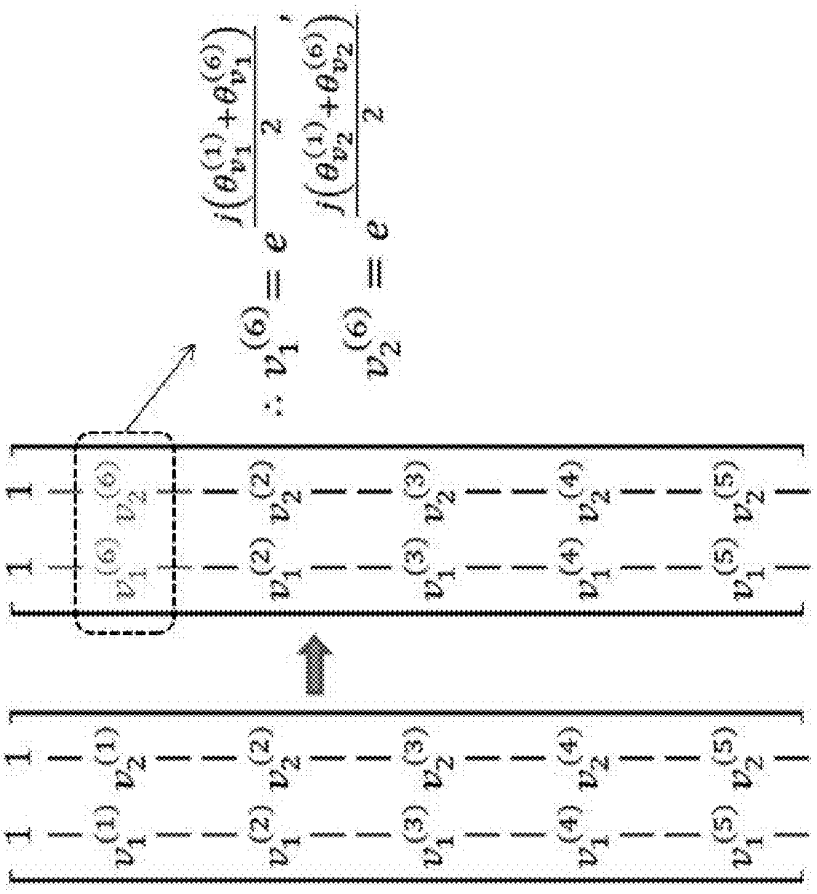

Beamformer V
Average angle error
1 1
$v_1^{(1)}$ $v_2^{(1)}$
$v_1^{(2)}$ $v_2^{(2)}$
$v_1^{(3)}$ $v_2^{(3)}$
$v_1^{(4)}$ $v_2^{(4)}$
$v_1^{(5)}$ $v_2^{(5)}$
1 1
31% 61%
27% 47%
22% 36%
16% 25%
0% 0%

FIG. 25


5th
6th
$\therefore v_1^{(6)} = e^{\frac{j\left(\theta_{v_1}^{(1)}+\theta_{v_1}^{(6)}\right)}{2}}$
$v_2^{(6)} = e^{\frac{j\left(\theta_{v_2}^{(1)}+\theta_{v_2}^{(6)}\right)}{2}}$

612

FIG. 26

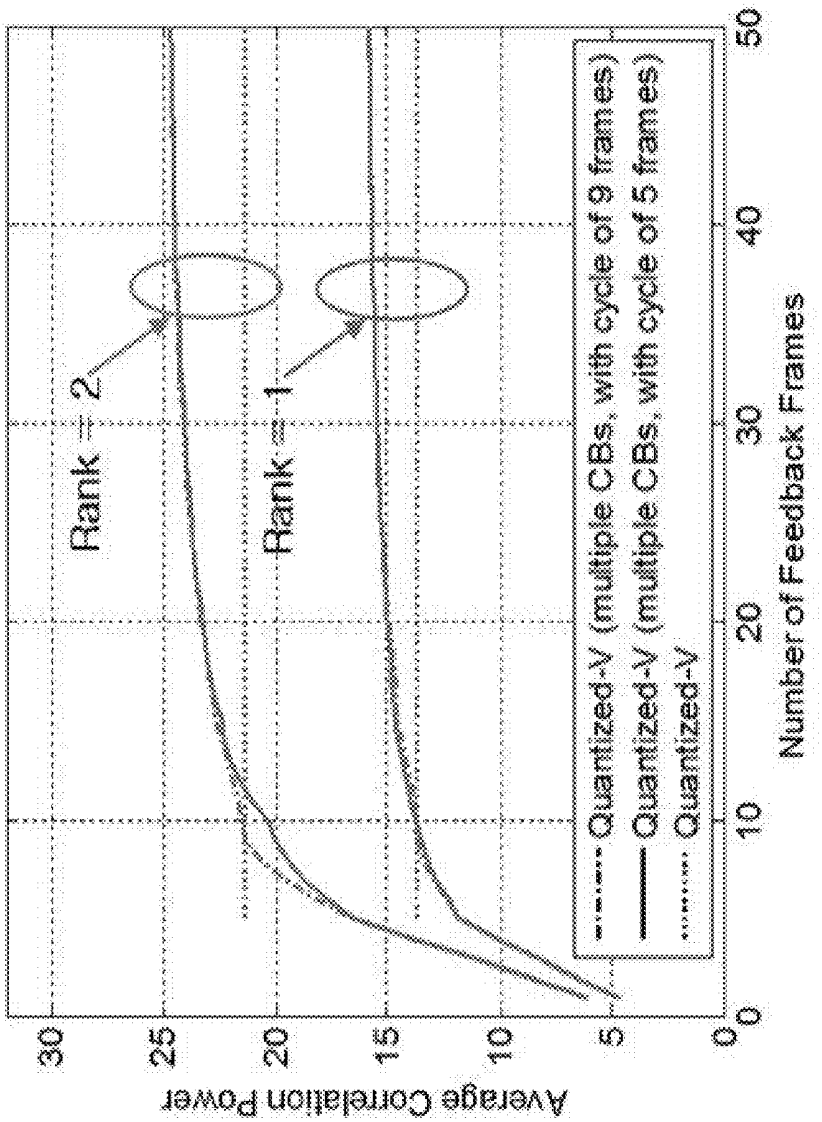
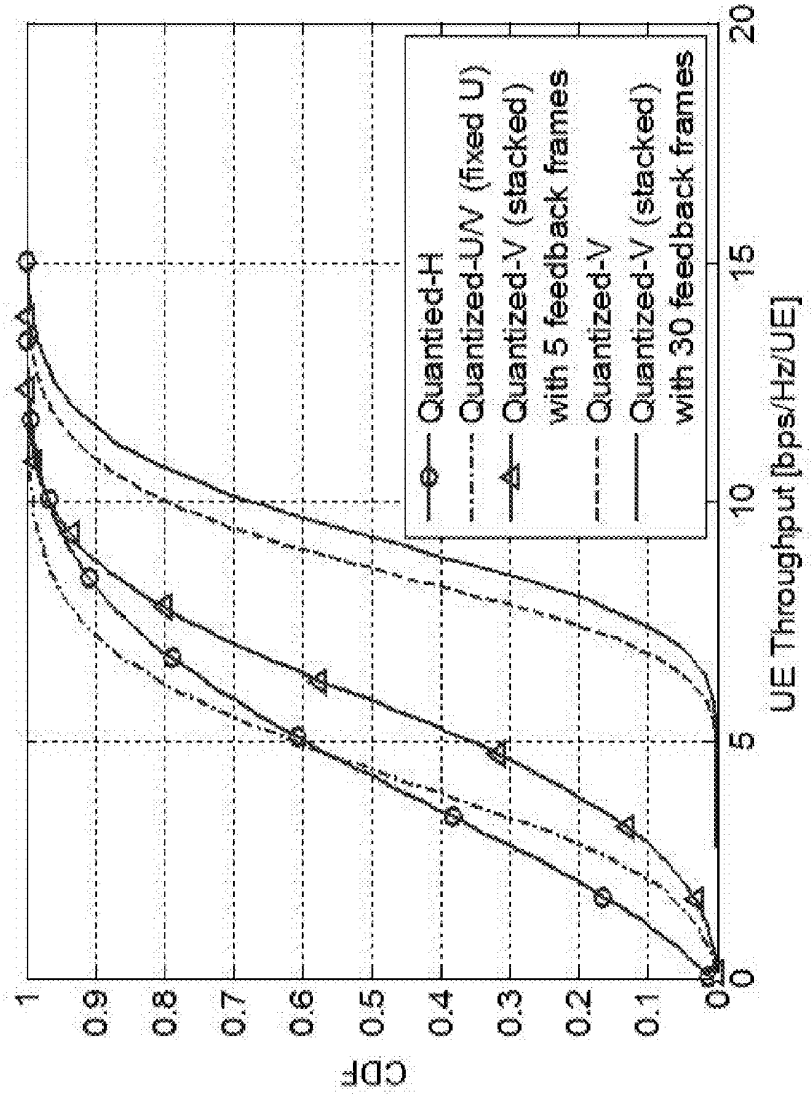

Average Correlation Power
Number of Feedback Frames
Rank = 2
Rank = 1
Quantized-V (multiple CBs, with cycle of 9 frames)
Quantized-V (multiple CBs, with cycle of 5 frames)
Quantized-V
0
5
10
15
20
25
30
0
10
20
30
40
50

FIG. 27

Beamforming	Codebook Size		$M = 4, L = 2$		$M = 16, L = 4$	
			R1	R2	R1	R2
Perfect CSI-T	∞	μ	6.22	8.00	20.39	32.00
		Ratio	100%	100%	100%	100%
Quantized-H	4^{M-1}	μ	3.98	4.95	9.41	15.93
		Ratio	64.0%	62.0%	46.2%	49.7%
Quantized-U/V	4^{M-1}	μ	4.49	5.24	10.34	13.36
		Ratio	72.2%	65.5%	50.7%	41.8%
Quantized-U/V (fixed U)	4^{M-1}	μ	4.49	5.22	10.34	12.21
		Ratio	72.2%	65.3%	50.7%	38.0%
Quantized-V	4^{M-1}	μ	4.78	6.16	13.40	21.16
		Ratio	76.8%	77.1%	65.7%	66.0%
Quantized-V (stacked)	4^{M-1}	μ	4.66	5.25	11.92	16.47
		Ratio	74.9%	65.6%	58.4%	51.4%

FIG. 28


CDF
UE Throughput [bps/Hz/UE]
Quantied-H
Quantized-U/V (fixed U)
Quantized-V (stacked) with 5 feedback frames
Quantized-V
Quantized-V (stacked) with 30 feedback frames

615

FIG. 29

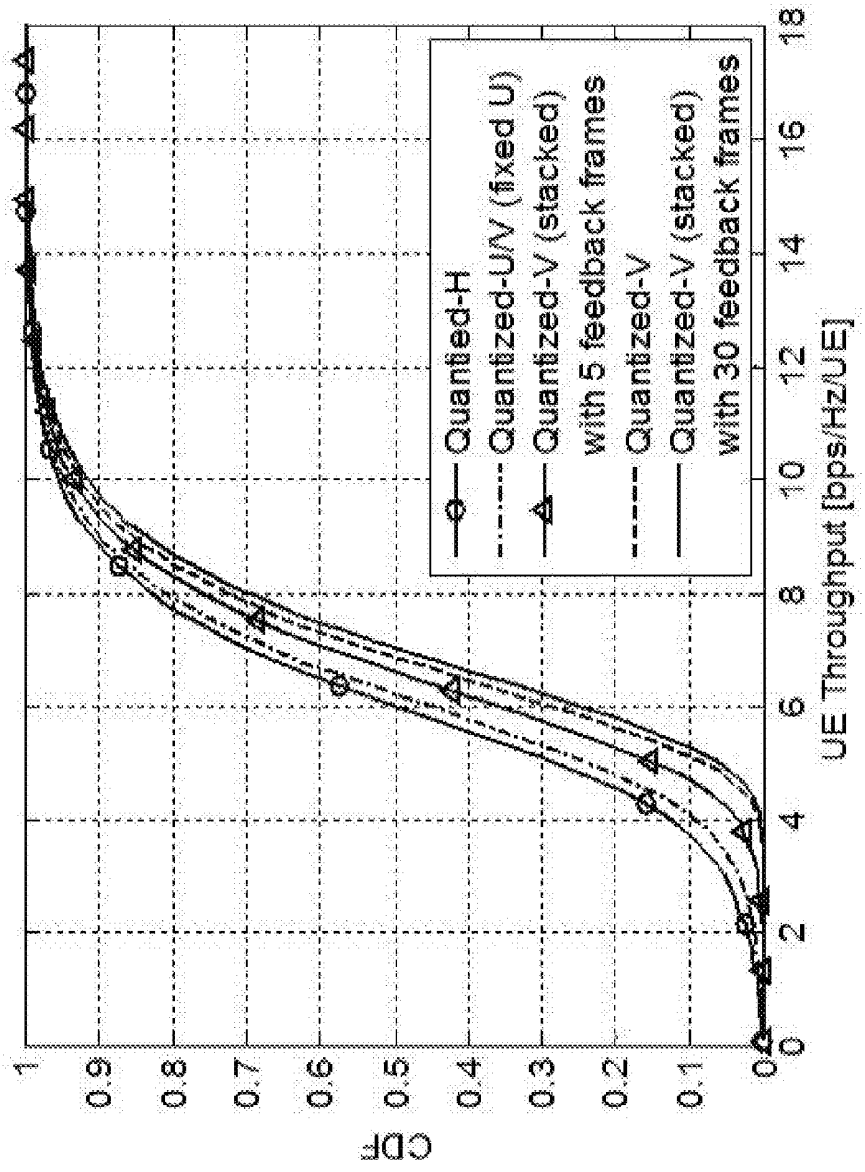

CDF
UE Throughput [bps/Hz/UE]
Quantized-H
Quantized-U/V (fixed U)
Quantized-V (stacked) with 5 feedback frames
Quantized-V
Quantized-V (stacked) with 30 feedback frames

FIG. 30

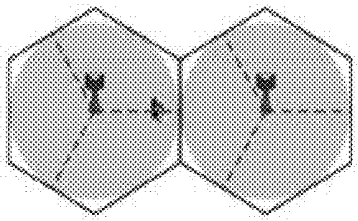
Parameters	Values
Cells	2-cell model 
UEs	U = 1 UEs per sector
Tx antenna	M = 16
Rx antenna	N = 2
Noise	Noise free
Fading	Rayleigh fading channel
Pathloss model	ITU-R M.2135-1 UMa model
Antenna height	BS: 25m, UE: 1.5m
Inter-eNB distance	500m
Carrier frequency	2GHz

FIG. 31

Beamforming	# of feedback bits	$M = 4, L = 2$		$M = 16, L = 4$	
		R1	R2	R1	R2
Perfect CSI-T	∞	∞	∞	∞	∞
Quantized-H	bits per frame	2	4	6	12
Quantized-U/V	bits per frame	4	8	8	16
Quantized-U/V (fixed U)	bits per frame	2	4	6	12
Quantized-V	bits per frame	2	4	6	12
	(bits per cycle)	6	12	30	60
Quantized-V (stacked)	bits per frame	2	4	6	12

618

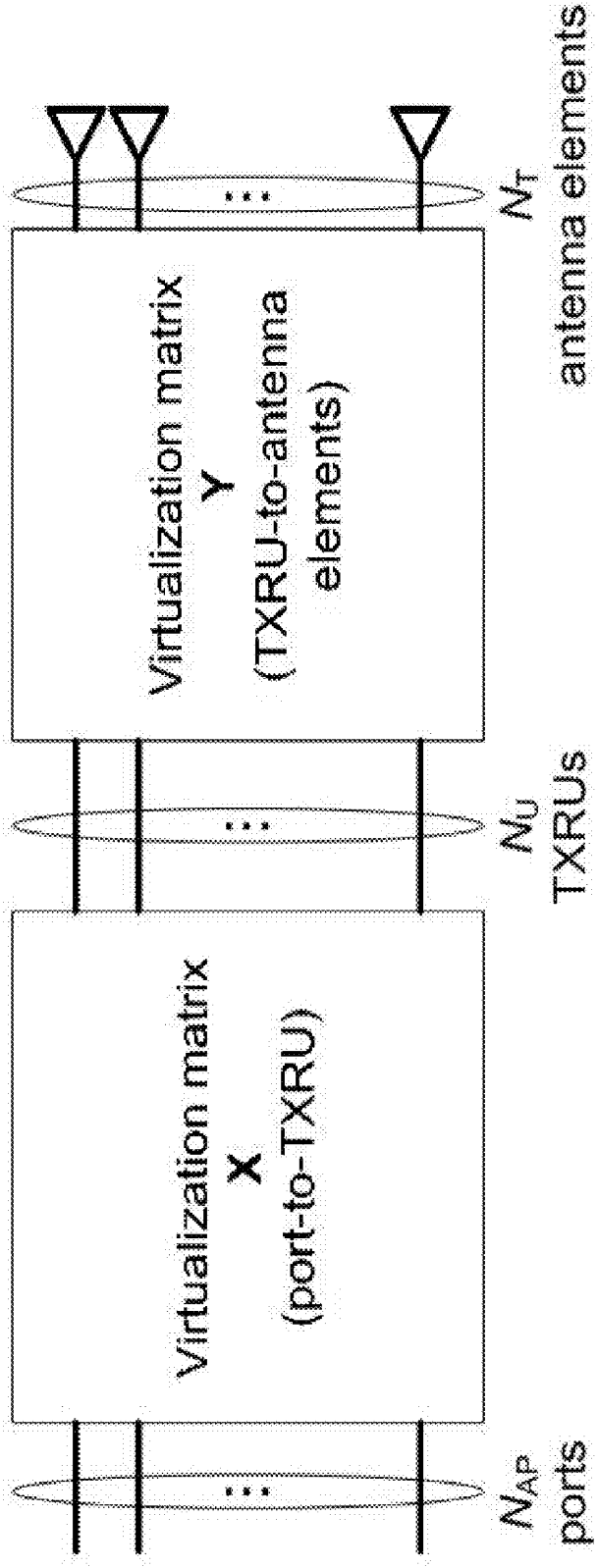

Virtualization matrix
X
(port-to-TXRU)
Virtualization matrix
Y
(TXRU-to-antenna elements)
N_{AP} ports
N_U TXRUs
N_T antenna elements

FIG. 32

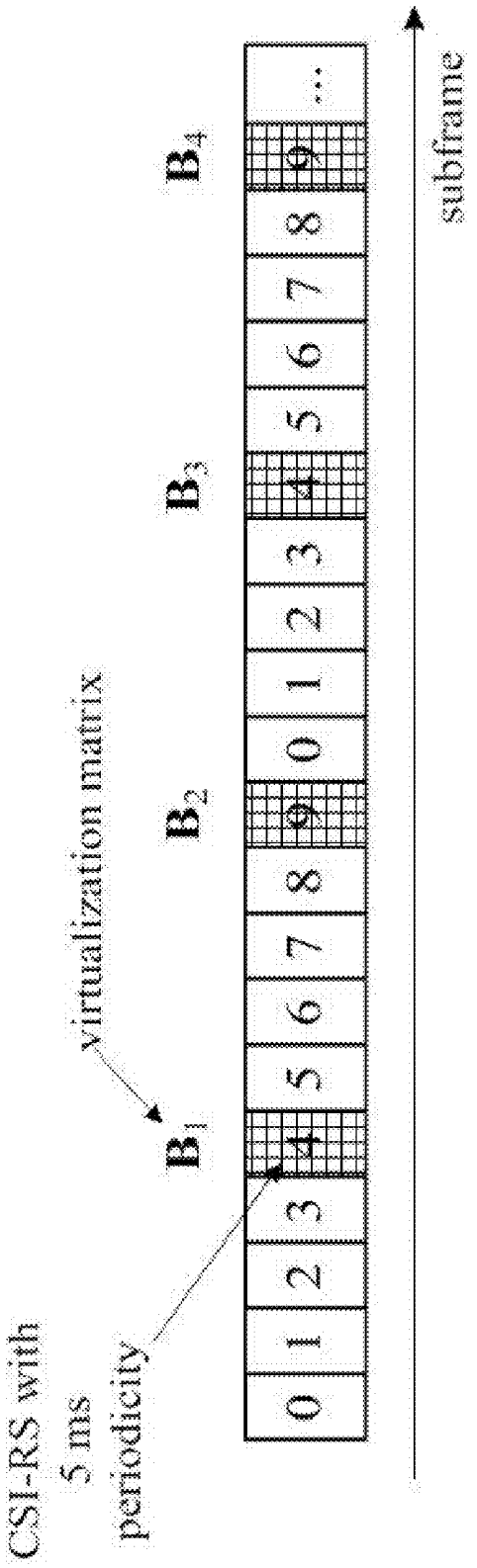

CSI-RS with
5 ms
periodicity
virtualization matrix
B_1
B_2
B_3
B_4
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 ...
subframe

FIG. 33

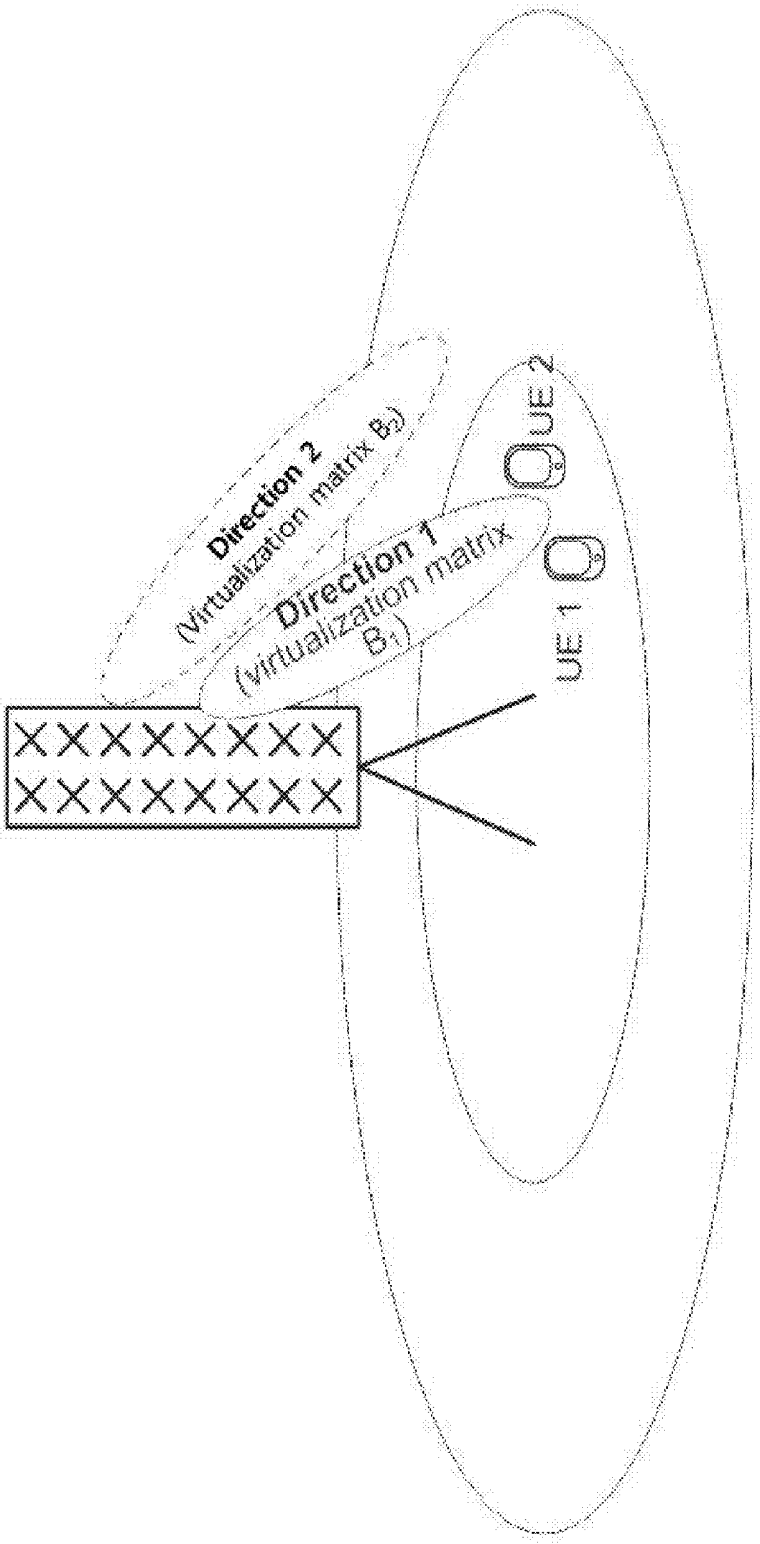
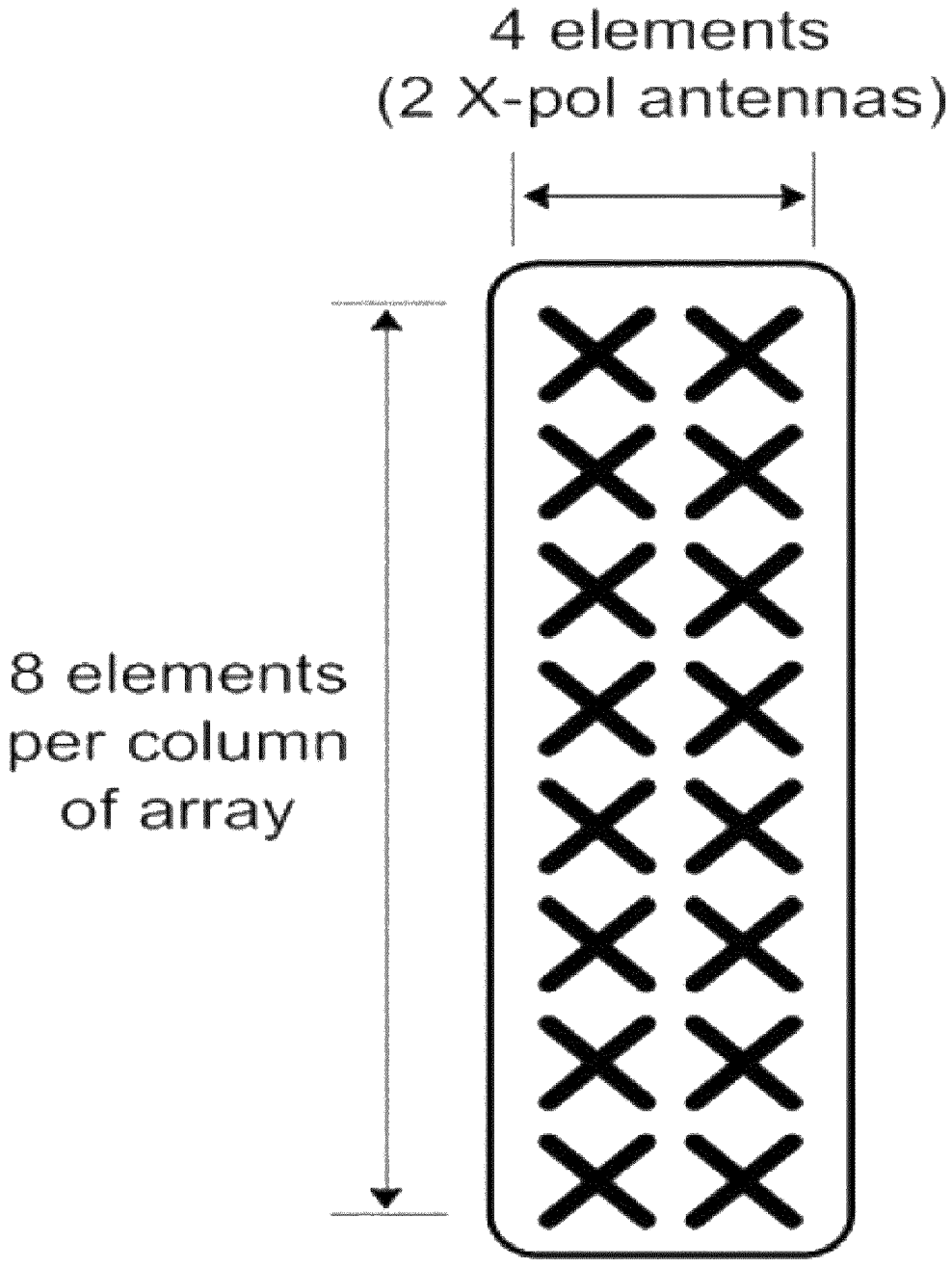

Direction 2
(Virtualization matrix B_2)
Direction 1
(virtualization matrix
B_1)
UE 2
UE 1

FIG. 34

FIG. 35



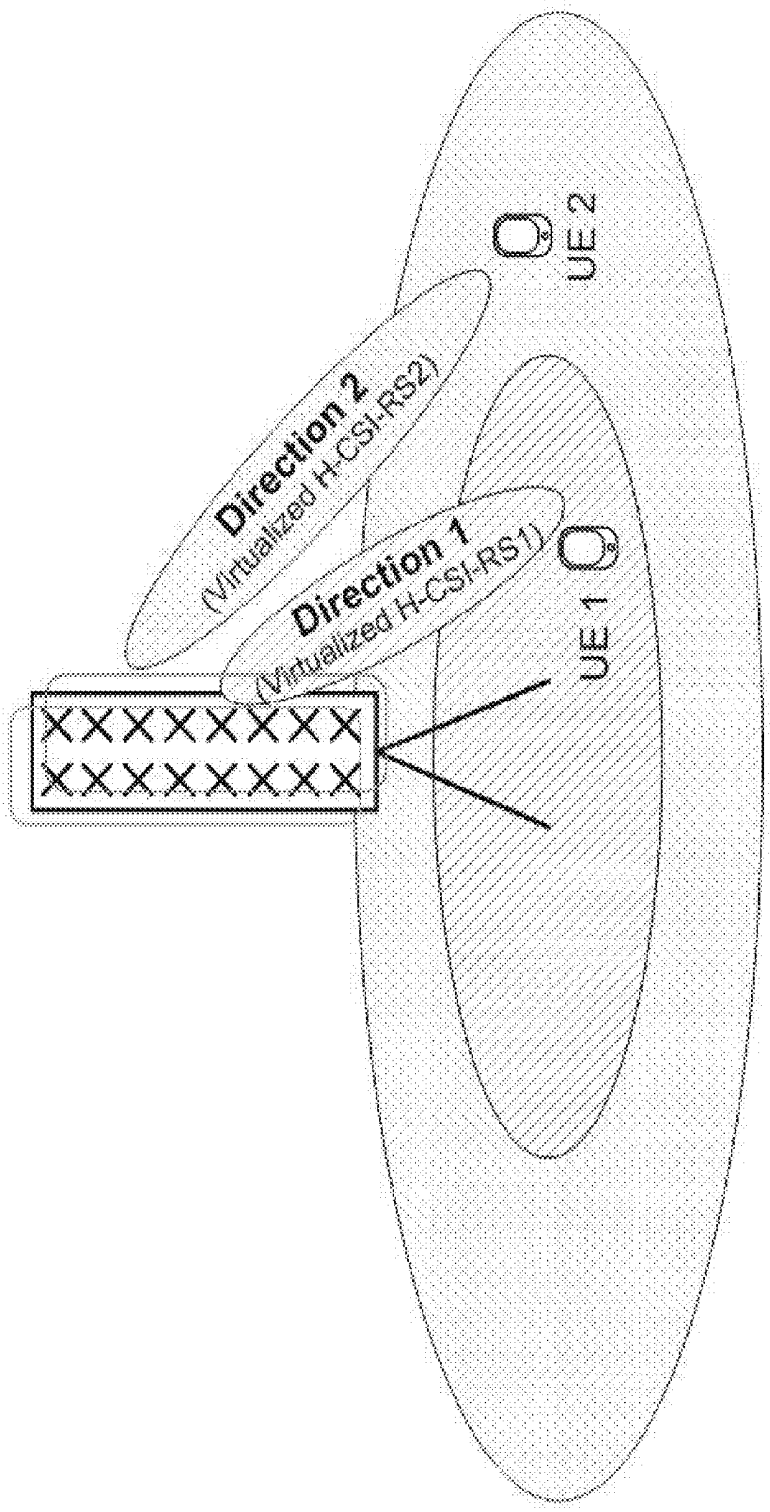
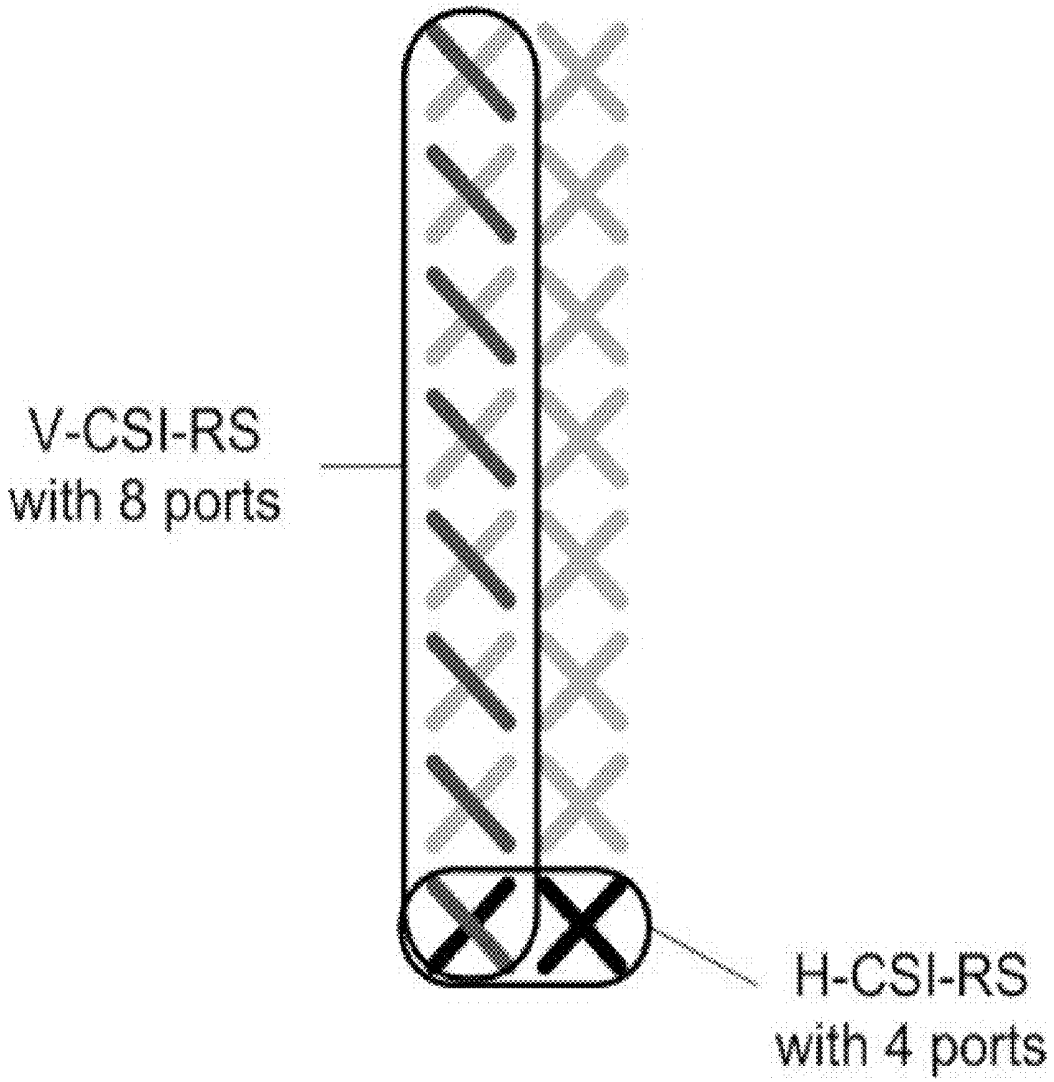

UE 2
Direction 2
(Virtualized H-CSI-RS2)
Direction 1
(Virtualized H-CSI-RS1)
UE 1

FIG. 36

FIG. 37



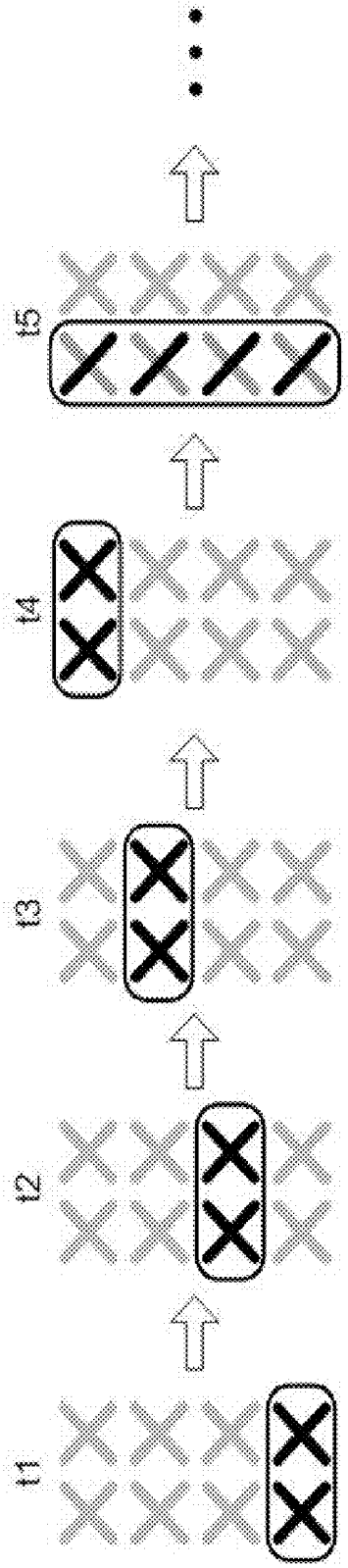
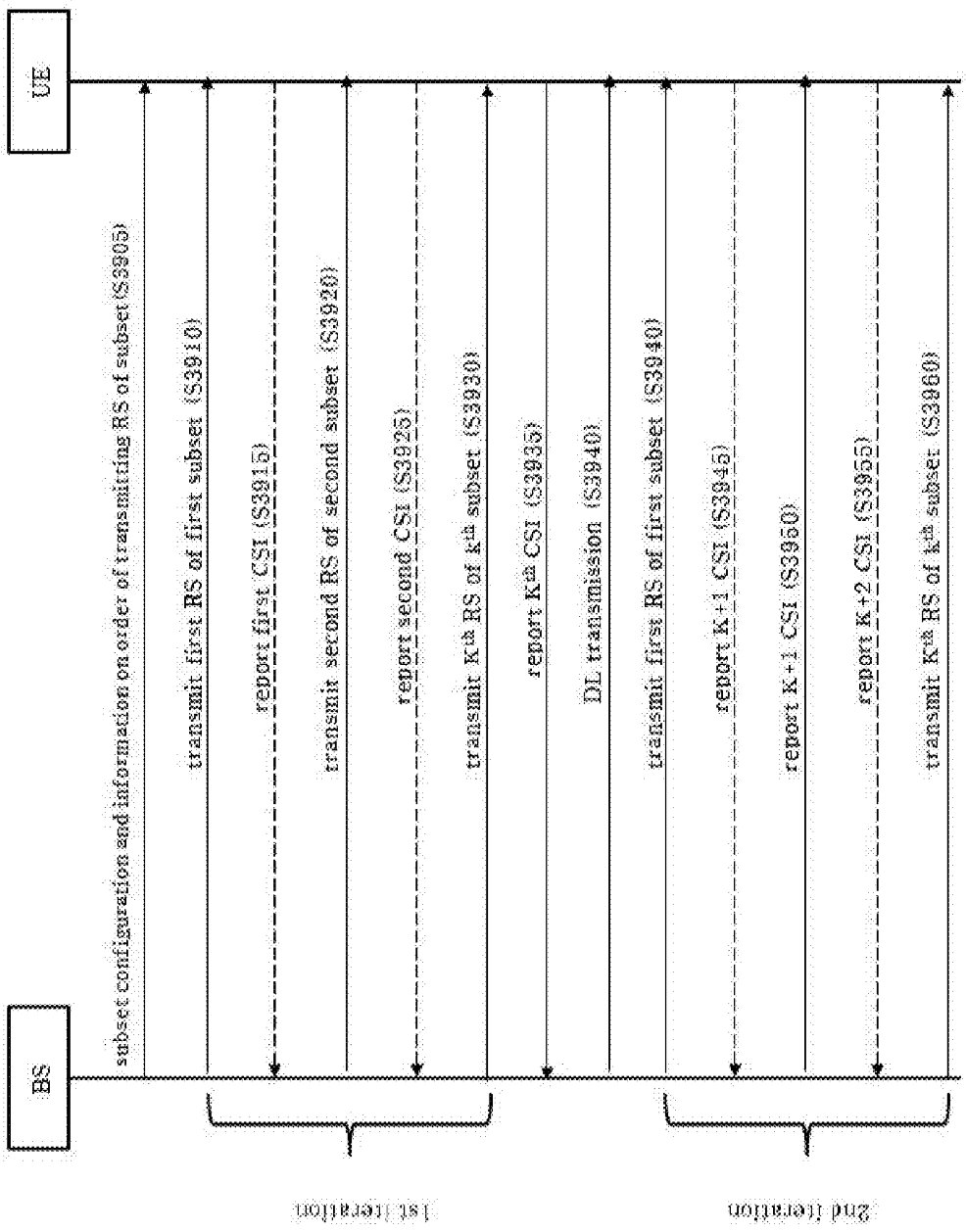


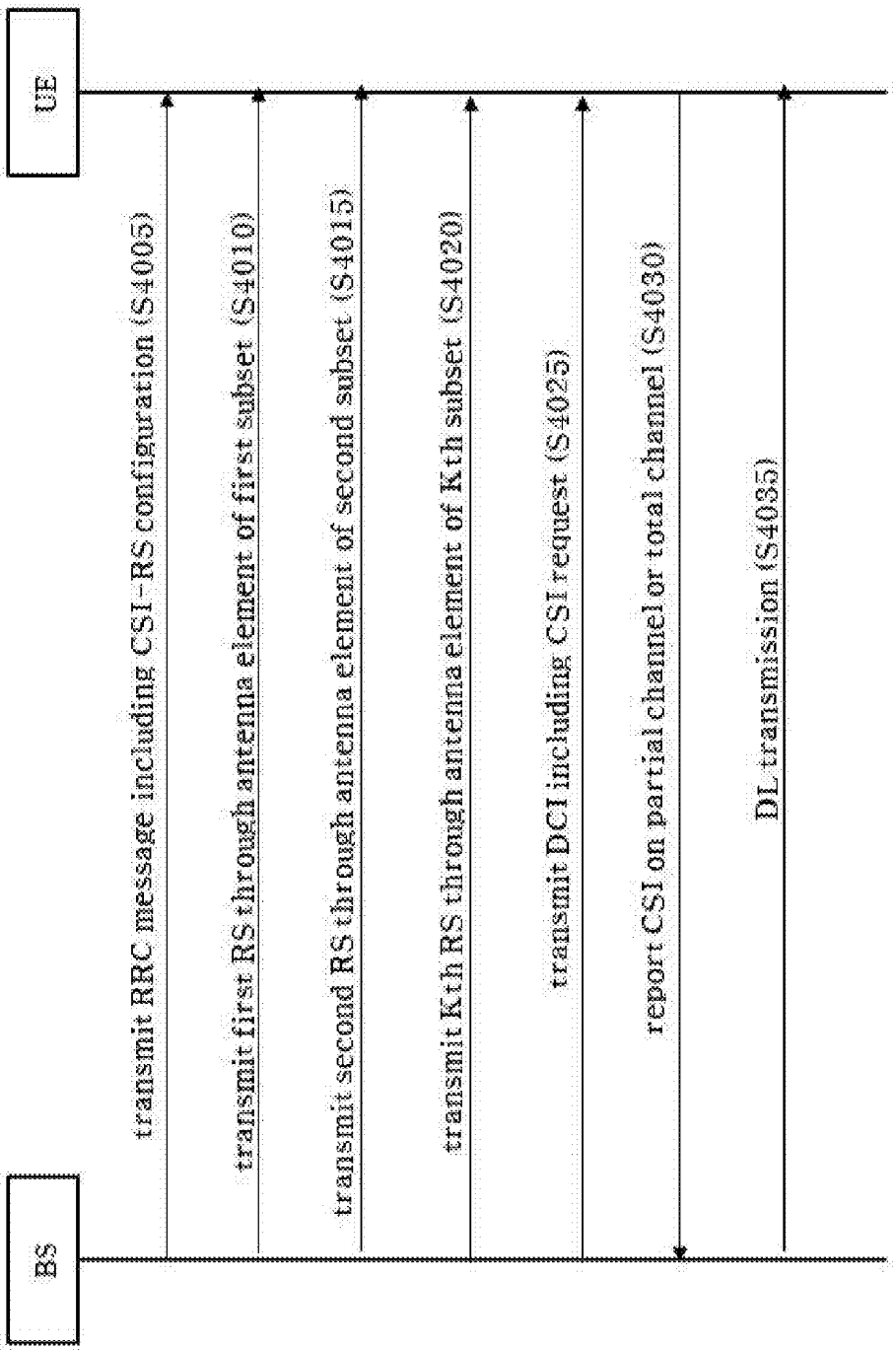
FIG. 38

FIG. 39


UE
BS
subset configuration and information on order of transmitting RS of subset (S3905)
transmit first RS of first subset (S3910)
report first CSI (S3915)
transmit second RS of second subset (S3920)
report second CSI (S3925)
transmit K^th RS of kth subset (S3930)
report K^th CSI (S3935)
DL transmission (S3940)
transmit first RS of first subset (S3940)
report K+1 CSI (S3945)
report K+1 CSI (S3950)
report K+2 CSI (S3955)
transmit K^th RS of kth subset (S3960)
1st iteration
2nd iteration

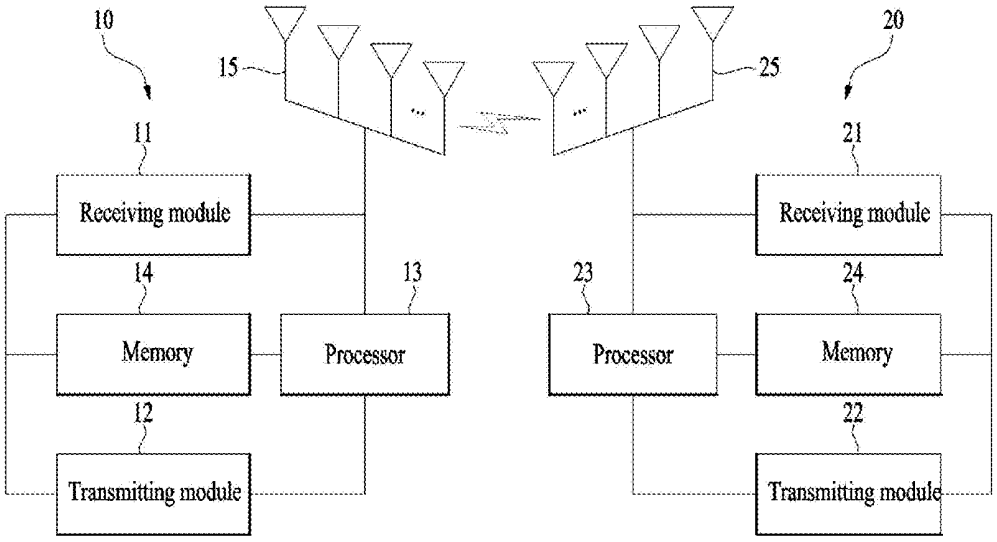
626

FIG. 40


BS
UE
transmit RRC message including CSI-RS configuration (S4005)
transmit first RS through antenna element of first subset (S4010)
transmit second RS through antenna element of second subset (S4015)
transmit Kth RS through antenna element of Kth subset (S4020)
transmit DCI including CSI request (S4025)
report CSI on partial channel or total channel (S4030)
DL transmission (S4035)

627

FIG. 41


10
15
25
20
11
21
Receiving module
Receiving module
14
13
23
24
Memory
Processor
Processor
Memory
12
22
Transmitting module
Transmitting module

METHOD FOR REPORTING CHANNEL STATE INFORMATION IN WIRELESS COMMUNICATION SYSTEM AND APPARATUS THEREFOR

TECHNICAL FIELD

[0001] The present invention relates to a wireless communication system, and more particularly, to a method of reporting channel state information in a wireless communication system and an apparatus therefor.

BACKGROUND ART

[0002] A brief description is now given of a 3rd Generation Partnership Project Long Term Evolution (3GPP LTE or, simply, LTE) communication system as an example of a wireless communication system to which the present invention is applicable.

[0003] FIG. **1** illustrates a schematic structure a network structure of an evolved universal mobile telecommunication system (E-UMTS). An E-UMTS system is an evolved version of the UMTS system and basic standardization thereof is in progress under the 3rd Generation Partnership Project (3GPP). The E-UMTS is also referred to as a Long Term Evolution (LTE) system. For details of the technical specifications of the UMTS and E-UMTS, refer to Release 7 and Release 8 of "3rd Generation Partnership Project; Technical Specification Group Radio Access Network".

[0004] Referring to FIG. **1**, the E-UMTS includes a User Equipment (UE), base stations (or eNBs or eNode Bs), and an Access Gateway (AG) which is located at an end of a network (E-UTRAN) and which is connected to an external network. Generally, an eNB can simultaneously transmit multiple data streams for a broadcast service, a multicast service and/or a unicast service.

[0005] One or more cells may exist for one BS. The cell provides a downlink or uplink transmission service to several UEs using any one of bandwidths of 1.4, 3, 5, 10, 15 and 20 MHz. Different cells may be set to provide different bandwidths. A BS controls data transmission or reception to or from a plurality of UEs. The BS transmits downlink scheduling information to a UE with respect to downlink (DL) data so as to inform the UE of time/frequency domain, coding, data size, Hybrid Automatic Repeat and reQuest (HARQ) associated information of data to be transmitted, or the like. The BS transmits uplink scheduling information to a UE with respect to uplink (UL) data so as to inform the UE of time/frequency domain, coding, data size, HARQ associated information used by the UE, or the like. An interface for transmitting user traffic or control traffic can be used between BSs. A Core Network (CN) may include the AG; a network node for user registration of the UE, or the like. The AG manages mobility of a UE on a Tracking Area (TA) basis. One TA includes a plurality of cells.

[0006] Wireless communication technology has been developed to reach the LTE based on Wideband Code Division Multiple Access (WCDMA), but demands and expectations of users and providers have continuously increased. In addition, since other aspects of wireless access technology continue to evolve, new advances are required to remain competitive in the future. There is a need for reduction in cost per bit, service availability increase, the use of a flexible frequency band, a simple structure and an open type interface, appropriate power consumption of a UE, etc.

[0007] Recently, ongoing standardization of the next technology of LTE is performed by 3GPP. Such technology shall be named LTE-A. The goal of LTE-A system is to support maximum 100 MZ wideband. To this end, LTE-A system uses a carrier aggregation (CA) technology to achieve the wideband using a plurality of frequency blocks. According to the carrier aggregation, a plurality of frequency blocks are used as one wide logical frequency band to use wider frequency band. And, a bandwidth of each frequency block may be defined based on a bandwidth of a system block used by LTE system. And, each frequency block can be referred to as a component carrier (CC) or a cell.

[0008] Multiple-Input Multiple-Output (MIMO) technology is a technology capable of improving data transmission/reception efficiency using multiple transmit (Tx) antennas and multiple receive (Rx) antennas instead of using a single Tx antenna and a single Rx antenna. A receiver using a single antenna receives data through a single antenna path, but a receiver using multiple antennas receives data through multiple paths. Accordingly, data transfer rate and data throughput may be improved, and coverage may be expanded.

[0009] To increase a multiplexing gain of MIMO operation, a MIMO transmitter may receive and use channel state information (CSI) fed back from a MIMO receiver.

[0010] It is anticipated that a MIMO system is to have extensive development as a result of size increase of a user equipment, technological advancement and cost reduction. For example, a plurality of antennas (or number of antennas increased compared to legacy number of antennas) can be installed not only in a MIMO transmitting end (e.g., base station) but also in a MIMO receiving end (e.g., UE). If the number of antenna ports of a transmitting end and/or a receiving end increase, since time taken for reporting CSI and a frequency resource are sharply increasing, a transfer rate may be considerably reduced.

DISCLOSURE OF THE INVENTION

Technical Task

[0011] An object of the present invention is to provide a method of reporting channel state information in a wireless communication system and an apparatus therefor based on the aforementioned discussion.

[0012] Technical tasks obtainable from the present invention are non-limited the above-mentioned technical task. And, other unmentioned technical tasks can be clearly understood from the following description by those having ordinary skill in the technical field to which the present invention pertains.

Technical Solution

[0013] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, according to one embodiment, a method of reporting channel state information (CSI) by a user equipment in a wireless communication system, includes receiving an RRC message including at least one CSI-RS configuration for a first direction domain from a base station, receiving, via different subframes respectively, a first CSI-RS and a second CSI-RS from a first subset and a second CSI-RS from a second subset among a plurality of physical antenna elements of the base station through subframes different from each other based on the at least one or more CSI-RS configu-

rations at least one CSI-RS configuration, and performing a CSI report using the first CSI-RS and the second CSI-RS. In this case, if a number of the at least one CSI-RS configuration for the first direction domain corresponds to one, the first CSI-RS and the second CSI-RS are respectively received from the first subset and the second subset according to virtualization-varying of antenna ports related to the one CSI-RS configuration, the virtualization-varying being performed in accordance with a predetermined period.

[0014] To further achieve these and other advantages and in accordance with the purpose of the present invention, according to a different embodiment, a method of receiving channel state information (CSI) by a base station in a wireless communication system, includes the steps of transmitting an RRC message including at least one CSI-RS configuration for a first direction domain to a user equipment, transmitting, to the user equipment via different subframes respectively, a first CSI-RS mapped to a first subset and a second CSI-RS mapped to a second subset among a plurality of physical antenna elements of the base station, and receiving a CSI report using the first CSI-RS and the second CSI-RS. In this case, if a number of the at least one CSI-RS configuration for the first direction domain corresponds to one, the first CSI-RS and the second CSI-RS are respectively received from the first subset and the second subset according to virtualization-varying of antenna ports related to the one CSI-RS configuration, the virtualization-varying being performed in accordance with a predetermined period.

[0015] To further achieve these and other advantages and in accordance with the purpose of the present invention, according to a further different embodiment, a user equipment reporting channel state information (CSI) in a wireless communication system includes a receiver configured to receive an RRC message including at least one CSI-RS configuration for a first direction domain from a base station and to receive, via different subframes respectively, a first CSI-RS and a second CSI-RS from a first subset and a second CSI-RS from a second subset among a plurality of physical antenna elements of the base station through subframes different from each other based on the at least one or more CSI-RS configurations at least one CSI-RS configuration and a processor configured to perform a CSI report using the first CSI-RS and the second CSI-RS. In this case, if a number of the at least one CSI-RS configuration for the first direction domain corresponds to one, the first CSI-RS and the second CSI-RS are respectively received from the first subset and the second subset according to virtualization-varying of antenna ports related to the one CSI-RS configuration, the virtualization-varying being performed in accordance with a predetermined period.

[0016] To further achieve these and other advantages and in accordance with the purpose of the present invention, according to a further different embodiment, a base station receiving channel state information (CSI) in a wireless communication system includes a transmitter configured to transmit an RRC message including at least one CSI-RS configuration for a first direction domain to a user equipment and to transmit, to the user equipment via different subframes respectively, a first CSI-RS mapped to a first subset and a second CSI-RS mapped to a second subset among a plurality of physical antenna elements of the base station, a receiver configured to receive a CSI report using the first CSI-RS and the second CSI-RS, and a processor configured to control the transmitter and the receiver. In this case, if a number of the at least one CSI-RS configuration for the first direction domain corresponds to one, the first CSI-RS and the second CSI-RS are respectively received from the first subset and the second subset according to virtualization-varying of antenna ports related to the one CSI-RS configuration, the virtualization-varying being performed in accordance with a predetermined period.

Advantageous Effects

[0017] According to embodiments of the present invention, it is able to precisely and efficiently report channel state information in a wireless communication system.

[0018] Effects obtainable from the present invention may be non-limited by the above mentioned effect. And, other unmentioned effects can be clearly understood from the following description by those having ordinary skill in the technical field to which the present invention pertains.

DESCRIPTION OF DRAWINGS

[0019] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

[0020] FIG. **1** is a schematic diagram of E-UMTS network structure as one example of a wireless communication system;

[0021] FIG. **2** is a diagram for structures of control and user planes of radio interface protocol between a 3GPP radio access network standard-based user equipment and E-UTRAN;

[0022] FIG. **3** is a diagram for explaining physical channels used for 3GPP system and a general signal transmission method using the physical channels;

[0023] FIG. **4** is a diagram for a structure of a radio frame in LTE system;

[0024] FIG. **5** is a diagram for a structure of a downlink radio frame in LTE system;

[0025] FIG. **6** is a diagram for a structure of an uplink subframe in LTE system;

[0026] FIG. **7** is a diagram for a configuration of a multiple antenna (MIMO) communication system;

[0027] FIG. **8** and FIG. **9** are diagrams for a structure of a downlink reference signal in LTE system supportive of downlink transmission using 4 antennas;

[0028] FIG. **10** is a diagram for an example of assigning a downlink DM-RS defined by a current 3GPP standard document;

[0029] FIG. **11** is a diagram for an example of a CSI-RS configuration #0 in case of a normal CP among downlink CSI-RS configurations defined by a current 3GPP standard document;

[0030] FIG. **12** is a conceptual diagram for a massive MIMO technology;

[0031] FIG. **13** is a diagram for a pattern of an antenna port transmitting an RS according to one embodiment of the present invention;

[0032] FIG. **14** is a diagram for a CSI feedback method according to one embodiment of the present invention;

[0033] FIG. **15** to FIG. **17** illustrate a result resulted from simulating embodiments of the present invention;

[0034] FIG. **18** is a diagram for a CSI feedback method according to a different embodiment of the present invention;

[0035] FIG. **19** to FIG. **21** illustrate a result resulted from simulating different embodiments of the present invention;

[0036] FIG. **22** and FIG. **23** are diagrams for a CSI feedback method according to a further different embodiment of the present invention;

[0037] FIG. **24** to FIG. **31** illustrate a result resulted from simulating further different embodiments of the present invention;

[0038] FIG. **32** is a diagram for mapping of an antenna port-TXRU-antenna element according to one embodiment of the present invention;

[0039] FIG. **33** is a diagram for transmission of a CSI-RS according to one embodiment of the present invention;

[0040] FIG. **34** is a diagram for EB/FD-MIMO environment according to one embodiment of the present invention;

[0041] FIG. **35** is a diagram for a 2D-AAS antenna according to one embodiment of the present invention;

[0042] FIG. **36** is a diagram for EB/FD-MIMO environment according to a different embodiment of the present invention;

[0043] FIG. **37** is a diagram for multiple CSI-RS configurations according to one embodiment of the present invention;

[0044] FIG. **38** is a diagram for a virtualization varying CSI-RS pattern according to one embodiment of the present invention;

[0045] FIG. **39** is a diagram for RS transmission and CSI feedback method according to one embodiment of the present invention;

[0046] FIG. **40** is a diagram for RS transmission and CSI feedback method according to a different embodiment of the present invention;

[0047] FIG. **41** is a diagram for structures of a user equipment and a base station according to one embodiment of the present invention.

BEST MODE

Mode for Invention

[0048] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. The following embodiments are examples in which the technical features of the present invention are applied to a 3GPP system.

[0049] Although the embodiments of the present invention will be described based on an LTE system and an LTE-advanced (LTE-A) system, the LTE system and the LTE-A system are purely exemplary and the embodiments of the present invention can be applied to any communication system corresponding to the aforementioned definition. In addition, although the embodiments of the present invention will be described based on frequency division duplexing (FDD), the FDD mode is purely exemplary and the embodiments of the present invention can easily be applied to half-FDD (H-FDD) or time division duplexing (TDD) with some modifications.

[0050] In this specification, the term base station may be comprehensively used to include remote radio head (RRH), evolved node B (eNB), transmission point (TP), reception point (RP), relay, etc.

[0051] FIG. **2** is a diagram showing the structure of a control plane and a user plane of a radio interface protocol between a UE and an E-UTRAN based on the 3GPP radio access network standard. The control plane refers to a path through which control messages used for managing a call by the UE and the E-UTRAN are transmitted. The user plane refers to a path through which data generated at an application layer, for example, voice data, Internet packet data or the like is transmitted.

[0052] The physical layer, which is the first layer, provides an information transfer service to a higher layer using a physical channel. The physical layer is connected with a medium access control (MAC) layer located at a higher level through a transport channel, and data is transferred between the MAC layer and the physical layer via the transport channel. Data is transferred between physical layers of a transmission side and a reception side via the physical channel. The physical channel uses time and frequency as radio resources. In detail, the physical channel is modulated using an Orthogonal Frequency Division Multiple Access (OFDMA) scheme in downlink and is modulated using a Single Carrier Frequency Division Multiple Access (SC-FDMA) scheme in uplink.

[0053] The MAC layer of the second layer provides services to a radio link control (RLC) layer, which is a higher layer, via a logical channel. The RLC layer of the second layer enables reliable data transmission. The function of the RLC layer is included as the functional block of the MAC layer. A Packet Data Convergence Protocol (PDCP) layer of the second layer performs a header compression function that reduces the size of an Internet protocol (IP) packet header containing unnecessary control information having a relatively large size in order to efficiently transmit the IP packets such as IPv4 or IPv6 packets over a radio interface having a limited bandwidth.

[0054] A Radio Resource Control (RRC) located at a lowest portion of the third layer is defined only in the control plane. The RRC layer handles logical channels, transport channels and physical channels for the configuration, re-configuration and release of Radio Bearers (RBs). Here, the RBs refer to services provided by the second layer, for data transfer between the UE and the network. The RRC layers of the UE and the network exchange RRC messages with each other. If the RRC layers of the UE and the network are RRC-connected, the UE is in an RRC connected mode and, if so not, is in an RRC idle mode. A Non-Access Stratum (NAS) layer located at a layer higher than the RRC layer performs a function such as session management and mobility management.

[0055] One cell configuring a base station (eNB) provides a downlink or uplink transmission service to several UEs using any one of bandwidths of 1.4, 3, 5, 10, 15 and 20 MHz. Different cells may be set to provide different bandwidths.

[0056] Examples of a downlink transport channel for transmitting data from the network to the UE include a Broadcast Channel (BCH) for transmitting system information, a Paging Channel (PCH) for transmitting a paging message, or a downlink Shared Channel (SCH) for transmitting user traffic or a control message. Traffic or a control message of a broadcast service or downlink multicast may be transmitted through the downlink SCH or a separate downlink Multicast Channel (MCH). Examples of an uplink transport channel for transmitting data from the UE to the network include a Random Access Channel (RACH) for transmitting an initial control message and an uplink SCH for transmitting user traffic or a control message. Examples of a logical channel located at a layer above the transport channel and mapped to the transport channel includes a Broadcast Control Channel (BCCH),

a Paging Control Channel (PCCH), a Common Control Channel (CCCH), a Multicast Control Channel (MCCH), a Multicast Traffic Channel (MTCH), etc.

[0057] FIG. **3** is a diagram illustrating physical channels used in a 3GPP system and a general signal transmitting method using the same.

[0058] If a UE is powered on or newly enters a cell, the UE performs an initial cell search operation such as synchronization with a base station (S**301**). The UE receives a primary synchronization channel (P-SCH) and a secondary synchronization channel (S-SCH) from the base station so as to synchronize with the base station and to acquire information such as a cell ID. Thereafter, the UE may receive a physical broadcast channel from the base station so as to acquire a broadcast signal in the cell. The UE may receive a downlink reference signal (DL RS) so as to check a downlink channel state in the initial cell search step.

[0059] The UE, upon completion of initial cell search, may receive a Physical Downlink Control Channel (PDCCH) and a Physical Downlink Shared Channel (PDSCH) according to information carried in the PDCCH so as to acquire more detailed system information (S**302**).

[0060] When the UE initially accesses the base station or when radio resources for signal transmission are not present, the UE may perform a Random Access Procedure (RACH) with respect to the base station (steps S**303** to S**306**). The UE may transmit a specific sequence using a preamble through a Physical Random Access Channel (PRACH) (S**303** and S**305**) and receive a response message of the preamble through the PDCCH and the PDSCH corresponding thereto (S**304** and S**306**). In the contention-based RACH, a contention resolution procedure may be additionally performed.

[0061] The UE which performs the above-described procedure may receive the PDCCH/PDSCH (S**307**) and transmit a Physical Uplink Shared Channel (PUSCH)/Physical Uplink Control Channel (PUCCH) (S**308**), as a general uplink/downlink signal transmission procedure. Specifically, the UE receives downlink control information (DCI) through the PDCCH. Here, the DCI includes control information such as resource allocation information for the UE, and has a different format depending on the use thereof.

[0062] Meanwhile, the information transmitted from the UE to the base station in uplink and transmitted from the base station to the UE may include a downlink/uplink ACK/NACK signal, a Channel Quality Indicator (CQI), a Precoding Matrix Index (PMI), a Rank Indicator (RI), etc. In the 3GPP LTE system, the UE may transmit the above-described information such as CQI/PMI/RI through the PUSCH and/or the PUCCH.

[0063] FIG. **4** illustrates exemplary radio frame structures in a LTE system.

[0064] Referring to FIG. **4**, a radio frame is 10 ms (307200 T_s) and divided into 10 equal-sized subframes. The 10 subframes of a radio frame may be indexed. Herein, T_s represents a sampling time and T_s=1/(2048*15 kHz) (approximately, 33 ns). Each subframe is 1 ms long, including two slots. Each slot is 0.5 ms (15360 T_s) long. A slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in the time domain and a plurality of resource blocks (RBs) in the frequency time. In a LTE system, single resource block includes 12 (subcarriers)*7 (or 6) OFDM symbols. TTI (Transmission Time Interval), which is unit time for data transfer, can be defined by one or more subframes. The aforementioned structure of the radio frame is shown for exemplary purposes only. Thus, the number of subframes included in the radio frame or the number of slots included in the subframe or the number of OFDM symbols included in the slot may be modified in various manners.

[0065] FIG. **5** illustrates control channels included in a control region of one subframe in a downlink radio frame.

[0066] Referring to FIG. **5**, the subframe consists of 14 OFDM symbols. Initial 1 to 3 OFDM symbols are used as the control region and the other 13 to 11 OFDM symbols are used as a data region depending on a subframe configuration. In this figure, R**1** to R**4** denote reference signals (RSs) (or pilot signals) for antennas 0 to 3. The RSs are fixed as a certain pattern in the subframe irrespective of the control region and the data region. The control channels are allocated to resources of the control region to which no RS is allocated, and traffic channels are allocated to resources of the data region to which no RS is allocated. The control channels allocated to the control region include a Physical Control Format Indicator Channel (PCFICH), a Physical HARQ (Hybrid-Automatic Repeat and Request) Indicator Channel (PHICH), a Physical Downlink Control Channel (PDCCH), etc.

[0067] The PCFICH signals the number of OFDM symbols used for the PDCCH in every subframe to the UE. The PCFICH is located in the first OFDM symbol and is configured prior to the PHICH and the PDCCH. The PCFICH consists of 4 resource element groups (REGs) each distributed over the control region based on cell identity (ID). One REG consists of 4 resource elements (REs). The RE refers to a minimum physical resource defined as one subcarrier×one OFDM symbol. The value of the PCFICH indicates one of values 1 to 3 or 2 to 4 depending on a bandwidth and is modulated through quadrature phase shift keying (QPSK).

[0068] The PHICH is used to carry HARQ ACK/NACK for uplink transmission. That is, the PHICH refers to a channel for transmitting DL ACK/NACK information for UL HARQ. The PHICH consists of 1 REG, and is scrambled cell-specifically. ACK/NACK is indicated using 1 bit, and is modulated through binary phase shift keying (BPSK). The modulated ACK/NACK is spread using a spreading factor (SF)=2 or 4. A plurality of PHICH channels mapped to the same resource form a PHICH group. The number of PHICH channels multiplexed into the PHICH group is determined depending on the number of spreading codes. The PHICH (group) is repeated 3 times to achieve diversity gain in the frequency domain and/or the time domain.

[0069] The PDCCH is allocated to initial n OFDM symbols of the subframe. Here, n is an integer equal to or greater than 1 and is indicated by the PCFICH. The PDCCH consists of one or more CCEs. The PDCCH signals information related to resource allocation of a Paging Channel (PCH) and a Downlink-Shared Channel (DL-SCH) which are transmission channels, uplink scheduling grant, HARQ information, etc. to each UE or UE group. The PCH and the DL-SCH are transmitted through a PDSCH. Accordingly, the base station and the UE generally transmit and receive data other than specific control information or specific service data through the PDSCH.

[0070] Information about a UE (or UEs) targeted by the data of the PDSCH, information about schemes for receiving and decoding the PDSCH data by the UEs, etc. are carried by the PDCCH. For example, it is assumed that a specific PDCCH is CRC-masked with radio network temporary identity (RNTI) "A" and information about data to be transmitted using radio resource (e.g., frequency location) "B" and DCI

format (i.e., transmission format information (e.g., transmission block size, modulation scheme, coding information, etc.)) "C" is transmitted in a specific subframe. In this case, a UE within a cell monitors, i.e., blind-decodes, the PDCCH in a search area using RNTI information of the UE. If one or more UEs have RNTI "A", the UEs receive the PDCCH, and receive a PDSCH indicated by "B" and "C" using information of the received PDCCH.

[0071] FIG. **6** illustrates the structure of a UL subframe in a LTE system.

[0072] Referring to FIG. **6**, the UL subframe can be divided into a region to which Physical Uplink Control Channels (PUCCHs) carrying control information are allocated, and a region to which Physical Uplink Shared Channels (PUSCHs) carrying user data are allocated. A middle part of the subframe is allocated for the PUSCHs, and two side parts of the data region in the frequency domain are allocated for the PUCCHs. The control information carried by the PUCCH includes ACK/NACK used for HARQ, a channel quality indicator (CQI) indicating DL channel state, a rank indicator (RI) for MIMO, a scheduling request (SR) which is a UL resource allocation request, etc. The PUCCH for one UE uses one resource block which occupies different frequencies in slots of the subframe. That is, 2 resource blocks allocated for the PUCCH are frequency hopped at a slot boundary. Specifically, FIG. **6** exemplarily shows that a PUCCH of m=0, a PUCCH of m=1, a PUCCH of m=2, and a PUCCH of m=3 are allocated to the subframe.

[0073] A description is now given of a MIMO system. Multiple-Input Multiple-Output (MIMO) is a method using multiple Tx antennas and multiple Rx antennas, and this method may improve transmission and reception efficiency of data. That is, a transmitter or receiver of a wireless communication system uses multiple antennas and thus the capacity and performance thereof may be improved. In the following description of the present invention, MIMO can be called 'multiple antenna technology'.

[0074] In the multiple antenna technology, reception of one whole message does not depend on a single antenna path. Instead, in the multiple antenna technology, data fragments received through multiple antennas are collected and combined to complete data. If the multiple antenna technology is used, a data transfer rate within a cell region of a specific size may be improved, or system coverage may be improved while ensuring a specific data transfer rate. In addition, this technology can be broadly used by mobile communication devices and relays. Due to the multiple antenna technology, restriction on mobile communication traffic based on a legacy technology using a single antenna can be solved.

[0075] FIG. **7** shows the configuration of a wireless communication system including multiple antennas. When both the number of transmit (Tx) antennas and the number of Rx antennas respectively to N_T and N_R, a theoretical channel transmission capacity of the MIMO communication system increases in proportion to the number of antennas, differently from the above-mentioned case in which only a transmitter or receiver uses several antennas, so that transmission rate and frequency efficiency can be greatly increased. In this case, the transfer rate acquired by the increasing channel transmission capacity can theoretically increase by a predetermined amount that corresponds to multiplication of a maximum transfer rate (R_o) acquired when one antenna is used and a rate of increase (R_i). The rate of increase (R_i) can be represented by the following equation 1.

$$R_i=\min(N_T,N_R) \quad \text{[Equation 1]}$$

[0076] For example, provided that a MIMO system uses four Tx antennas and four Rx antennas, the MIMO system can theoretically acquire a high transfer rate which is four times higher than that of a single antenna system. After the above-mentioned theoretical capacity increase of the MIMO system was demonstrated in the mid-1990s, many developers began to conduct intensive research into a variety of technologies which can substantially increase data transfer rate using the theoretical capacity increase. Some of the above technologies have been reflected in a variety of wireless communication standards, for example, third-generation mobile communication or next-generation wireless LAN, etc.

[0077] A variety of MIMO-associated technologies have been intensively researched by many companies or developers, for example, research into information theory associated with MIMO communication capacity under various channel environments or multiple access environments, research into a radio frequency (RF) channel measurement and modeling of the MIMO system, and research into a space-time signal processing technology.

[0078] Mathematical modeling of a communication method for use in the above-mentioned MIMO system will hereinafter be described in detail. As can be seen from FIG. **7**, it is assumed that there are N_T Tx antennas and N_R Rx antennas. In the case of a transmission signal, a maximum number of transmission information pieces is N_T under the condition that N_T Tx antennas are used, so that the transmission information can be represented by a specific vector shown in the following equation 2.

$$s=[s_1,s_2,\ldots,s_{N_T}]^T \quad \text{[Equation 2]}$$

[0079] In the meantime, individual transmission information pieces $s_1, s_2, \ldots, s_{NT}$ may have different transmission powers. In this case, if the individual transmission powers are denoted by $P_1, P_2, \ldots, P_{NT}$, transmission information having an adjusted transmission power can be represented by a specific vector shown in the following equation 3.

$$\hat{s}=[\hat{s}_1,\hat{s}_2,\ldots,\hat{s}_{N_T}]^T=[P_1s_1,P_2s_2,\ldots,P_{N_T}s_{N_T}]^T \quad \text{[Equation 3]}$$

[0080] In Equation 3, ŝ is a transmission vector, and can be represented by the following equation 4 using a diagonal matrix P of a transmission power.

$$\hat{s}=\begin{bmatrix} P_1 & & 0 \\ & P_2 & \\ & & \ddots \\ 0 & & P_{N_T} \end{bmatrix}\begin{bmatrix} s_1 \\ s_2 \\ \vdots \\ s_{N_T} \end{bmatrix}=Ps \quad \text{[Equation 4]}$$

[0081] In the meantime, the information vector ŝ having an adjusted transmission power is applied to a weight matrix W, so that N_T transmission signals $x_1, x_2, \ldots, x_{NT}$ to be actually transmitted are configured. In this case, the weight matrix W is adapted to properly distribute transmission information to individual antennas according to transmission channel situations. The above-mentioned transmission signals $x_1, x_2, \ldots, x_{NT}$ can be represented by the following equation 5 using the

vector X. Here, W_{ij} denotes a weight corresponding to i-th Tx antenna and j-th information. W represents a weight matrix or precoding matrix.

$$x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_i \\ \vdots \\ x_{N_T} \end{bmatrix} = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1N_T} \\ w_{21} & w_{22} & \cdots & w_{2N_T} \\ \vdots & & \ddots & \\ w_{i1} & w_{i2} & \cdots & w_{iN_T} \\ \vdots & & \ddots & \\ w_{N_T1} & w_{N_T2} & \cdots & w_{N_TN_T} \end{bmatrix} \begin{bmatrix} \hat{s}_1 \\ \hat{s}_2 \\ \vdots \\ \hat{s}_j \\ \vdots \\ \hat{s}_{N_T} \end{bmatrix} = W\hat{s} = WPs \quad \text{[Equation 5]}$$

[0082] Generally, a matrix rank is defined by a smaller number between the number of rows and the number of columns, in which the rows and the columns are independent of each other. Therefore, the matrix rank cannot be higher than the number of rows or columns. The rank of the channel matrix H can be represented by the following equation 6.

$$\text{rank}(H) \leq \min(N_T, N_R) \quad \text{[Equation 6]}$$

[0083] In addition, each of different pieces of information transmitted using the multiple antenna technology is now defined as a 'transport stream' or simply a 'stream'. This 'stream' can be called a 'layer'. Then, the number of transport streams cannot be greater than a channel rank which is the maximum number of different pieces of information transmittable using the multiple antenna technology. Accordingly, a channel matrix H can be expressed as given by Equation 7.

$$\text{\# of streams} \leq \text{rank}(H) \leq \min(N_T, N_R) \quad \text{[Equation 7]}$$

[0084] Here, "# of streams" denotes the number of streams. Meanwhile, it should be noted here that one stream can be transmitted through one or more antennas.

[0085] There can be a variety of methods for mapping one or more streams to multiple antennas. These methods may be described as follows depending on the type of the multiple antenna technology. A case in which a single stream is transmitted through multiple antennas can be regarded as a spatial diversity scheme, and a case in which multiple streams are transmitted through multiple antennas can be regarded as a spatial multiplexing scheme. Alternatively, a hybrid of spatial diversity and spatial multiplexing can also be used.

[0086] A detailed description is now given of reference signals (RSs).

[0087] In general, a reference signal known to both a transmitter and a receiver is transmitted from the transmitter to the receiver for channel measurement together with data. This reference signal indicates a modulation scheme as well as a channel measurement scheme to perform a demodulation procedure. The reference signal is divided into a dedicated RS (DRS), i.e., a UE-specific RS, for a base station and a specific UE, and a common RS (CRS), i.e., a cell-specific RS, for all UEs in a cell. In addition, the cell-specific RS includes a reference signal for reporting CQI/PMI/RI measured by the UE to the base station, which is called a channel state information-RS (CSI-RS).

[0088] FIGS. **8** and **9** are diagrams showing the structures of reference signals in a LTE system supporting downlink transmission using 4 antennas. Specifically, FIG. **8** illustrates the case of a normal cyclic prefix (CP), and FIG. **9** illustrates the case of an extended CP.

[0089] Referring to FIGS. **8** and **9**, 0 to 3 marked in the grid denote common RSs (CRSs) which are cell-specific RSs transmitted through antenna ports 0 to 3 for channel measurement and data demodulation, and the CRSs which are the cell-specific RSs can be transmitted to UEs over a control information region as well as a data information region.

[0090] In addition, 'D' marked in the grid denotes a downlink demodulation-reference signal (DM-RS) which is a UE-specific RS, and the DM-RS supports single antenna port transmission through a data region, i.e., PDSCH. The UE receives a higher layer signal indicating whether a DM-RS, which is a UE-specific RS, is present. FIGS. **8** and **9** exemplarily illustrate a DM-RS corresponding to antenna port 5, and 3GPP 36.211 also defines DM-RSs corresponding to antenna ports 7 to 14, i.e., a total of 8 antenna ports.

[0091] FIG. **10** exemplarily illustrates downlink DM-RS allocation currently defined by the 3GPP specification.

[0092] Referring to FIG. **10**, DM-RSs corresponding to antenna ports {7, 8, 11, 13} are mapped to DM-RS group 1 using antenna port sequences, and DM-RSs corresponding to antenna ports {9, 10, 12, 14} are mapped to DM-RS group 2 using antenna port sequences.

[0093] Meanwhile, unlike CRS, CSI-RS has been proposed above for PDSCH channel measurement, and can be defined as up to 32 different CSI-RS configurations to reduce inter-cell interference (ICI) in a multiple-cell environment.

[0094] The CSI-RS configuration differs depending on the number of antenna ports, and neighboring cells are configured to transmit CSI-RSs defined as different CSI-RS configurations as possible. Unlike CRS, CSI-RS supports up to 8 antenna ports, and a total of 8 antenna ports from antenna port 15 to antenna port 22 are allocated as antenna ports for CSI-RS in the 3GPP specification. Tables 1 and 2 show CSI-RS configurations defined in the 3GPP specification. Specifically, Table 1 shows the case of a normal CP, and Table 2 shows the case of an extended CP.

TABLE 1

		Number of CSI reference signals configured					
	CSI reference signal	1 or 2		4		8	
	configuration	(k', l')	n_s mod 2	(k', l')	n_s mod 2	(k', l')	n_s mod 2
Frame	0	(9, 5)	0	(9, 5)	0	(9, 5)	0
structure	1	(11, 2)	1	(11, 2)	1	(11, 2)	1
type 1	2	(9, 2)	1	(9, 2)	1	(9, 2)	1
and 2	3	(7, 2)	1	(7, 2)	1	(7, 2)	1
	4	(9, 5)	1	(9, 5)	1	(9, 5)	1
	5	(8, 5)	0	(8, 5)	0		
	6	(10, 2)	1	(10, 2)	1		

TABLE 1-continued

		Number of CSI reference signals configured					
	CSI reference signal	1 or 2		4		8	
	configuration	(k', l')	n_s mod 2	(k', l')	n_s mod 2	(k', l')	n_s mod 2
	7	(8, 2)	1	(8, 2)	1		
	8	(6, 2)	1	(6, 2)	1		
	9	(8, 5)	1	(8, 5)	1		
	10	(3, 5)	0				
	11	(2, 5)	0				
	12	(5, 2)	1				
	13	(4, 2)	1				
	14	(3, 2)	1				
	15	(2, 2)	1				
	16	(1, 2)	1				
	17	(0, 2)	1				
	18	(3, 5)	1				
	19	(2, 5)	1				
Frame	20	(11, 1)	1	(11, 1)	1	(11, 1)	1
structure	21	(9, 1)	1	(9, 1)	1	(9, 1)	1
type 2	22	(7, 1)	1	(7, 1)	1	(7, 1)	1
only	23	(10, 1)	1	(10, 1)	1		
	24	(8, 1)	1	(8, 1)	1		
	25	(6, 1)	1	(6, 1)	1		
	26	(5, 1)	1				
	27	(4, 1)	1				
	28	(3, 1)	1				
	29	(2, 1)	1				
	30	(1, 1)	1				
	31	(0, 1)	1				

TABLE 2

		Number of CSI reference signals configured					
	CSI reference signal	1 or 2		4		8	
	configuration	(k', l')	n_s mod 2	(k', l')	n_s mod 2	(k', l')	n_s mod 2
Frame	0	(11, 4)	0	(11, 4)	0	(11, 4)	0
structure	1	(9, 4)	0	(9, 4)	0	(9, 4)	0
type 1	2	(10, 4)	1	(10, 4)	1	(10, 4)	1
and 2	3	(9, 4)	1	(9, 4)	1	(9, 4)	1
	4	(5, 4)	0	(5, 4)	0		
	5	(3, 4)	0	(3, 4)	0		
	6	(4, 4)	1	(4, 4)	1		
	7	(3, 4)	1	(3, 4)	1		
	8	(8, 4)	0				
	9	(6, 4)	0				
	10	(2, 4)	0				
	11	(0, 4)	0				
	12	(7, 4)	1				
	13	(6, 4)	1				
	14	(1, 4)	1				
	15	(0, 4)	1				
Frame	16	(11, 1)	1	(11, 1)	1	(11, 1)	1
structure	17	(10, 1)	1	(10, 1)	1	(10,1)	1
type 2	18	(9, 1)	1	(9, 1)	1	(9,1)	1
only	19	(5, 1)	1	(5, 1)	1		
	20	(4, 1)	1	(4, 1)	1		
	21	(3, 1)	1	(3, 1)	1		
	22	(8, 1)	1				
	23	(7, 1)	1				
	24	(6, 1)	1				
	25	(2, 1)	1				
	26	(1, 1)	1				
	27	(0, 1)	1				

[0095] In Tables 1 and 2, (k',l') denotes an RE index, k' denotes a subcarrier index, l' denotes an OFDM symbol index. FIG. **11** exemplarily illustrates CSI-RS configuration #0 in the case of a normal CP among CSI-RS configurations currently defined in the 3GPP specification.

[0096] CSI-RS subframe configurations can also be defined, and each CSI-RS subframe configuration includes a periodicity $T_{CSI\text{-}RS}$ and a subframe offset $\Delta_{CSI\text{-}RS}$ which are expressed on a subframe basis. Table 3 shows the CSI-RS subframe configurations defined in the 3GPP specification.

TABLE 3

CSI-RS-SubframeConfig $I_{CSI\text{-}RS}$	CSI-RS periodicity $T_{CSI\text{-}RS}$ (subframes)	CSI-RS subframe offset $\Delta_{CSI\text{-}RS}$ (subframes)
0-4	5	$I_{CSI\text{-}RS}$
5-14	10	$I_{CSI\text{-}RS}$-5
15-34	20	$I_{CSI\text{-}RS}$-15
35-74	40	$I_{CSI\text{-}RS}$-35
75-154	80	$I_{CSI\text{-}RS}$-75

[0097] Enhanced CSI Feedback

[0098] A receiving end (e.g., UE) measures a state of a channel formed by each of antenna ports of a transmitting end (e.g., base station) and may be able to report a result of the measurement. In this case, the receiving end can determine or calculate RI, PMI and/or CQI using an RS of each antenna port of the transmitting end to measure the channel state. In this case, the PMI is defined as an index value for indicating a precoding matrix appropriate for a channel measured in the aspect of the receiving end. The precoding matrix can be selected or determined from among a set of precoding matrix candidates, which are determined in advance and shared between the transmitting end and the receiving end. In this case, the set of precoding matrix candidates is called a codebook. The PMI can indicate a proper precoding matrix in a specific rank.

[0099] Meanwhile, a next generation wireless communication system considers introduction of an active antenna system (AAS). Unlike a legacy passive antenna of which an amplifier capable of controlling a phase and a size of a signal and an antenna are separated from each other, the active antenna is configured to have an active element such as an amplifier. It is not necessary for an active antenna system to have a separate cable, a connector and other hardware for connecting an amplifier with an antenna and the active antenna system has a characteristic of high efficiency in terms of energy and management cost. In particular, since the active antenna system is able to support an electronic beam control scheme according to each antenna, the active antenna system enables such an enhanced MIMO technology as forming a delicate beam pattern or a 3-dimensional beam pattern in consideration of beam direction and beam width.

[0100] With the help of the introduction of an advanced antenna system such as the active antenna, it may also consider a massive MIMO structure including a plurality of input/output antennas and a multidimensional antenna structure. As an example, unlike a legacy straight antenna array (or one-dimensional antenna array), in case of forming a 2-dimensional antenna array, it may be able to form a 3-dimensional beam pattern by an active antenna of the active antenna system.

[0101] FIG. **12** is a conceptual diagram for a massive MIMO technology. In particular, FIG. **12** shows a system that an eNB or a UE has a plurality of active antenna system-based transmission/reception antennas capable of forming a 3D beam.

[0102] Referring to FIG. **12**, if a 3-dimensional beam pattern is utilized in terms of a transmission antenna, semi-static or dynamic beam forming can be performed not only in horizontal direction but also in vertical direction of a beam and it may also consider such an application as sector forming in vertical direction and the like. In terms of a reception antenna, when a reception beam is formed by utilizing a massive reception antenna, it may be able to expect a signal power increasing effect according to an antenna array gain. Hence, in case of uplink, an eNB can receive a signal transmitted from a UE through a plurality of antennas. In this case, the UE can configure transmit power of the UE to be very low in consideration of a gain of the massive reception antenna to reduce an impact of interference.

[0103] In order to perform 3D beamforming in a massive MIMO system, it is required to feedback more delicate CSI compared to legacy CSI. And, in order to support the increased number of antenna ports such as the massive MIMO system, it is necessary to define or add a new codebook. If a codebook is defined or added, a feedback overhead increasing problem may occur. And, as the number of antenna ports increases, the number of RS for identifying each antenna port also increases. As a result, an amount of using a resource (e.g., time, frequency and/or a code resource) for transmitting an RS increases and an amount of using a resource for transmitting data may decrease among total system resources. In particular, overhead for supporting the increased number of antenna ports increases, whereas user data processing ratio decreases.

[0104] In order to solve the aforementioned problem, a CSI feedback method for maximizing MIMO transmission efficiency is required in a system to which a massive MIMO scheme is applied. As a method of enhancing CSI feedback, the present invention proposes a method of designing a codebook for a massive MIMO system supporting the increased number of antenna ports (or antenna elements) and a method of reducing or mitigating feedback overhead of a CSI report based on the codebook. Moreover, the present invention proposes a method of performing efficient CSI feedback and transmission/reception beamforming based on the CSI feedback in a massive MIMO system. More specifically, the present invention includes a method of making a feedback on CSI in a manner of measuring a partial channel in a receiving end, a method of generating a beam former corresponding to the number of physical antennas in a manner that a transmitting end matches repetitive CSI feedbacks received from a receiving end with each other, and a method of separating a received signal into a plurality of data streams.

[0105] According to one embodiment of the present invention, a transmitting end performs grouping on physical antenna ports. If a subframe in which an RS is transmitted is differently configured according to an antenna port group, an RS is transmitted over a plurality of subframes. A receiving end measures a channel using an RS and may be able to generate and report CSI. The transmitting end generates a beamforming codebook or a code vector using the CSI reported from the receiving end to transmit a plurality of data streams or multiple layers.

[0106] In the following examples of the present invention, for example, a transmitting end of MIMO transmission (i.e., a receiving end of feedback information) and a receiving end

of MIMO transmission (i.e., a transmitting end of feedback information) correspond to an eNB and a UE, respectively, by which the present invention may be non-limited.

[0107] I. Antenna Port Configuration for RS Transmission

[0108] A pattern of an antenna port transmitting an RS according to one embodiment of the present invention is explained with reference to FIG. **13** in the following. The RS may correspond to a CSI-RS, by which the present invention may be non-limited. In an embodiment of FIG. **13**, assume that an RS is transmitted through the total M number of antenna ports. The RS is transmitted by L number of antenna ports among the M number of antenna ports over K number of time durations or instances instead of being transmitted by the M number of antenna ports at the same time. In this case, the L is a natural number smaller than the M. The K number of time durations may correspond to the K number of OFDMA symbols, the K number of slots, the K number of subframes or the K number of frames, by which the present invention may be non-limited. For example, the M corresponds to 4, the K corresponds to 3 and the L corresponds to 2 in FIGS. **13** (*a*) and (*b*). On the contrary, the M corresponds to 4, the K corresponds to 6 and the L corresponds to 2 in FIG. **13** (*c*).

[0109] In FIG. **13**, a UE performs channel measurement using RSs transmitted from 2 antenna ports over one time duration (e.g., subframe unit). In FIG. **13** (*a*) and FIG. **13** (*b*), although RSs are transmitted from antenna ports different from each other over K time duration corresponding to 3, a pattern of antenna ports selected for transmitting the RSs is different from each other in FIG. **13** (*a*) and FIG. **13** (*b*).

[0110] The UE measures a partial radio channel corresponding to the L number of antenna ports at every time duration (e.g., subframe unit) in a manner of receiving signaling on pattern information of the antenna ports from an eNB. For example, the eNB signals at least one selected from the group consisting of transmission timing of an RS transmitted by the antenna ports and an offset, sequence scrambling information of an RS, information on RE (resource element) mapping of an RS to the UE together with a pattern of the antenna ports. If the eNB operates in a transmission mode for CoMP operation (mode **10**), the sequence scrambling information of RS may correspond to a scrambling initialization parameter using a virtual cell ID.

[0111] Meanwhile, the UE can feedback CSI on a partial channel to the eNB as many as K times based on partial channel measurement measured over K number of time durations. For example, the UE feedbacks CSI 3 times over single iteration in FIG. **13** (*a*) and FIG. **13** (*b*) and the UE can feedback CSI 6 times over single iteration in FIG. **13** (*c*). The eNB matches the CSI on the K number of partial channels with each other and obtains CSI on total channels.

[0112] On the contrary, the UE can feedback CSI to the eNB in a manner of matching channel measurements measured n times (n is a natural number equal to or less than K) with each other. For example, in FIG. **13** (*a*), the UE matches channel measurements measured 3 times within single iteration with each other and may be able to feedback CSI to the eNB one time. On the contrary, the UE matches channel measurements measured 2 times within single iteration with each other and may be then able to feedback CSI to the eNB twice (e.g., (1,2) matching feedback, (2,3) matching feedback, etc.)

[0113] In order to more accurately match channel measurements measured over time durations different from each other, at least one or more ports transmitting an RS should be in common in the time durations different from each other. For example, in FIG. **13** (*a*), a P**0** transmits an RS in all time durations including first to third time duration. Hence, the P**0** and the RS transmitted by the P**0** become a reference for matching channel measurements measured over time durations different from each other. For example, in order to make strength or phase of an RS received from the P**0** to be practically same in the time durations including the first to the third time duration, the channel measurements measured over the first to the third time duration can be revised. In FIG. **13** (*b*), a reference for matching channel measurements in the second and the third time duration corresponds to a P**1** and a reference for matching channel measurements in the second and the third time duration corresponds to a P**3**. It is not mandatory that an antenna port becoming a reference for matching channel measurements corresponds to a single antenna port. A reference antenna port may change in various ways depending on an embodiment.

[0114] Meanwhile, according to a legacy scheme that all antenna ports transmit an RS to a same subframe, a UE or an eNB is able to obtain CSI in a manner of averaging n number of channel measurements measured in n number of subframes. Yet, according to one embodiment of the present invention, antenna ports transmitting an RS change according to time duration. Hence, channel measurements can be averaged only in time durations where a pattern of an antenna port is identical to each other. For example, in FIG. **13** (*a*), it is unable to average channel measurements in the first, the second and the third time duration of single iteration.

[0115] Yet, since antenna ports transmitting an RS are identical to each other in (1,4) time duration, (2,5) time duration and (2,5) time duration respectively belonging to iterations different from each other, channel measurements can be averaged in the time durations. Meanwhile, the eNB can provide the UE with information on time duration in which averaging of channel measurements is unavailable (or time duration in which averaging of channel measurements is available). For example, CSI measurement averaging window information can be set to the UE to indicate time duration at which CSI measurement values are averaged among iterations. The eNB makes the UE identify the CSI measurement averaging window in a manner of informing the UE of a pattern of an antenna port transmitting an RS.

[0116] II. CSI Feedback Based on Partial Channel Measurement

[0117] In the following description, an embodiment for a UE to make a feedback to an eNB in a manner of performing singular value decomposition on a channel measurement result (channel matrix) in a plurality of time durations (e.g., subframes) is explained.

[0118] II-1. CSI Feedback Including Quantized-V

[0119] Singular value decomposition can be performed after channel measurements are accumulated for prescribed time durations. And, a result of the singular value decomposition is not fed back whenever the singular value decomposition is performed. Instead, the result can be intermittently fed back according to a prescribed interval.

[0120] For example, a UE measures RSs transmitted from the L number of antenna ports of an eNB in every time duration (e.g., subframe) and accumulates measurement results. The UE performs singular value decomposition (SVD) on the channel measurements accumulated to the eNB as shown in Equation 8.

$$H=U\Sigma V^{H} \quad \text{[Equation 8]}$$

[0121] A matrix H is a channel matrix of m×n size. U is an orthogonal matrix of m×m size and is referred to as a left

singular matrix. Σ is a diagonal matrix of m×n size. V is a unitary matrix and is referred to as a right singular matrix.

[0122] According to one embodiment, a UE feedbacks a right singular matrix V extracted from a result of singular value decomposition to an eNB. Meanwhile, if a single antenna is mounted on the UE, a right singular vector V is transmitted to the eNB.

[0123] According to a different embodiment, the UE searches for a precoding matrix of which similarity of phase information with the quantized right singular matrix V is biggest in a codebook and may be then able to report a precoding matrix index (PMI) to the eNB rather than feedbacks the right singular matrix V as it is. In this case, the codebook may correspond to a codebook of a legacy mobile communication system or a codebook newly defined for a quantized right singular matrix V_q.

[0124] FIG. **14** is a diagram for a CSI feedback process according to one embodiment of the present invention. In FIG. **14**, assume that an eNB transmits an RS according to a pattern shown in FIG. **13** (*a*) and two reception antenna ports are installed in a UE. Hence, total channels can be represented by a channel matrix of a size of 2×4. The aforementioned assumption is just an example for clarity. Those skilled in the art can understand that the scope of the present invention includes massive MIMO environment.

[0125] Although the eNB transmits an RS through a part of antenna ports, the UE can be configured to perform CSI feedback at a time after channel measurements are all finished. All channel measurements measured by the UE can be obtained in a manner of performing interpolation on partial channel measurement values. To this end, it is preferable for the eNB to inform the UE of at least one of the number of antenna ports (e.g., M'), which becomes a unit of CSI feedback, after that UE performs interpolation using the number of RS transmission antenna ports (e.g., such information as M=4), a size of single iteration (e.g., such information as K=3), the number of RS transmission antenna ports corresponding to a partial channel (e.g., such information as L=2) and partial channel measurement values. If the number of antenna ports M' becoming a CSI feedback unit is delivered to the UE, the UE obtains CSI corresponding to the M' number of antenna ports via interpolation and may be able to feedback the CSI to the eNB. In this case, the M' may be equal to M, by which the present invention may be non-limited. If the M' is equal to M, channels obtained by the UE by performing interpolation on the partial channel measurement values correspond to total channels. In a different embodiment, the M' may exceed the L and may correspond to a natural number equal to or less than the M. Meanwhile, the CSI fed back to the eNB by the UE may include M'-Tx PMI.

[0126] Meanwhile, the UE can configure a CSI feedback period to be greater than K value received from the eNB. When CSI feedback on total channels is performed at a time, the CSI feedback is performed with a lower frequency compared to a case that CSI feedback is immediately performed whenever measurement for a partial channel is performed.

[0127] Meanwhile, when the UE performs CSI feedback through interpolation of partial channel measurement values, it is not mandatory that a CSI-RS is transmitted over a plurality of time durations. For example, the UE is able to obtain measurement values of a first partial channel in a manner of measuring a first CSI-RS transmitted in first time duration. Subsequently, the UE is able to obtain CSI of all channels in a manner of performing interpolation on the measurement values of the first partial channel.

[0128] In a different embodiment, the UE can perform CSI feedback in a manner of performing interpolation on measurement values of partial channels transmitted in time durations different from each other. For example, the UE measures a first CSI-RS transmitted in first time duration and measures a second CSI-RS transmitted in second time duration. The UE can report CSI on all channels corresponding to the M' number of antenna ports or CSI on a partial channel in a manner of performing interpolation on measurement values of a first partial channel obtained by measuring the first CSI-RS and measurement values of a second partial channel obtained by measuring the second CSI-RS.

[0129] In order to perform interpolation on measurement values of partial channels, which are measured in time durations different from each other, there may exist a reference antenna port. For example, the reference antenna port may correspond to an antenna port configured to transmit a CSI-RS in both first time duration and second time duration. After at least a part of measurement values of partial channels is revised through the reference antenna port, it may be then able to perform interpolation using the revised measurement values.

[0130] Meanwhile, in order to perform interpolation on the measurement values of the partial channel, the UE can use information on a pattern of an antenna port that transmits an RS. In particular, if it is assumed that it is necessary to perform interpolation on a first measurement value and a second measurement value and it is unable to perform interpolation on a first measurement value and a third measurement value among the measurement values of the partial channel, information on the aforementioned contents can be provided to the UE by the eNB.

[0131] In a further different embodiment, it is not mandatory for the UE to perform interpolation on a partial channel only. For example, if the UE performs CSI feedback based on measurement of a partial channel, the eNB may perform interpolation on the partial channel.

[0132] In the first time duration of FIG. **13** (*a*), the UE receives RSs from the antenna port P**0** and the P**1** and obtains $H^{(1)}$ [S**1405**]. The UE can wait for receiving an RS in the second time duration without immediately making a feedback on the $H^{(1)}$ to the eNB.

[0133] In the second time duration of FIG. **13** (*a*), the UE receives RSs from the antenna port P**0** and the P**1** and obtains $H^{(2)}$ [S**1410**].

[0134] In the third time duration of FIG. **13** (*a*), the UE receives RSs from the antenna port P**0** and the P**1** and obtains $H^{(3)}$ [S**1415**].

[0135] The UE obtains a total channel matrix H and a matrix V_q in a manner of matching the $H^{(1)}$, the $H^{(2)}$ and the $H^{(3)}$ with each other [S**1420**]. For example, the UE performs singular value decomposition on the obtained channel matrix H. The UE obtains the V_q by quantizing a right singular matrix V.

[0136] The UE feedbacks the quantized right singular matrix V_q to the eNB [S**1425**]. For example, the UE feedbacks an index of a precoding matrix (PMI) of which a similarity with the right singular matrix V_q quantized from a codebook is biggest to the eNB.

[0137] After the quantized right singular matrix V_q is initially fed back, in other word, after a first PMI is transmitted, the UE updates the channel matrix H in a manner of reflecting

a channel measurement result of an antenna port in which an RS is transmitted in time duration to the previously calculated channel matrix H only in every time duration. The UE performs singular value decomposition on the updated channel matrix H and transmits obtained V_q to the eNB. For example, in FIG. **13** (*a*), the channel matrix H is updated in every time duration such as fourth time duration, fifth time duration, sixth time duration, and the like and the quantized right singular matrix V_q can be fed back to the eNB.

[0138] The eNB transmits downlink data on which beamforming (or precoding) is performed based on the quantized right singular matrix V_q to the UE [**S1430**]. The UE receives the downlink data using a Hermitian matrix U^H of a left singular matrix U or a minimum mean square error (MMSE) scheme.

[0139] FIG. **15** illustrates a result resulted from comparing CSI feedback capability according to the embodiment of FIG. **14** and CSI feedback capability in ideal environment with each other. Perfect CSI-T corresponds to the ideal environment. In this case, an eNB and a UE are aware of perfect channel information (channel matrix H with no error). The perfect CSI-T corresponds to capability in case that the eNB and the UE performs transmission and reception beamforming through a left singular matrix U or a right singular matrix V obtained from the perfect channel information. Since it is able to transmit a not-quantized channel measurement value to the eNB as it is in the ideal environment, it is considered as a codebook size has an infinite size and resolution. Quantized V corresponds to capability of the present embodiment. A codebook size is restricted by a prescribed size and a channel measurement value is quantized like actual environment.

[0140] When the number of antenna ports M corresponds to 2, 4, 8 or 16 and the number of antenna ports L assigned to transmit an RS per every duration (e.g., every subframe) corresponds to 2 or 4, average correlation power μ is measured as an indicator of capability. The average correlation power μ is defined as Equation 9 in the following.

$$\mu=E\{\mathrm{diag}|U^H H V|^2\} \quad \text{[Equation 9]}$$

[0141] In Equation 9, H corresponds to USV^H and V is quantized. diag indicates a diagonal element in a matrix.

[0142] FIG. **16** shows a case that M corresponds to 4 and L corresponds to 2. FIG. **16** shows a change of average correlation power according to channel information obtained in every time duration (e.g., subframe). A ratio of transmit power to noise power of a channel is defined as $\gamma=E|H|^2/2\sigma^2$. FIG. **16** shows 3 cases. It may be able to relatively ignore the noise power in an infinite case and a 20 dB case.

[0143] In a 10 dB case, average correlation power increases as CSI feedback for each time duration is accumulated. Consequently, if M corresponds to 4 and L corresponds to 2, since the average correlation power gently increases after third time duration, K=3 may become an appropriate point of compromise between CSI feedback overhead and beamforming capability.

[0144] FIG. **17** (*a*) and FIG. **17** (*b*) show a change of average correlation power according to channel information obtained in every time duration (e.g., subframe) when M corresponds to 8 and L corresponds to 4 and when M corresponds to 16 and L corresponds to 4, respectively.

[0145] II-2. CSI Feedback Including Quantized-U or Quantized-U/V

[0146] FIG. **18** is a diagram for a CSI feedback method according to a different embodiment of the present invention. Assume that an eNB transmits an RS according to a pattern of FIG. **13** (*a*) and a UE has 2 reception antenna ports. Having received the RS, the UE feedbacks a quantized left singular matrix U_q and a quantized right singular matrix V_q to the eNB.

[0147] First of all, the eNB transmits an RS through antenna ports (P**0** and P**1**) [**S1805**]. The UE obtains a matrix $H^{(1)}$ (hereinafter, a partial channel matrix) for partial channels corresponding to the antenna ports (P**0** and P**1**) through the received RS. The UE performs singular value decomposition on the $H^{(1)}$ and obtains a partial left singular matrix $U^{(1)}$ and a partial right singular matrix $V^{(1)}$. The UE quantizes the partial left singular matrix $U^{(1)}$ and the partial right singular matrix $V^{(1)}$ and feedbacks the quantized partial left singular matrix $U^{(1)}$ and the partial right singular matrix $V^{(1)}$ to the eNB [**S1810**].

[0148] The eNB preferentially estimates the partial channel $H^{(1)}$ for first time duration by the calculation of $U_q^{(1)}\Sigma^{(1)}(V_q^{(1)})^H=\hat{H}^{(1)}$. A diagonal matrix $\Sigma^{(1)}$ can be represented using a CQI (channel quality indicator) corresponding to one of legacy feedback information. The eNB estimates the partial channel matrix $H^{(1)}$ for the antenna ports (P**0** and P**1**) through the diagonal matrix $\Sigma^{(1)}$, a quantized partial right singular matrix $V_q^{(1)}$ and a quantized partial left singular matrix $U_q^{(1)}$.

[0149] Such a process as **S1805** and **S1801** is repeated for second time duration and third time duration [**S1815**, **S1820**, **S1825**, and **S1830**]. For example, the UE performs singular value decomposition on a partial channel matrix obtained in time duration j and may be able to obtain a partial left singular matrix $U^{(j)}$ and a partial right singular matrix $V^{(j)}$. The UE obtains $U_q^{(j)}$ and $V_q^{(j)}$ in a manner of quantizing each element of the partial left singular matrix $U^{(j)}$ and the partial right singular matrix $V^{(j)}$ to a phase. The UE feedbacks the $U_q^{(j)}$ and the $V_q^{(j)}$ to the eNB in every time duration.

[0150] The eNB estimates a jth partial channel $H^{(j)}$ by the calculation of $U_q^{(j)}\Sigma^{(j)}(V_q^{(j)})^H=\hat{H}^{(j)}$.

[0151] According to a further different embodiment, the UE does not feedback the left singular matrix U_q to the eNB and the eNB may use a random orthogonal matrix satisfying a characteristic of a not-quantized left singular matrix U. For example, it may use $u_q(1)=[1; 1]$ and $u_q(2)=[1; -1]$, by which the present invention may be non-limited.

[0152] The eNB obtains channel information on total antenna ports over time duration as much as K=3. The eNB estimates an overall channel matrix $\hat{H}$ in a manner of matching partial channel matrixes, which are estimated in each time duration, with each other. In order to match the partial channel matrixes, the eNB can select a partial channel matrix from among the partial channel matrixes as a reference of matching. The partial channel matrix becoming the reference of matching (hereinafter, a reference matrix) may correspond to a channel matrix of which a channel state is best or a partial channel matrix of which phase information is most accurate based on a CQI. Phase of the rest of the partial channel matrixes can be adjusted based on a phase of the reference matrix. For example, if an RS is transmitted as shown in FIG. **13** (*a*), although phase information of an antenna port P**0** is included in all partial channel matrixes, the phase information of the antenna port P**0** may delicately vary in each time duration. For example, the eNB calculates a difference between a phase of a reference antenna port P**0** of a reference matrix determined as being most accurate and a phase of an antenna port P**0** in a specific partial channel matrix and may

be able to adjust phase of the rest of antenna ports of the specific partial channel matrix.

[0153] For example, the eNB executes phase revision for partial channels obtained via **S1810**, **S1820** and **S1803** process [**S1835**]. If a CQI of a partial channel obtained through j=2 is best among CQIs received through the **S1810**, the **S1820** and the **S1803**, the eNB executes phase revision as follows.

[0154] In case of estimating a reference matrix $H^{(2)}$ among the total channels, the eNB reflects the estimation of the reference matrix $H^{(2)}$ to H as it is. Yet, in case of estimating $H^{(1)}$ and $H^{(3)}$, the eNB excludes a first row corresponding to the **P0** and reflects it to a second row and a fourth row, respectively. A result of the estimation is shown in Equation 10 in the following.

$$\hat{H} = \begin{bmatrix} \hat{h}_{11}^{(0)} & \hat{h}_{12}^{(1)} & \hat{h}_{13}^{(2)} & \hat{h}_{14}^{(3)} \\ \hat{h}_{21}^{(0)} & \hat{h}_{22}^{(1)} & \hat{h}_{23}^{(2)} & \hat{h}_{24}^{(3)} \end{bmatrix} \quad \text{[Equation 10]}$$

[0155] It is necessary to perform phase revision on Equation 10. If the phase revision is performed on Equation 10 and a result of the phase revision is represented as Equation 11, Equation 12 shows a calculation for revising phase of H(1) and H(3) on the basis of a first row of $H^{(2)}$, i.e., an antenna port **P0**.

$$\hat{H} = \begin{bmatrix} \hat{h}_{11} & \hat{h}_{12} & \hat{h}_{13} & \hat{h}_{14} \\ \hat{h}_{21} & \hat{h}_{22} & \hat{h}_{23} & \hat{h}_{24} \end{bmatrix} \quad \text{[Equation 11]}$$

$$\angle\hat{h}_{12} = \angle h_{12}^{(1)} + (\angle h_{11}^{(2)} - \angle h_{11}^{(1)}), \quad \angle\hat{h}_{14} = \angle h_{14}^{(3)} + (\angle h_{11}^{(2)} - \angle h_{14}^{(3)}), \quad \text{[Equation 12]}$$
$$\angle\hat{h}_{22} = \angle h_{22}^{(1)} + (\angle h_{21}^{(2)} - \angle h_{22}^{(1)}), \quad \angle\hat{h}_{24} = \angle h_{24}^{(3)} + (\angle h_{21}^{(2)} - \angle h_{24}^{(3)})$$

[0156] As shown in the above, phase revision is not performed on a partial channel matrix corresponding to j index, which becomes a reference, and phase revision can be performed on elements of the rest of partial channel matrixes on the basis of the partial channel matrix corresponding to the j index.

[0157] Meanwhile, an RI (rank indicator) of a CSI reported in every time duration may be different from each other. The UE reports vectors of $u_q^{(j)}$ and $v_q^{(j)}$ as many as the rank number to the eNB and the eNB estimates channels as many as the limited rank number according to the report of the UE. The eNB performs downlink transmission within a range not exceeding a corresponding rank. For example, if a rank calculated for a jth partial channel (j=1) by the UE corresponds to 1, dimension of a matrix $U_q^{(j=1)}$ and dimension of a matrix $V_q^{(j=1)}$ correspond to $N_{RX}\times 1$ and $1\times L$, respectively.

$$\left(\text{e.g., } U_q = \begin{bmatrix} 1 \\ 1 \end{bmatrix}, V_q = [\,1 \quad -1\,]\right).$$

If a rank calculated for a jth partial channel (j=2) by the UE corresponds to 2, dimension of a matrix $U_q^{(j=2)}$ and dimension of a matrix $V_q^{(j=2)}$ correspond to $N_{RX}\times 2$ and $2\times L$, respectively.

$$\left(\text{e.g., } U_q = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}, V_q = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}\right).$$

[0158] In other word, an RI of a CSI report (e.g., RI, PMI, and/or CQI) can be independent from each other according to a partial channel index j or time duration. As mentioned in the foregoing description, if CSIs including an RI value different from each other is respectively fed back, the eNB estimates/reconfigures partial channels according to each index j and matches the estimated/reconfigured partial channels with each other. In particular, although CSIs including an RI different from each other are fed back, the eNB is able to estimate/reconfigure a total channel matrix. If CSI feedback including an independent RI value is permitted according to a partial channel index j, the UE can report CSI feedback optimized according to corresponding time duration. This may lead to increase efficiency and accuracy in case that the eNB performs transmission beamforming after a total channel is estimated or reconfigured.

[0159] The eNB performs singular value decomposition on the estimated total channel matrix $\hat{H}$ and generates a code vector. The code vector is formed in a manner that vectors as many as rank number are selected from a right singular matrix $\hat{V}$ of $\hat{H}=\hat{U}\hat{S}\hat{V}$. The eNB performs transmission beamforming through the formed code vectors.

[0160] If the UE feedbacks CSI to the eNB, the UE is able to know all of the total channel information. Hence, the UE performs singular value decomposition on the total channel matrix and obtains a left singular matrix U. When the UE receives downlink data, the UE eliminates or minimizes interference of a reception antenna using a Hermitian matrix U^H of the left singular matrix.

[0161] FIG. **19** illustrates average correlation power according to the embodiment of FIG. **18**. Assume that M corresponds to 4 or 8. R**1** corresponds to a case that a single reception antenna is used only and R**2** corresponds to a case that 2 reception antennas are used. A rank of the R**1** is restricted to a half of the R**2**. A quantized-UN (fixed U) indicates a case that the eNB quantizes a random orthogonal matrix ($u_q(1)=[1; 1]$ and $u_q(2)=[1; -1]$) among the aforementioned embodiments. The quantized-U/V corresponds to average correlation power of which the eNB receives feedback on a quantized U matrix from the UE and the eNB uses the quantized U matrix. The quantized-UN (fixed U) and the quantized-UN show identical capability.

[0162] II-3. CSI Feedback Including Quantized-H

[0163] FIG. **20** is a diagram for a CSI feedback method according to a different embodiment of the present invention. Assume that an eNB has 4 transmission antenna ports and a UE has 2 reception antenna ports. According to the embodiment of FIG. **20**, a process of performing singular value decomposition on a partial channel matrix performed by the UE is omitted. The UE quantizes a partial channel matrix (phase information of the partial channel matrix) and feedback the quantized partial channel matrix to the eNB.

[0164] The eNB transmits an RS according to the pattern shown in FIG. **13** (*a*) [**S2005**, **S2015**, **S2025**]. The UE can obtain a partial channel matrix $H^{(1)}$, $H^{(2)}$ and $H^{(3)}$ using the RS received in each time duration. The UE quantizes the partial channel matrix $H^{(1)}$, $H^{(2)}$ and $H^{(3)}$ and feedback the quantized partial channel matrix $H^{(1)}$, $H^{(2)}$ and $H^{(3)}$ to the eNB [**S2010**, **S2020**, **S2030**].

[0165] The eNB obtains a quantized total channel matrix H_q in a manner of accumulating the partial channel matrixes received via the **S2010**, **S2020** and the **S2030** and matching the partial channel matrixes with each other. The eNB performs singular value decomposition on the channel matrix H_q and obtains a right singular matrix V_{Hq}. The right singular matrix V_{Hq} is used as a code vector for transmission beam-

forming. The eNB performs transmission beamforming (or precoding) using a code vector consisting of column vectors of the right singular matrix V_{Hq} [S2035].

[0166] The UE performs singular value decomposition on a channel matrix, which is known in a CSI feedback process, and receives downlink data transmitted by the eNB via transmission beamforming using a left singular matrix.

[0167] FIG. **21** illustrates average correlation power according to the embodiment of FIG. **20**. Since it is able to understand a result of FIG. **21** based on the contents mentioned earlier in FIG. **15** to FIG. **19**, explanation is omitted at this time.

[0168] II-4. CSI Feedback Including Quantized-V (Stacked)

[0169] According to a further different embodiment of the present invention, the UE can make a feedback on an antenna port transmitting an RS in a unit of every time duration (e.g., subframe) whenever the UE receives the RS. According to the aforementioned II-1 Quantized-V scheme, a matrix V_q is fed back via singular value decomposition after the UE obtains channel information on the total M number of antenna ports. In order to more reduce the burden of a feedback resource consumed at a time compared to the aforementioned II-1 Quantized-V scheme, the present invention proposes a method of making a feedback on accumulated Quantized-V.

[0170] FIG. **22** explains a calculation process of a UE according to Quantized-V (stacked) when M corresponds to 4, L corresponds to 2 and the UE has 2 reception antennas. FIG. **22** shows channel information fed back in every time duration or each feedback reporting instance determined in advance.

[0171] The UE makes feedback on channel information of an antenna port transmitting an RS in current time duration and calculates channel information of antenna ports transmitting RSs from previous time durations to current time duration in an accumulation manner. The UE performs singular value decomposition on the accumulated channel information (or channel matrixes).

[0172] A size of a right singular matrix V on which singular value decomposition is performed is getting bigger as CSI feedback is repeated according to the accumulation of the channel information, thereby increasing overhead of the CSI feedback. Hence, the UE can transmit a part corresponding to an antenna port transmitting a current RS only to the eNB in a manner of extracting the part from the right singular matrix V instead of reporting the whole of the calculated right singular matrix V.

[0173] For example, when a rank corresponds to 2, the UE can feedback a part (2×2 matrix) represented by a dotted line to the eNB among elements of the right singular matrix in each CSI feedback instance. If a rank corresponds to 1, the UE can feedback 2×1 matrix corresponding to a left column of the dotted line only to the eNB. Those skilled in the art can understand that embodiments of the present invention are also applicable to a case that a rank exceeds 2.

[0174] It may consider a method of transmitting Quantized-V (stacked) using a codebook for PMI feedback of 3GPP LTE. Table 4 shows a codebook for transmitting maximum 2 layers in LTE system. If a rank corresponds to 1, an index is selected from the group consisting of an index 0, 1 and 2 in v=1 and the selected index is fed back. If an RI corresponds to 2, an index is selected from the group consisting of an index 0, 1 and 2 in v=2 and the selected index is fed back. For example, the UE selects a matrix (or vector) of which a similarity with a quantized right singular matrix (or vector) is biggest from among matrixes (or vectors) corresponding to each index.

TABLE 4

Codebook index	Number of layers υ	
	1	2
0	$\frac{1}{\sqrt{2}}\begin{bmatrix}1\\1\end{bmatrix}$	$\frac{1}{\sqrt{2}}\begin{bmatrix}1&0\\0&1\end{bmatrix}$
1	$\frac{1}{\sqrt{2}}\begin{bmatrix}1\\-1\end{bmatrix}$	$\frac{1}{2}\begin{bmatrix}1&1\\1&-1\end{bmatrix}$
2	$\frac{1}{\sqrt{2}}\begin{bmatrix}1\\j\end{bmatrix}$	$\frac{1}{2}\begin{bmatrix}1&1\\j&-j\end{bmatrix}$
3	$\frac{1}{\sqrt{2}}\begin{bmatrix}1\\-j\end{bmatrix}$	—

[0175] Operations of an eNB and a UE according to the Quantized-V (stacked) scheme are explained in the following with reference to FIG. **23**. For clarity, assume that the eNB transmits an RS according to the pattern shown in FIG. **13** (*a*).

[0176] The eNB transmits an RS in each time duration through the L number of antenna ports [S2305, S2315, S2325].

[0177] The UE accumulates information on a partial channel based on the RS received in each of the time durations. For example, in the step S2320, the UE generates a channel matrix using the information on the antenna ports accumulated via the step S2305 and the step S2315. In the step S2330, the UE generates a channel matrix in a manner of accumulating information of partial channels obtained through the step S2305, the step S2315 and the step S2325. The UE performs singular value decomposition on the accumulated channel matrixes.

[0178] For example, a dimension of the channel matrixes accumulated until j^{th} time duration corresponds to $\{(N_{RX})\times(1+(L-1)\cdot j)\}$. In this case, N_{RX} corresponds to the number of antenna ports of the UE. A dimension of a right singular matrix V, which is obtained as a result of performing the singular value decomposition performed on the accumulated channel matrixes, corresponds to $\{(1+(L-1)\cdot j)\times(1+(L-1)\cdot j)\}$. In this case, a code vector used by the eNB for transmission beamforming corresponds to the N_{RX} number of column vectors from the left of the right singular matrix V. Meanwhile, information fed back in each feedback instance corresponds to a partial matrix including column vectors corresponding to antenna ports transmitting an RS only among the V matrix consisting of the N_{RX} number of columns. Hence, in the step S2320 and the step S2330 of FIG. **23**, the remaining part except a part represented by a dotted line is CSI fed back to the eNB. More generally speaking, if a dimension of channel matrixes calculated in a manner of being accumulated corresponds to $\{(N_{RX})\times(L)\}$, a partial matrix of the fed back right singular matrix V corresponds to $\{(L)\times(N_{RX})\}$.

[0179] The eNB obtains the whole of the right singular matrix V in a manner of accumulating the partial matrixes of the right singular matrix V obtained in each feedback instance [S2335].

[0180] According to the present embodiment, as a feedback instance increases, in particular, as the II-4 Quantized-V (stacked) fed back by the UE is accumulated, the II-4 Quantized-V (stacked) converges into a beamforming result of II-1 Quantized-V (non-stacked).

[0181] FIG. **24** shows an average quantization error ratio of II-1 Quantized-V (non-stacked) to II-4 Quantized-V (stacked) in environment that M corresponds to 16 and L corresponds to 4. As shown in FIG. **22**, similar to a legacy codebook-based feedback, a first element of partial matrixes for L number of ports, which are fed back in j^{th} order, is fixed to 1. And, $[-v_1^{(j)}-]^T$, $[-v_1^{(j)}-]^T$ respectively indicate vectors including 3 elements in j^{th} time duration (e.g., subframe).

[0182] In the present embodiment, a process of making a feedback on a quantized code vector can be applied to a process of making a feedback on a codebook-based PMI in a legacy LTE mobile communication system.

[0183] In case of making a feedback on an RI, the UE can feedback the RI in a manner of calculating PMI/CQI based on an RI selected by the UE. On the contrary, when the UE makes a feedback on CSI, if the UE differently selects an RI for a partial channel in every feedback instance, it may confuse the eNB. Hence, it may be able to restrict the UE not to change an RI within an identical iteration, i.e., K time duration (higher-layer signaling). In this case, the UE calculates PMI using a single RI in a process of generating a total channel matrix.

[0184] Meanwhile, similar to the embodiment of II-4, a CQI used for determining a MCS (modulation and coding scheme) can also be fed back based on accumulated channel information. In a different embodiment, the UE can feedback not only a CQI for a corresponding partial channel but also a CQI for all antenna ports based on the accumulated channel information when a feedback is made on K^{th} time duration. For example, the UE can feedback a different with a past CQI (differential CQI) together with a complete CQI for a total channel. In a further different embodiment, a CQI feedback on all antenna ports can be performed via a separate feedback instance or a separate message based on the accumulated channel information. One of the aforementioned embodiments can be indicated to the UE via RRC signaling.

[0185] II-5. Repetition of Pattern and CSI Update

[0186] As mentioned earlier in FIG. **13**, each antenna port transmits an RS according to a pattern and the pattern can be repeated. For example, if K corresponds to 3, RS transmission in fourth time duration can be performed by an antenna port identical to an antenna port transmitting an RS in first time duration.

[0187] When a pattern is repeated and CSI feedback is performed according to the pattern, an additional method of improving capability is explained in the following.

[0188] When a CSI is fed back according to a CSI-RS of a pattern such as a previous iteration, it may be able to enhance CSI feedback accuracy using previous CSI information. For example, in case of reporting a quantized matrix V_q using PMI, it may be able to increase accuracy in a manner of averaging previous phase information and current phase information. Meanwhile, the current phase information can be selected from a codebook different from a codebook from which the previous phase information is selected.

[0189] FIG. **25** corresponds to an embodiment of making a feedback on a CSI in response to a repetition of a pattern when M corresponds to 16, L corresponds to 4 and K corresponds to 5 in II-4 Quantized-V (stacked) scheme. A UE performs quantization on a right singular matrix V in 6th time duration using a codebook including a random phase as a configuration element. $v_1^{(6)}$ and $v_2^{(6)}$ are updated through phase information selected from codebooks different from each other. For example, the UE selects phase information through a second codebook in 6th time duration (e.g., 6th subframe), selects phase information through a first codebook in 1st time duration (e.g., 1st subframe), calculates a phase information average and may be able to update a matrix V.

[0190] An eNB and the UE can preconfigure or discuss about a codebook to be used in each feedback instance among a plurality of codebooks (e.g., RRC signaling).

[0191] FIG. **26** illustrates a capability improvement effect improved by the embodiment mentioned earlier in II-5. In FIG. **26**, time duration corresponds to a subframe unit and capability is measured on the basis of average correlation power. Assume that M corresponds to 16, L corresponds to 4, K corresponds to 5 or 9 and a UE has 2 reception antenna ports. After beamforming is performed using the II-4 Quantized-V (stacked) scheme, a previous pattern uses 'random codebook' of which phase of each code vector element has a random value for repeated time duration instead of a codebook using a QPSK symbol. In order to identically maintain the number of feedback bits assigned to every subframe, a random codebook of a size equal to a size of the codebook using the QPSK symbol is used.

[0192] II-5. Comparison of CSI Feedback Schemes

[0193] FIG. **27** illustrates a result resulted from simulating the aforementioned CSI feedback methods in terms of average correlation power.

[0194] FIG. **28** and FIG. **29** illustrate a transfer rate of a user using the aforementioned CSI feedback methods. In this case, assume that a UE has 2 reception antenna ports and K corresponds to 5. FIG. **28** illustrates accumulation probability distribution of a transfer rate of a user when the UE receives information using two reception antenna ports and FIG. **29** illustrates accumulation probability distribution of a transfer rate of a user when the UE receives information using one reception antenna port only. A solid line indicates a transfer rate after feedback is performed 30 times in Quantized-V (stacked) scheme.

[0195] FIG. **30** illustrates simulation environment of FIG. **28** and FIG. **29**. A user exists between a serving eNB and a neighboring eNB and a distance between the two eNBs corresponds to 500 m. A UE is located at a point within 150 m radius from the serving eNB.

[0196] FIG. **31** illustrates the number of CSI feedback bits transmitted according to each CSI feedback scheme. Depending on transmitted information, if one element of a matrix is quantized by one element among {1, −1, I, −i}, two bits are used. In case of Quantized-H, Quantized-UN and Quantized-V (stacked), when a subframe is transmitted, it is able to immediately feedback information on every subframe. Yet, in case of Quantized-V, accumulated information are transmitted at a time when information on all antenna ports are received through a plurality of subframes. Hence, in case of Quantized-H, Quantized-UN and Quantized-V (stacked), the number of feedback bits consumed in each every subframe corresponds to '2×(L−1)×(rank)'. In case of Quantized-V, the number of feedback bits consumed at a time after all subframes for the total M number of antenna ports corresponds to '2×(M−1)×(channel rank)'. If the aforementioned number of feedback bits is converted into a value of the number of

feedback bits per subframe, consequently, the number of feedback bits of the three proposed schemes are identical with each other.

II-6. CSI Feedback Mode

[0197] In order to provide backward compatibility to a legacy UE not supporting enhanced RS transmission, a CSI feedback mode and a control signal, an eNB can selectively configure a legacy mode and an advanced mode. The UE signals whether or not the UE supports the advance mode to the eNB (capability signaling). The eNB can semi-statically signal switching of a mode to the UE (e.g., semi-static indication via RRC signaling). On the contrary, switching of a mode can be dynamically signaled via signaling of a physical layer or MAC layer (dynamic indication). In order to switch a mode, the eNB can transmit a control signal to the UE to indicate that enhanced CSI feedback is available. The eNB transmits a control signal for initiating the enhanced CSI feedback to the UE. For example, information exchanged between the eNB and the UE to switch a mode includes at least one selected from the group consisting of the number of physical antennas of the eNB, the number of antennas for transmitting an RS in a subframe, RS configuration (e.g., CSI-RS port number and CSI-RS configuration) and pattern information of an antenna port transmitting an RS.

[0198] III. Elevation Beamforming and Full-Dimension MIMO

[0199] III-1. High Level View

[0200] In the following description, in case of performing elevation beamforming (EB) and FD (full-dimension)-MIMO, a method of increasing system performance, which does not cause any serious overhead due to many numbers of antennas and measurement of an RS resource, is explained.

[0201] In the following description, the elevation beamforming and the FD-MIMO can be classified into 2 types. A first type corresponds to a type using a horizontal-domain CSI feedback only. The first type has a relatively low complexity. A second type a type using both a horizontal domain and a vertical domain. Although the second type shows a relatively accurate and high performance compared to the first type, the second type may have a complexity problem and an overhead problem.

[0202] III-1-(i) Relation Between TXRU (RF Chain) and Antenna Elements/Ports

[0203] Among terminologies used in the present specification, such a terminology as 'TXRU' is an abbreviation of a transceiver unit and may be referred to as an RF chain. For example, the TXRU corresponds to a base band processor capable of independently controlling a single RF chain or size and phase of a transmission symbol. The TXRU can be mapped to a plurality of transmission antenna elements by a corresponding phase shifters. For example, the number of TXRU may be equal to or less than the number of antenna elements.

[0204] For clarity, assume that a transmitter (or an eNB) includes 32 antenna elements in a cell, 4 elements are arrayed in horizontal direction and 8 elements are arrayed in vertical direction. Since the 8 elements arrayed in vertical direction are connected with a single TXRU, each of the 4 elements arrayed in horizontal direction is connected with 4 TXRUs.

[0205] As mentioned in the foregoing description, the number of TXRUs and the number of antenna elements may be different from each other and it may be necessary to virtualize an antenna port (hereinafter, an RS port) for transmitting an RS. It is able to virtualize an RS port to 4 TXRUs in various ways. A virtualization scheme may vary according to a mapping RS among a CRS, a CSI-RS and a DMRS. Specifically, in case of the CSI-RS, when a CSI-RS configuration including 4 CSI-RS ports is set to a UE, each of the 4 CSI-RS ports may correspond to each TXRU. In case of the CRS, if 2 CRS ports are used in a cell, one CRS port corresponds to 2 TXRUs and another CRS port may correspond to the remaining 2 TXRUs.

[0206] DMRS port virtualization may vary according to the number of layers transmitted based on a DMRS. For example, antenna ports can be variously mapped according to an RS, TXRUs, or antenna elements.

III-1-(ii). Elevation Beamforming

[0207] Beamforming in vertical direction (elevation beamforming) can be considered as vertical sectorization. For example, in case of the aforementioned example that there exist 4×8 antenna elements, 2 vertical sectors are formed and each vertical sector i is operated by 4 TXRUs (N_i=4) among total 8 TXRUs. In particular, in order to manage 2 vertical sectors, it may be necessary to have TXRUs as many as twice of the vertical sectors. Each vertical sector may have a unique CRS irrespective of physical cell ID virtualization by the corresponding TXRUs. Each vertical sector may have a relevant N_i-port CSI-RS configuration for a CSI feedback on the vertical sector. It is necessary to semi-statically change a tilting angle of each vertical sector to control load balancing and interference. In this case, vertical sector tilting is associated with a phase shifter for analog beamforming.

[0208] III-1-(iii). Full-Dimension MIMO

[0209] As mentioned in the foregoing description, each TXRU can be connected with a plurality of antenna elements, a sub-array, or a single antenna element. For performance of FD-MIMO, although it may be preferable to configure one-to-one (1:1) mapping between a TXRU and an antenna element, a subarray structure for mapping a TXRU to a plurality of antenna elements is more practical. In FD-MIMO, each antenna port of a CSI-RS is mapped to a TXRU in general. A CRS antenna port is mapped to a TXRU or is mapped to a plurality of TXRUs in a manner of being virtualized.

[0210] As mentioned in the foregoing description, the first type among the EB and the FD MIMO-scheme uses CSI feedback in horizontal domain only. In this case, in order to use a vertical domain, it is necessary to set and measure an additional CSI-RS in a UE. The UE reports a power level received per a port or a result of selecting an optimized antenna port through the additional CSI-RS. It is able to determine optimized vertical direction of long term for the UE based on the report of the UE.

[0211] In this case, each CSI-RS port in which a CSI-RS is transmitted is virtualized in response to antenna elements arrayed in vertical direction according to vertical direction becoming a target. The UE performs legacy horizontal domain short term feedback on a CSI-RS which is pre-coded in vertical direction becoming the target. In this case, it is preferable to transmit a non-periodical CSI-RS, which is associated with the UE or a UE group only, in consideration of overhead of a CSI-RS resource.

[0212] The second type among the FD-MIMO scheme can enhance vertical domain capability of a channel in a manner of using a new vertical domain feedback together with a horizontal domain feedback. It is necessary to newly define a vertical direction codebook and the codebook may corre-

spond to a DFT-based codebook, by which the preset invention may be non-limited. In particular, a vertical domain shows characteristics different from a legacy horizontal domain. For example, a target codebook range may cover a specific angle only instead of whole range of vertical angles. It is preferable to generate a codebook on the basis of an angle at which the UE is positioned or the UE is able to position except a vertical angle heading to the sky (in 3D-Uma, zenith angles less than 90 degrees are excluded). Hence, a vertical direction codebook is limited in a subset or an angle.

[0213] Meanwhile, it is necessary to consider how many vertical direction ranks are used. In one embodiment, a vertical rank may be restricted to 1.

[0214] In summary, according to one embodiment of the present invention, vertical sector tilting can be semi-statically performed based on up/down data traffic and/or interference measurement to control load balancing and interference. And, a legacy short-term feedback can be performed based on a CSI-RS which is pre-coded in long-term vertical direction. In another embodiment of the present invention, it is able to perform vertical direction feedback together with legacy horizontal direction feedback.

[0215] III-2. RS Design Aspect

[0216] In one embodiment of the present invention, assume at least one among items described in the following. It may use a 2 dimensional antenna array. The 2 dimensional antenna array also includes a single column array of a cross pole antenna. It may use various numbers of TXRUs including 8, 16, 32 and 64 TXRUs. It may configure to measure maximum 64 (8×8) antenna ports. Designing an RS such as an SRS, a CSI-RS and a DMRS may change for EB/FD-MIMO. It is able to define an enhanced codebook and CSI feedback for a single user/multi-user MIMO (e.g., CQI definition, layer mapping, precoder/rank indication, etc.). The EB/FD-MIMO can operate based on channel reciprocity. A transmission diversity mode can be improved for the EB/FD-MIMO. Control signaling can be enhanced for SU/MU-MIMO in the EB/FD-MIMO. It is able to define eNB antenna calibration for the EB/FD-MIMO. The maximum number of reception layers per UE may also be restricted to 8 in the EB/FD-MIMO. In the following, RS design for the EB/FD-MIMO is explained in more detail.

[0217] FIG. **32** is a diagram for briefly describing a mapping relation among an antenna port-TXRU-antenna element according to one embodiment of the present invention. Each antenna port is mapped to one or more TXRUs through a virtualization matrix X. Each TXRU is mapped to one or more antenna elements by a phase shifter corresponding to a virtualization matrix Y.

[0218] In the following, for clarity, all mapping relations between an antenna port and a physical antenna element are commonly called a virtualization matrix B. For example, the virtualization matrix B may correspond to a multiplication of the virtualization matrix X and Y, by which the present invention may be non-limited.

[0219] Meanwhile, similar to the EB/FD-MIMO, when there exist huge number of transmission antennas, it is necessary to determine how many RS ports are to be used to transmit and measure an RS. More specifically, it is necessary to consider radio resource management in the aspect of a method of setting CSI-RSs to a UE, whether or not there is a problem for a legacy RS configuration and usage for other RSs (e.g., DMRS, SRS and RS for RRM) to support the EB and FD-MIMO operation, in particular, a coverage mismatch problem between a data channel of high beam gain and a common control channel, etc.

[0220] III-2-(i). Enhancements on CSI-RS

[0221] According to one embodiment of the present invention, a CSI-RS can be virtualized over a plurality of antenna elements. Although it is able to provide a current CSI-RS configuration through UE-dedicated RRC signaling, an identical CSI-RS configuration is provided to UEs in an identical cell in general and the UEs measure and report a corresponding CSI-RS.

[0222] In another embodiment, in order to accurately configure a beam direction in an EB/FD-MIMO operation, CSI-RS transmission in a specific beam direction can be set to a UE. Meanwhile, it may use weighted vectors to virtualize a CSI-RS.

[0223] When a system performing an EB/FD-MIMO operation based on a 2-dimensional antenna array including many antenna elements is considered, there is a problem of whether to increase the number of antenna ports of a CSI-RS. In particular, there is a problem of whether to have N-port (N>8) CSI-RS configuration. In a massive MIMO system, it is able to increase the number of ports for transmitting a CSI-RS in proportion to the number of antenna elements. In particular, it may consider a method of configuring CSI-RS ports exceeding 8 CSI-RS ports (e.g., a method of increasing positions of a candidate RE according to every PRB pair). In this case, there is a demerit in that change of a legacy system is not small. Moreover, as the number of ports included in a CSI-RS configuration increases, there is a problem in that overhead of an RS resource also increases.

[0224] Hence, according to one embodiment of the present invention, the maximum number of antenna ports of a CSI-RS configuration may correspond to 8, by which the present invention may be non-limited.

[0225] It is able to estimate a channel correlation matrix through Kronecker multiplication of correlation in azimuth dimension and elevation dimension. Hence, in one embodiment of the present invention, a method of performing Kronecker precoding in a manner of combining a CSI-RS of azimuth dimension and a CSI-RS of elevation dimension with each other is proposed. In particular, the two CSI-RSs of the azimuth dimension and the elevation dimension are provided to a UE. In this case, each of the CSI-RSs has maximum 8 ports. Hence, it may be able to provide maximum 64 ports to the UE by the Kronecker multiplication.

[0226] In another embodiment, a single CSI-RS configuration including maximum 8 ports is provided to the UE. The single CSI-RS configuration can be used for virtualization-varying of CSI-RS transmissions at every time instance according to a CSI-RS period. For example, the UE can receive a single CSI-RS configuration including a sort of virtualization-varying pattern information. In order to obtain channel state information on many ports using a relatively less CSI-RS port configuration, the UE can perform CSI reporting based on a partial channel or an interpolated channel according to a CSI feedback configuration.

[0227] Meanwhile, it is necessary to consider whether or not instantaneous CSI-RS (or shirt-term CSI-RS) transmission is required for EB/FD-MIMO operation. FIG. **33** shows instantaneous CSI-RS transmission. In this case, a network can alternately use multiple virtualization matrixes for a single CSI-RS configuration (e.g., Bi for I=1, 2, . . . , K). And, the network can trigger a UE to report a CSI feedback in

specific vertical beam direction only. For example, a CSI feedback can be triggered in a manner that the network indicates instantaneous CSI to be measured in a subframe where a CSI-RS to which a virtualization matrix Bi is applied is applied. If the UE is triggered to report a plurality of aperiodic CSI feedbacks in a plurality of subframes, each trigger is associated with virtual matrix Bi different from each other. An eNB can determine a beam direction appropriate for the UE based on the CSI feedbacks.

[0228] FIG. **34** illustrates an EB/FD-MIMO operation according to one embodiment of the present invention. As shown in FIG. **34**, instantaneous CSI-RS transmission can be used to reduce network overhead when huge number of antenna elements are implemented in a corresponding cell.

[0229] Meanwhile, in order not to waste an RS resource in a situation that there is no UE for measuring a virtualized CSI-RS, a network can control instances of transmitting the virtualized CSI-RS with an aperiodic scheme. For example, as shown in FIG. **34**, when UEs are distributed in a whole cell radius and the UEs are moving, all UEs can be served at an internal area of a center of a cell at a part of the transmission instances. Hence, it is preferable to transmit a virtualized CSI-RS corresponding to the internal area of the cell only in first direction.

[0230] In other word, although a virtualized CSI-RS is not transmitted in second direction at the outer area adjacent to a cell boundary, it is O.K. Since UEs do not measure the CSI-RS in second direction, it is preferable not to transmit the CSI-RS in the second direction in the aspect of efficiency of radio resource management. Although the embodiment of FIG. **34** illustrates two areas only, if the areas are more segmented, a radio resource effect due to omission of a CSI-RS can be more increased.

[0231] III-2-(ii). Enhancements on Other RSs.

[0232] Practically, since the number of transmission antenna ports of most eNBs corresponds to 2, MU-MIMO is limited to 2. Under this limitation, there is no considerable problem in performing a MU-MIMO operation using current standard. If the huge number of transmission antenna elements and ports are activated for EB/FD-MIMO, it is able to support the huge number of MU-MIMO UE pairs in principle. In relation to this, necessity for enhancing a DMRS is raised to support the huge number of MU-MIMO pairs at the same time. For example, according to a current standard, it is a question whether it is preferable to set DMRS virtual cell IDs different from each other to MU-MIMO UE pairs different from each other. According to one embodiment of the present invention, it may be able to set a DMRS virtual cell ID to the MU-MIMO UE pairs different from each other.

[0233] In a situation that the number of antennas of an eNB is far more than the number of antennas of a UE, in case of a TDD system, the eNB can obtain channel state information base on channel reciprocity. For example, an SRS transmitted by the UE in uplink can also be used for channel measurement to determine a beam direction appropriate for downlink transmission transmitted from the eNB.

[0234] If the channel reciprocity based on a closed-loop scheme is also used for an FDD system, the eNB can set the SRS transmission to an FDD downlink band. By doing so, it is able to solve a serious mismatch problem between uplink measurement and an actual channel state of downlink.

[0235] In a heterogeneous network in which a macro cell and a small cell coexist, the macro cell can use a 2-dimensional active antenna system (2D-AAS). For example, a coverage mismatch problem inevitably occurs between not-pre-coded SRS transmission and pre-coded DMRS-based PDSCH transmission. More specifically, in the aspect of CRS-based control channel coverage, macro cell connection for DMRS-based PDSCH reception can be relatively better for a UE positioned at small cell coverage. This is because an eNB obtains higher beam gain from huge number of antenna elements. According to one embodiment of the present invention, in the aforementioned situation, although the UE is geographically positioned at the small cell coverage, it may be preferable for the UE to be associated with the macro cell to make the UE receive a service from the macro cell. To this end, it is necessary to enhance CRS-based legacy radio resource management. For example, it may be able to configure a radio resource management report based on a virtualized CSI-RS or it may be able to use an additional RS for a radio resource management report.

[0236] The aforementioned embodiments for the RS design can be summarized as follows. When a CSI-RS is configured in an EB/FD-MIMO operation, the number of antenna ports may not exceed 8 and it may be preferable to transmit an instantaneous CSI-RS. In order to transmit huge number of MU-MIMO pairs at the same time, it is necessary to enhance a DMRS. In order to efficiently manage a radio resource, it is necessary to enhance an SRS.

[0237] III-3. CSI Feedback and Codebook Aspect

[0238] In the following description, a CSI feedback scheme and a codebook enhanced for EB/FD-MIMO are mainly explained according to one embodiment of the present invention.

[0239] For clarity, an antenna configuration shown in FIG. **35** is assumed, by which the present invention may be non-limited. Referring to FIG. **35**, a 2-dimensional active antenna array includes 32 antenna elements. In this case, at least 4 TXRUs exist in horizontal domain (H-domain) and each of the TXRUs is mapped to a single CSI-RS port. For example, 4-port-H-CSI-RS can be set to a UE for a horizontal domain CSI feedback. In a vertical domain, how many additional TXRUs are necessary may vary depending on a transmission scheme.

[0240] III-3-(i). Relying on H-Domain CSI Feedback

[0241] As mentioned in the foregoing description, according to one embodiment of the present invention, it may use H-domain CSI feedback only in an EB/FD MIMO operation.

[0242] Meanwhile, an additional V-CSI-RS can be measured and set to a UE for vertical direction beamforming and a reception power level per port or a result of selecting the optimized N number of antenna ports can be fed back to an eNB. The eNB determines a long-term vertical direction optimized for the UE based on the feedback. More specifically, referring to an embodiment of FIG. **36**, a cell is divided into an internal area (center part of the cell) in which 4-port H-CSI-RS1 corresponding to 4 TXRUs are transmitted and an external area (edge part of the cell) in which 4-port H-CSI-RS1 corresponding to other 4 TXRUs are transmitted. Those skilled in the art can understand that legacy horizontal direction sectorization is not depicted for clarity.

[0243] Each H-CSI-RS port is virtualized over vertically arrayed 8 antenna elements according to targeting vertical direction.

[0244] It may be able to provide 2-port V-CSI-RS configuration to a UE. One V-CSI-RS port is associated with a port of the H-CSI-RS1 and another V-CSI-RS port is associated with a port of the H-CSI-RS2. This is intended for a UE to select an

optimized antenna port and make a feedback on the selected antenna port. The UE performs a horizontal domain short-term feedback on H-CSI-RSi virtualized by a target vertical direction i. When CSI-RS resource overhead for the horizontal domain short-term feedback is considered, it may be preferable to transmit an aperiodic CSI-RS to the UE or a UE group.

[0245] III-3-(ii). Consideration on Vertical Codebook

[0246] According to one embodiment of the present invention, a vertical codebook is newly defined for EB/FD-MIMO. The vertical codebook may correspond to a DFT-based codebook, by which the present invention may be non-limited. As mentioned in the foregoing description, since a UE may not exist in a specific vertical direction, it is preferable to define a codebook on the basis of an angle at which the UE is positioned or an angle at which the UE is able to be positioned. To this end, it may be able to set a limit on a subset or an angle of a codebook.

[0247] The aforementioned contents should be considered in terms of interference control. In a 3D channel model including not only an azimuth domain but also a vertical domain, interference characteristics different from each other may occur according to each domain. For example, if each transmitter (or an eNB) targets a UE positioned at a high location of a building, beams targeting a high direction may considerably affect a neighbor cell including a high beam gain. Hence, it may be able to set a limit on a specific beam direction to increase throughput of overall system.

[0248] When a vertical direction codebook is determined, it is also necessary to consider vertical channel environment. For example, since it is able to anticipate that a vertical channel has a lower angular spread in horizontal environment and has low probability of having a high transmission rank, relatively less number of multi-path components will appear. Hence, the number of available vertical ranks can be determined based on a vertical domain channel characteristic or it may be able to configure a vertical rank to be equal to or less than a specific value.

[0249] III-3-(iii). Closed-Loop Based Scheme

[0250] The number of antenna ports transmitting a CSI-RS is restricted in consideration of a trade-off relation between network overhead and performance and a CSI-RS can be transmitted over all transmission antenna elements by antenna port virtualization. A simple closed-loop scheme can be implemented by Kronecker precoding based on a horizontal domain feedback and a vertical domain feedback. According to a Kronecker precoding scheme, as shown in Equation 13 in the following, a total channel precoding matrix P can be obtained by Kronecker multiplication between a vertical-precoding matrix P_V and a horizontal-precoding matrix P_H.

$$P=P_V \otimes P_H \quad \text{[Equation 13]}$$

[0251] In order to obtain the precoding matrix P_V and P_H, a UE performs CSI measurement on both a vertical domain and a horizontal domain. For example, as shown in FIG. **37**, the CSI measurements can be performed based on an 8-port V-CSI-RS configuration and a 4-port H-CSI-RS configuration, respectively.

[0252] According to the present embodiment, a codebook for a massive active antenna system can be divided into a vertical direction codebook and a horizontal direction codebook. Consequently, a legacy horizontal direction codebook is reused or expanded and a vertical direction codebook can be defined based on a linear phase increase. And, it is able to reduce RS and CSI feedback overhead compared to a case that total 32 (8*4)-port CSI-RS configuration is provided to a UE. This is because it is able to measure total 12 (8+4) antenna ports and individually design CSI feedback chains according to each CSI-RS configuration.

[0253] A CSI process configuration and a CQI definition may change under a dual feedback structure. For example, 2 CSI processes respectively corresponding to a vertical and horizontal feedback can be set to a UE. The UE independently determines a CSI of each process. Yet, it may be difficult for an eNB to calculate an appropriate CQI again based on a reported CQI and a reported RI may be different from an optimized rank. This is because a reported CSI is not generated based on all channels.

[0254] According to a different embodiment of the present invention, it may use a single CSI-RS configuration for EB/FD-MIMO. The single CSI-RS configuration is used for virtualization-varying CSI-RS transmission in every transmission timing according to a CSI-RS period. More specifically, a single CSI-RS configuration including a sort of virtualization-varying pattern information is included in a UE and the UE is able to perform CSI reporting based on a partial channel or an interpolation channel using the CSI-RS configuration. Meanwhile, an eNB can inform the UE of whether the CSI reporting is performed on a partial channel in every instance or a plurality of instances or is fed back at a time in a manner of combining CSIs for all channels with each other (e.g., CSI configuration).

[0255] FIG. **38** is a diagram for a virtualization varying CSI-RS through 4 ports. An eNB sets a 4-port CSI-RS configuration to a UE and the 4-port CSI-RS configuration makes 16 antenna elements to be measured for a plurality of timings or frequency resources in a manner of being divided. The UE may report a partial channel in every instance or report total channels over a plurality of instances in a manner of reconfiguring the total channels. In order to reconfigure the total channels, the UE can combine measurements measured over a plurality of instances with each other.

[0256] Meanwhile, a measurement window can be set to the UE. For example, the UE should not average measurement results among a plurality of L instances belonging to a virtualization-varying CSI-RS. In FIG. **38**, measurements measured in **t1** to **t4** should not be averaged with each other. An eNB can obtain a CSI for massive antenna ports from the UE based on CSI feedbacks on the smaller number of CSI-RS ports.

[0257] In the foregoing description, although such a terminology as virtualization-varying CSI-RS is used for clarity, the scope of the present invention is not limited to the change of a virtualization matrix. For example, as shown in FIG. **38**, a CSI-RS transmitted at each time instance may correspond to an unprecoded RS that an antenna port is directly mapped to a physical antenna element. Yet, since the aforementioned case can be considered as one of subsets of various virtualization matrixes, such a comprehensive term as a virtualization-varying CSI-RS is used in the present invention.

[0258] Meanwhile, in a different embodiment, a plurality of CSI-RS configurations can be set to a UE. For example, a CSI-RS configuration may exist in each of multiple partial channels measured by the UE over a plurality of timings. An RS transmitted in each time is mapped/set to an individual CSI-RS resource and a CSI-RS port number different from each other can be provided to every CSI-RS configuration of each time. For example, in FIG. **38**, the total 16 port numbers

can be defined and the port numbers can be set to the UE. Yet, a CSI-RS is transmitted in a part of the ports only according to each timing and the UE measures the CSI-RS. The UE accumulates measurements or performs interpolation on the measurements in consideration of a 16-port structure, calculates total RI/PMI/CQI and reports it to the eNB.

[0259] When a CSI is generated through interpolation of partial channel, the interpolation can be performed on a horizontal domain and a vertical domain, respectively. Or, the interpolation can be performed on either the horizontal domain or the vertical domain only. The eNB can explicitly signal a domain on which the interpolation is to be performed. According to a different embodiment, a criterion for whether to perform the interpolation of the partial channel can be implicitly defined between the eNB and the UE. For example, the criterion can be determined in consideration of a measurement value of a CSI-RS, a size of total channels, the number of antenna ports configured to transmit an RS and the like, by which the present invention may be non-limited.

[0260] The interpolation of the partial channel can be performed according to a subset of 2-dimensional antenna. For example, assume that a 2-dimensional antenna array includes a plurality of subsets. Yet, it is not mandatory that a plurality of the subsets are mutually exclusive. A part of a plurality of the subsets can be overlapped with each other. Assume that a UE obtains a measurement value of a first partial channel in a manner of measuring a first CSI-RS transmitted from a first subset and obtains a measurement value of a second partial channel in a manner of measuring a second CSI-RS transmitted from a second subset. The UE obtains a CSI on a third partial channel including the first partial channel in a manner of performing interpolation on measurement values of the first partial channel. Similarly, the UE obtains a CSI on a fourth partial channel in a manner of performing interpolation on measurement values of the second partial channel. The UE feedbacks the CSIs to the eNB in a manner of respectively transmitting the CSI on the third partial channel and the CSI on the fourth channel to the eNB or matching the CSI on the third partial channel and the CSI on the fourth channel with each other.

[0261] Meanwhile, the eNB can signal the UE to make a feedback on a partial channel or make a feedback on total channels. In particular, in case of an aperiodic CSI report, information for indicating whether a CSI request corresponds to a CSI request for a partial channel or a CSI request for total channels can be included in a corresponding DCI including a CSI request field. In case of a periodic CSI report, pattern information for indicating a reporting instance and a measurement value on which a CSI report is to be made can be provided to the UE.

[0262] In summary, the eNB can provide a single CSI-RS configuration or a plurality of CSI-RS configurations to the UE. And, the eNB can configure the UE to make a feedback on a CSI report for a partial channel whenever a partial channel is measured. Or, the eNB can configured the UE to make a feedback on a CSI report for total channels at a time in a manner of matching measurement results measured for partial channels with each other. Hence, there may mainly exist 4 configurations and a CSI feedback scheme of the UE may vary according to each configuration.

[0263] Case 1. A CSI-RS Configuration & CSI Feedback Configuration for Total Channels

[0264] In 3GPP standard, except a case of operating in a CoMP mode (transmission mode **10**), a single CSI-RS configuration is provided to a UE and maximum 8 CSI-RS ports can be set to the UE.

[0265] Meanwhile, referring to FIG. **38**, a single CSI-RS configuration is shifted over t**1** to t**4** and CSI-RSs are transmitted from the total 16 antenna elements. In order to perform CSI feedback on the CSI-RSs at a time, it is necessary to have a codebook supporting 16 ports similar to a case of making a feedback on one-time CSI-RS transmission through 16 antenna ports. Hence, it is difficult to use a legacy codebook supporting maximum 8 CSI-RS ports only for EB/FD-MIMO. Hence, according to one embodiment of the present invention, a method of newly defining a codebook supporting total 16 (or 32, 64) CSI-RS antenna ports is proposed. For example, if an EB/FD-MIMO mode is set to a UE used to use a codebook supporting 4 or 8 antenna ports, the UE may perform CSI feedback through a codebook supporting 16, 32 or 64 antenna ports. Meanwhile, the 16/32/64-port codebook for EB/FD-MIMO may correspond to a codebook corresponding to the aforementioned quantized right singular matrix V_q.

[0266] Meanwhile, if CSI is reported at a time for the total 16 CSI-RS ports, an RI may indicate rank=16. Since the RI is unable to exceed the number of CSI-RS ports, although a maximum value of the RI corresponds to 8 in a legacy system, the maximum value of the RI can be extended to 16 or 32 in the EB/FD-MIMO, by which the present invention may be non-limited.

[0267] Case 2. A CSI-RS Configuration & CSI Feedback Configuration for Partial Channel

[0268] It is able to configure an eNB to set a single CSI-RS configuration to a UE and configure the UE to make a CSI report on a partial channel. In this case, it is necessary to define transmission timing of a CSI-RS to make a feedback on a CSI report. For example, it is able to configure the UE to make a feedback on a CSI from a subframe appearing as many as N subframes prior to a subframe carrying a DCI including a CSI-request to a subframe in which a most recent CSI-RS is transmitted, by which the present invention may be non-limited.

[0269] Meanwhile, if it is assumed that the UE measures a CSI-RS transmitted at t**1** and reports a CSI according to an embodiment of FIG. **38**, an RI becomes rank<=4. In particular, since the RI is restricted to be a number equal to or less than the number of CSI-RS ports, the RI does not exceed a range of 2 cross-poll antennas (4 antenna ports). And, it may reuse a legacy 4-port-based codebook for reporting PMI.

[0270] When the case 1 and the case 2 are compared with each other, it is able to know that a type of a codebook and the number of rank may vary depending on whether a UE reports CSI for a partial channel or the UE reports CSI for the total channels.

[0271] Case 3. A Plurality of CSI-RS Configurations & CSI Feedback Configuration for Total Channels

[0272] It is able to provide a plurality of CSI-RS configurations to a UE at the same time. In this case, each of a plurality of the CSI-RS configurations may correspond to an instance different from each other in FIG. **38**. Referring to FIG. **38**, an eNB can provide a CSI-RS configuration for t**1**, a CSI-RS configuration for t**2**, . . . , a CSI-RS configuration for t**4** to the UE at the same time.

[0273] According to one embodiment of the present invention, at least one or more horizontal direction (or azimuth direction) CSI-RS configurations and at least one or more vertical direction CSI-RS configurations can be included in a plurality of the CSI-RS configurations. For example, in FIG. **38**, it may be able to provide a horizontal direction CSI-RS

configuration for t1 and a vertical direction VSI-RS configuration for t5 to the UE at the same time. Horizontal direction CSI-RS configurations for t3 to t4 can be obtained from the horizontal direction CSI-RS configuration for t1 and a vertical direction CSI-RS configuration for t6 can be obtained from a vertical direction CSI-RS configuration for t5.

[0274] Meanwhile, when the UE makes a feedback on a CSI report for total channels, as mentioned earlier in case 1, a rank corresponds to 16/32 and a PMI can be selected from a 16/32-port codebook.

[0275] Case 4. A Plurality of CSI-RS Configurations & CSI Feedback Configuration for Partial Channel

[0276] If it is assumed that a plurality of CSI-RS configurations are associated with subframes different from each other, a UE can report a CSI based on a CSI-RS configuration which is associated with a subframe in which a CSI report is triggered.

[0277] Meanwhile, if a CSI-RS configuration is not associated with a subframe in which a CSI report is triggered, it is able to implicitly define as a UE makes a feedback on a CSI report based on CSI-RSs received through the N number of most recent subframes.

[0278] The aforementioned CSI-RS configuration and the CSI feedback configuration can be provided to the UE via an RRC message. The CSI-RS configuration and the CSI feedback configuration can be respectively transmitted via RRC messages different from each other or can be transmitted via a single RRC message. According to a different embodiment, a CSI-RS configuration is transmitted via an RRC message, whereas a CSI feedback configuration can be transmitted via an MAC message or PDCCH. For example, it may be able to additionally add a field indicating a CSI feedback configuration to a CSI-request field in a DCI or a size of the CSI-request field itself can be expanded.

[0279] III-3-(iv). Open-Loop Based Scheme

[0280] Depending on a channel state, it may be difficult to use the aforementioned closed-loop scheme due to overhead and a complexity problem. Hence, it may be able to consider an open-loop scheme through enhancement of SFBC or LD-CDD precoding. According to the open-loop scheme, it may be able to reduce feedback overhead and obtain a diversity gain without precoding information. Yet, since a legacy open-loop scheme operates based on a CRS, it is difficult to apply the open-loop scheme to a massive antenna array.

[0281] Meanwhile, according to one embodiment of the present invention, it may be able to use a closed loop and an open loop using a hybrid scheme. A CSI feedback is restricted to be performed for a part of RS ports only and the rest of the RS ports are used using an open-loop precoding scheme. More specifically, the total RS ports to be measured can be classified into several antenna port groups. Inter-group precoding can be performed using the closed-loop scheme and inner-group precoding can be performed using the open-loop scheme and vise-versa. By doing so, it may be able to reduce overhead of the closed-loop scheme.

[0282] In summary, a legacy short-term feedback can be performed for a CSI-RS virtualized by a preferred long-term vertical direction and a new vertical domain codebook can be defined based on a vertical direction range at which a UE is positioned. It may be able to use a Kronecker scheme. The present invention proposes a method of transmitting a virtualization-varying CSI-RS. In order to reduce feedback overhead in FD-MIMO, it may use the open-loop scheme.

[0283] IV. Exemplary Operations and Structures of UE and/or BS

[0284] Exemplary operations and structures of a UE and/or a BS are explained based on the aforementioned embodiments in the following. Contents overlapped with the aforementioned explanation are omitted.

[0285] FIG. **39** is a flowchart for a method of reporting and receiving a CSI according to one embodiment of the present invention. Referring to FIG. **39**, first of all, a BS transmits a subset configuration of a plurality of antenna ports and information on a reference signal transmission order of each subset within an iteration interval to a UE [S**3905**]. In particular, as mentioned earlier in FIG. **13**, the BS transmits a reference signal to a part of antenna ports only during an interval. Hence, the BS informs the UE of a subset configuration of antenna ports and a transmission order.

[0286] In this case, at least one or more antenna ports among a plurality of the antenna ports are included in all subsets.

[0287] Meanwhile, averaging results of measuring reference signals transmitted by each subset is prohibited in a same iteration interval. In particular, averaging S**3910**, S**3920** and S**3930** belonging to a first iteration interval is prohibited.

[0288] The BS transmits a first reference signal, a second reference signal and a third reference signal through antenna ports of a first subset, antenna ports of a second subset and antenna ports of a K subset, respectively [S**3910**, S**3920**, S**3930**]. The UE can obtain partial channel information in a manner of measuring the first reference signal, the second reference signal and the third reference signal, respectively.

[0289] Meanwhile, a method for the UE to report a CSI may vary according to an embodiment. For example, the UE can transmit information on all radio channels to a number 1 after the first iteration interval elapses. In this case, the step S**3915** and the step S**3925** are omitted. For example, the UE matches first partial channel information based on measurement of the first reference signal and second partial channel information based on measurement of the second reference signal with each other. The UE transmits a matched result to the BS.

[0290] At least one or more antenna ports included in all subsets provide phase information becoming a reference for matching the first partial channel information based on measurement of the first reference signal and the second partial channel information based on measurement of the second reference signal with each other.

[0291] On the contrary, the UE is able to report a CSI whenever a reference signal is measured. For example, the UE transmits first partial channel information corresponding to an antenna port of a first subset based on a measurement result of a first reference signal [S**3915**] and transmits second partial channel information corresponding to an antenna port of a second subset based on a measurement result of a second reference signal [S**3925**]. The BS can reconfigure the first partial channel information and the second partial channel information as overall channel information.

[0292] For example, the UE performs singular value decomposition on channel information which is generated based on at least one of the measurement of the first reference signal and the measurement of the second reference signal. The UE compares a right singular matrix according to the singular value decomposition with matrixes included in a prescribed codebook in terms of a phase and quantizes the right singular matrix. The UE transmits at least one of the quantized right singular matrix and a left singular matrix

according to the singular value decomposition to the BS. Meanwhile, the quantized right singular matrix may correspond to a matrix which is generated by accumulating the measurement result of the first reference signal and the measurement result of the second reference signal.

[0293] FIG. **40** is a flowchart for a method of reporting and receiving a CSI according to a different embodiment of the present invention. Explanation on contents overlapped with the aforementioned contents is omitted at this time.

[0294] First of all, a BS transmits an RRC message including at least one CSI-RS configuration for a first direction domain to a UE [**S4005**]. The RRC message can further include at least one CSI-RS configuration for a second direction domain. In this case, the first direction and the second direction may correspond to a vertical direction or a horizontal direction (or azimuth direction).

[0295] A CSI-RS configuration for a single direction may have a single CSI-RS configuration (the aforementioned case 1 and 2) or may have a plurality of CSI-RS configurations (the aforementioned case 3 and 4).

[0296] If a single CSI-RS configuration is set to a UE for a single direction, the CSI-RS configuration can include information on a pattern of virtualization varying. For example, the virtualization varying is to map a first antenna port used to be mapped to a first antenna element of a first subset to a second antenna element of a second subset according to a CSI-RS transmission interval.

[0297] The BS transmits the K number of CSI-RSs to the UE through antenna elements of the K number of subsets [**S4010**. **S4015**, **S4020**]. The K number of CSI-RSs can be transmitted from subframes different from each other.

[0298] If there is a single CSI-RS configuration for a first direction domain, a first CSI-RS and a second CSI-RS are transmitted through a first subset and a second subset, respectively, as antenna ports related to the single CSI-RS configuration are virtualization varying according to a CSI-RS transmission interval.

[0299] If there are pluralities of CSI-RS configurations for the first direction domain, the first CSI-RS and the second CSI-RS respectively correspond to CSI-RS configurations different from each other.

[0300] The BS transmits a DCI including a CSI request filed to the UE [**S4025**]. In case of periodic CSI transmission, the present step can be omitted. Meanwhile, the DCI can further include information on a CSI reporting scheme. The information on the CSI reporting scheme indicates either a first reporting scheme or a second reporting scheme. According to the first reporting scheme, the UE individually reports a CSI for a first partial channel corresponding to a first subset and a CSI for a second partial channel corresponding to a second subset (the aforementioned case 2 and 4). According to the second reporting scheme, the UE reports a CSI for total channels obtained based on at least one of the first partial channel and the second partial channel (the aforementioned case 1 and 3). Meanwhile, the total channels in the second reporting scheme can be obtained in a manner of performing interpolation on at least one of the first partial channel and the second partial channel or matching the first partial channel and the second partial channel with each other.

[0301] In another embodiment, the information on the CSI reporting scheme can be transmitted through a MAC or RRC message.

[0302] The UE performs a CSI reporting using the K number of CSI-RSs. If the UE performs the CSI reporting according to the first reporting scheme, the CSI reporting includes at least one of a PMI (precoding matrix index) selected from a 4 or 8-port based codebook and an RI (rank indicator) indicating 4 or 8. If the UE performs the CSI reporting according to the second reporting scheme, the CSI reporting includes at least one of a PMI (precoding matrix index) selected from a 16 or 32-port based codebook and an RI (rank indicator) indicating 16 or 32.

[0303] The aforementioned technology proposed by the present invention can be identically or similarly applied to a case of performing CSI measurement based on a CSI-RS and a case of performing CSI measurement based on a different reference signal (e.g., a CRS, an SRS, a TRS (tracking RS), a DMRS, a cell-specific reference signal of a different form, or a UE-specific reference signal) and performing CSI feedback.

[0304] The aforementioned various examples of the present invention can be independently applied or two or more embodiments can be applied at the same time.

[0305] FIG. **41** is a diagram for structures of a user equipment and a base station according to one embodiment of the present invention. In order to prevent a topic of the present invention from being unclear, a common configuration element is not depicted in FIG. **41**. And, since the depicted configuration elements are not mandatory configuration elements, those skilled in the art can understand that a part of the configuration elements can be omitted or replaced with a different configuration element. The aforementioned embodiments and methods can be performed by the UE and the BS depicted in FIG. **41**.

[0306] A base station (BS) **10** according to one embodiment of the present invention can include a transmitter **11**, a receiver **12**, a processor **13**, a memory **14** and a plurality of antennas **15**. The transmitter **11** can transmit various signals, data and information to an external device (e.g., a user equipment (UE)). The receiver **12** can receive various signals, data and information from an external device (e.g., a user equipment (UE)). The processor **13** can control overall operation of the BS **10**. For example, a plurality of the antennas **15** can be configured according to a 2-dimensional antenna array.

[0307] The processor **13** of the BS according to one example of the present invention can be configured to receive channel state information according to examples proposed by the present invention. Besides, the processor **13** of the BS **10** performs a function of calculating and processing information received by the BS **10**, information to be transmitted to the external and the like. The memory **14** can store processed information for prescribed time and can be replaced with such a configuration element as a buffer (not depicted).

[0308] A UE **20** can include a transmitter **21**, a receiver **22**, a processor **23**, a memory **24** and a plurality of antennas **25**. A plurality of the antennas **25** indicates a UE supporting MIMO transmission and reception. The transmitter **21** can transmit various signals, data and information to an external device (e.g., a base station (BS)). The receiver **22** can receive various signals, data and information from an external device (e.g., a base station (BS)). The processor **23** can control overall operation of the UE **20**.

[0309] The processor **23** of the UE **20** according to one example of the present invention can be configured to transmit channel state information according to examples proposed by the present invention. Besides, the processor **23** of the UE **20** performs a function of calculating and processing information received by the UE **20**, information to be trans-

mitted to the external and the like. The memory **24** can store processed information for prescribed time and can be replaced with such a configuration element as a buffer (not depicted).

[0310] For a concrete configuration of the UE **10**, items mentioned earlier in various embodiments of the present invention can be independently applied or two or more embodiments can be applied at the same time. For clarity, explanation on contents overlapped with the aforementioned contents is omitted.

[0311] When the various embodiments of the present invention are explained, a downlink transmission entity or an uplink transmission entity is mainly explained as a base station for example and a downlink reception entity or an uplink transmission entity is mainly explained as a user equipment for example, by which the present invention may be non-limited. For example, explanation on the base station can be identically applied to a case that a cell, an antenna port, an antenna port group, a remote radio head (RRH), a transmission point, a reception point, an access point, a relay or the like becomes a downlink transmission entity to the UE or an uplink reception entity from the UE.

[0312] And, if a relay becomes a downlink transmission entity to the UE or an uplink reception entity from the UE, or the relay becomes an uplink transmission entity to the BS or a downlink reception entity from the BS, the principle of the present invention can also be identically applied via various embodiments of the present invention.

[0313] The embodiments of the present invention may be implemented through various means. For example, the embodiments can be implemented by hardware, firmware, software, or a combination thereof.

[0314] When implemented as hardware, a method according to embodiments of the present invention may be embodied as one or more application specific integrated circuits (ASICs), one or more digital signal processors (DSPs), one or more digital signal processing devices (DSPDs), one or more programmable logic devices (PLDs), one or more field programmable gate arrays (FPGAs), a processor, a controller, a microcontroller, a microprocessor, etc.

[0315] When implemented as firmware or software, a method according to embodiments of the present invention may be embodied as a module, a procedure, or a function that performs the functions or operations described above. Software code may be stored in a memory unit and executed by a processor. The memory unit is located at the interior or exterior of the processor and may transmit and receive data to and from the processor via various known means.

[0316] Preferred embodiments of the present invention have been described in detail above to allow those skilled in the art to implement and practice the present invention. Although the preferred embodiments of the present invention have been described above, those skilled in the art will appreciate that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. For example, those skilled in the art may use a combination of elements set forth in the above-described embodiments. Thus, the present invention is not intended to be limited to the embodiments described herein, but is intended to accord with the widest scope corresponding to the principles and novel features disclosed herein.

INDUSTRIAL APPLICABILITY

[0317] Although a method of reporting channel state information for 3-dimensional beamforming in a wireless communication system and an apparatus therefor are explained centering on examples applied to 3GPP LTE system, the method and the apparatus can also applied to various wireless communication systems as well as 3GPP LTE system.

What is claimed is:

1. A method of reporting channel state information (CSI) by a user equipment in a wireless communication system, the method comprising:

receiving an RRC message containing at least one CSI-reference signal (CSI-RS) configuration for a first direction domain from a base station;

receiving, via different subframes respectively, a first CSI-RS from a first subset and a second CSI-RS from a second subset among a plurality of physical antenna elements of the base station based on the at least one CSI-RS configuration; and

performing CSI reporting using the first CSI-RS and the second CSI-RS,

wherein if a number of the at least one CSI-RS configuration for the first direction domain corresponds to one, the first CSI-RS and the second CSI-RS are respectively received from the first subset and the second subset according to virtualization-varying of antenna ports related to the one CSI-RS configuration, the virtualization-varying being performed in accordance with a predetermined period.

2. The method of claim **1**, wherein the virtualization-varying comprises mapping a first antenna port used to be mapped to a first antenna element of the first subset to a second antenna element of the second subset according to the predetermined period.

3. The method of claim **1**, wherein the CSI-RS configuration comprises information on a pattern of the virtualization-varying.

4. The method of claim **1**,

wherein the RRC message further comprises at least one CSI-RS configuration for a second direction domain and

wherein performing the CSI reporting comprises transmitting first CSI for the first direction domain and second CSI for the second direction domain.

5. The method of claim **1**, wherein if a number of the at least one CSI-RS configuration for the first direction domain is greater than one, the first CSI-RS and the second CSI-RS are received based on different CSI-RS configurations respectively.

6. The method of claim **1**, wherein the CSI reporting is performed according to:

a first reporting scheme for respectively reporting separate CSI on a first partial channel corresponding to the first subset and a second partial channel corresponding to the second subset or

a second reporting scheme for reporting CSI on total channels obtained based on at least one of the first partial channel and the second partial channel.

7. The method of claim **6**, wherein the total channels in the second reporting scheme are obtained by

performing interpolation on at least one of the first partial channel and the second partial channel or

matching the first partial channel and the second partial channel with each other.

8. The method of claim 6, further comprising receiving information indicating either the first reporting scheme or the second reporting scheme.

9. The method of claim 6,

wherein if the CSI reporting is performed according to the first reporting scheme, the CSI report comprises at least one of a precoding matrix index (PMI) selected from a 4 or 8-port-based codebook and an rank indicator (RI) indicating 4 or 8 and

wherein if the CSI reporting is performed according to the second reporting scheme, the CSI report comprises at least one of a precoding matrix index (PMI) selected from a 16 or 32-port-based codebook and a rank indicator (RI) indicating 16 or 32.

10. A method of receiving channel state information (CSI) by a base station in a wireless communication system, the method comprising:

transmitting an RRC message containing at least one CSI-RS configuration for a first direction domain to a user equipment;

transmitting, to the user equipment via different subframes respectively, a first CSI-RS mapped to a first subset and a second CSI-RS mapped to a second subset among a plurality of physical antenna elements of the base station; and

receiving a CSI report using the first CSI-RS and the second CSI-RS,

wherein if a number of the at least one CSI-RS configuration for the first direction domain corresponds to one, the first CSI-RS and the second CSI-RS are respectively transmitted through the first subset and the second subset according to virtualization-varying of antenna ports related to the one CSI-RS configuration, the virtualization-varying being performed in accordance with a predetermined period.

11. The method of claim 10, wherein the virtualization-varying comprises mapping a first antenna port used to be mapped to a first antenna element of the first subset to a second antenna element of the second subset according to the predetermined period.

12. The method of claim 10, wherein the CSI-RS configuration comprises information on a pattern of the virtualization-varying.

13. The method of claim 10,

wherein the RRC message further comprises at least one CSI-RS configuration for a second direction domain and

wherein receiving the CSI report comprises receiving first CSI for the first direction domain and second CSI for the second direction domain.

14. The method of claim 9, wherein if a number of the at least one CSI-RS configuration for the first direction domain is greater than one, the first CSI-RS and the second CSI-RS are received based on different CSI-RS configurations respectively.

15. The method of claim 9, wherein the CSI report is received according to:

a first reporting scheme for respectively reporting separate CSI on a first partial channel corresponding to the first subset and a second partial channel corresponding to the second subset or

a second reporting scheme for reporting CSI on total channels obtained based on at least one of the first partial channel and the second partial channel.

16. The method of claim 15, wherein the total channels in the second reporting scheme are obtained by

performing interpolation on at least one of the first partial channel and the second partial channel or

matching the first partial channel and the second partial channel with each other.

17. The method of claim 15, further comprising transmitting information indicating either the first reporting scheme or the second reporting scheme.

18. The method of claim 15,

wherein if the CSI report is performed according to the first reporting scheme, the CSI report comprises at least one of a precoding matrix index (PMI) selected from a 4 or 8-port-based codebook and a rank indicator (RI) indicating 4 or 8 and

wherein if the CSI report is performed according to the second reporting scheme, the CSI report comprises at least one of a precoding matrix index (PMI) selected from a 16 or 32-port-based codebook and a rank indicator (RI) indicating 16 or 32.

19. A user equipment reporting channel state information (CSI) in a wireless communication system, comprising:

a receiver configured to receive an RRC message containing at least one CSI-RS configuration for a first direction domain from a base station and to receive, via different subframes respectively, a first CSI-RS from a first subset and a second CSI-RS from a second subset among a plurality of physical antenna elements of the base station based on the at least one CSI-RS configuration; and

a processor configured to perform CSI reporting using the first CSI-RS and the second CSI-RS,

wherein if a number of the at least one CSI-RS configuration for the first direction domain corresponds to one, the first CSI-RS and the second CSI-RS are respectively received from the first subset and the second subset according to virtualization-varying of antenna ports related to the one CSI-RS configuration, the virtualization-varying being performed in accordance with a predetermined period.

20. A base station receiving channel state information (CSI) in a wireless communication system, comprising:

a transmitter configured to transmit an RRC message containing at least one CSI-RS configuration for a first direction domain to a user equipment and to transmit, to the user equipment via different subframes respectively, a first CSI-RS mapped to a first subset and a second CSI-RS mapped to a second subset among a plurality of physical antenna elements of the base station;

a receiver configured to receive a CSI report using the first CSI-RS and the second CSI-RS; and

a processor configured to control the transmitter and the receiver,

wherein if a number of the at least one CSI-RS configuration for the first direction domain corresponds to one, the first CSI-RS and the second CSI-RS are respectively received from the first subset and the second subset according to virtualization-varying of antenna ports related to the one CSI-RS configuration, the virtualization-varying being performed in accordance with a predetermined period.

* * * * *

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HU et al.

(54) **ANTENNA SWITCHING DEVICES, METHODS, AND SYSTEMS FOR SIMULTANEOUS COMMUNICATION**

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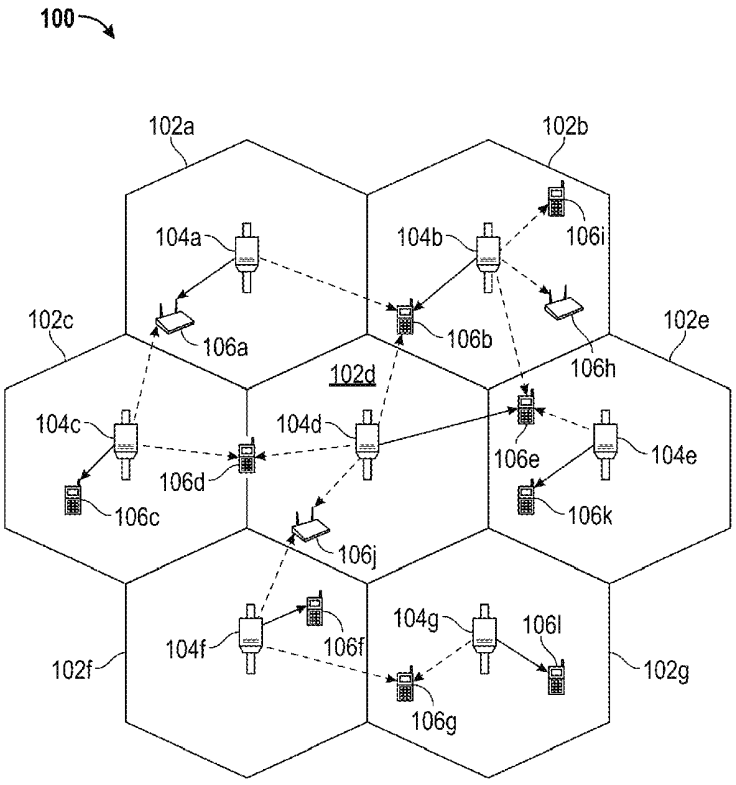
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(52) **U.S. Cl.**
CPC ***H04W 36/30*** (2013.01)
USPC **370/334**

(57) **ABSTRACT**

This disclosure provides systems, methods, and apparatus for antenna switching for simultaneous communication. One apparatus embodiment includes a plurality of antennas including a first antenna, a second antenna, and a third antenna. The wireless communication apparatus further includes a plurality of receive circuits including a first receive circuit, at least two of the plurality of receive circuits each configured to simultaneously receive, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies. The wireless communication apparatus further includes a controller configured to selectively switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on one or more performance characteristics of at least one of the first antenna and the second antenna. Other aspects, embodiments, and features are also claimed and described.



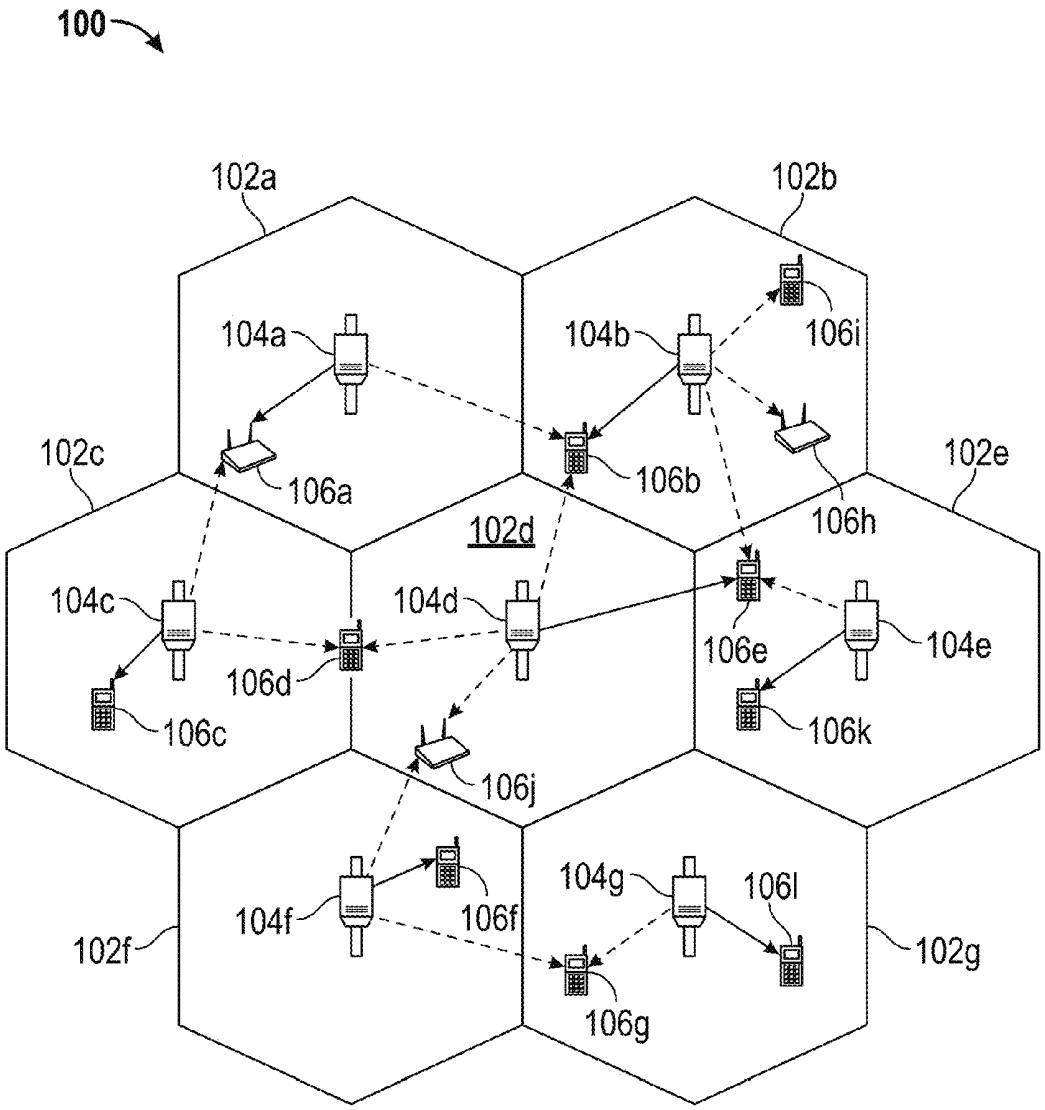

100
102a
102b
104a
104b
106i
102c
106a
106b
102e
106h
102d
104c
104d
106e
104e
106d
106k
106c
106j
104f
106f
104g
106l
102f
102g
106g

FIG. 1

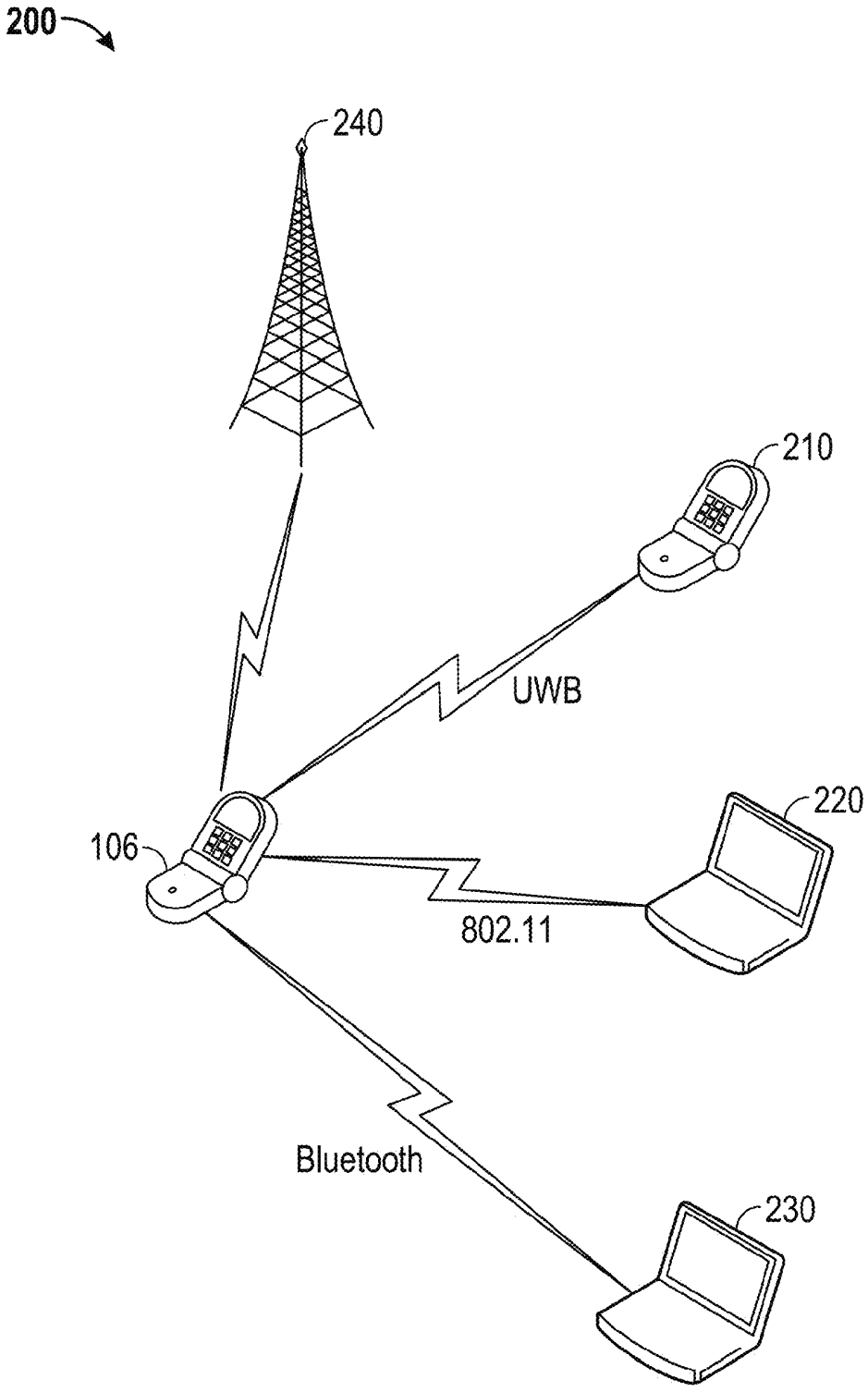


FIG. 2

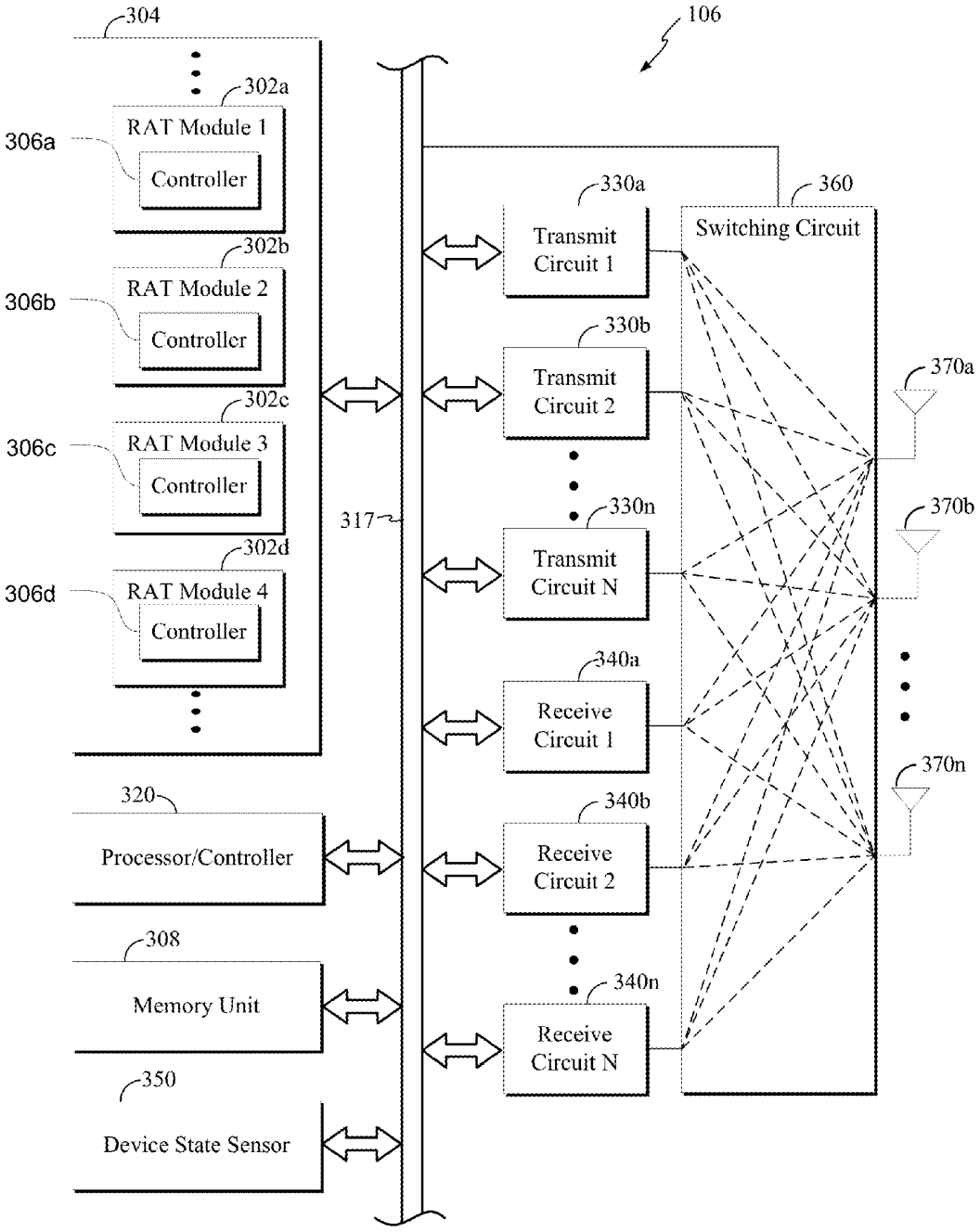

304
106
302a
RAT Module 1
306a
Controller
302b
RAT Module 2
306b
Controller
302c
RAT Module 3
306c
Controller
302d
RAT Module 4
306d
Controller
317
330a
Transmit Circuit 1
330b
Transmit Circuit 2
330n
Transmit Circuit N
340a
Receive Circuit 1
340b
Receive Circuit 2
340n
Receive Circuit N
360
Switching Circuit
370a
370b
370n
320
Processor/Controller
308
Memory Unit
350
Device State Sensor

FIG. 3

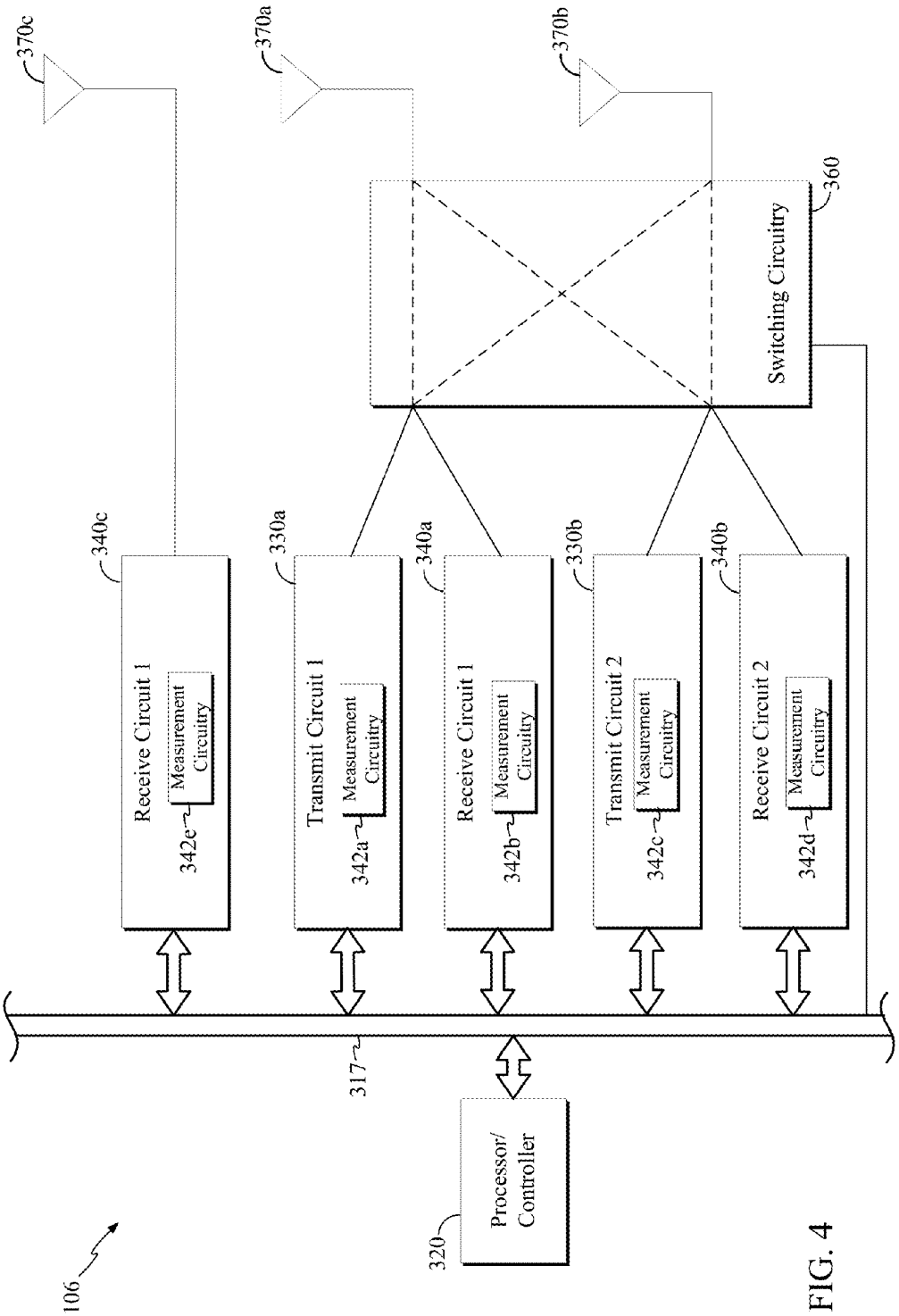

370c
370a
370b
360
Switching Circuitry
340c
330a
340a
330b
340b
Receive Circuit 1
Measurement Circuitry
342e
Transmit Circuit 1
342a
Receive Circuit 1
342b
Transmit Circuit 2
342c
Receive Circuit 2
342d
317
Processor/ Controller
320
106
656

FIG. 4

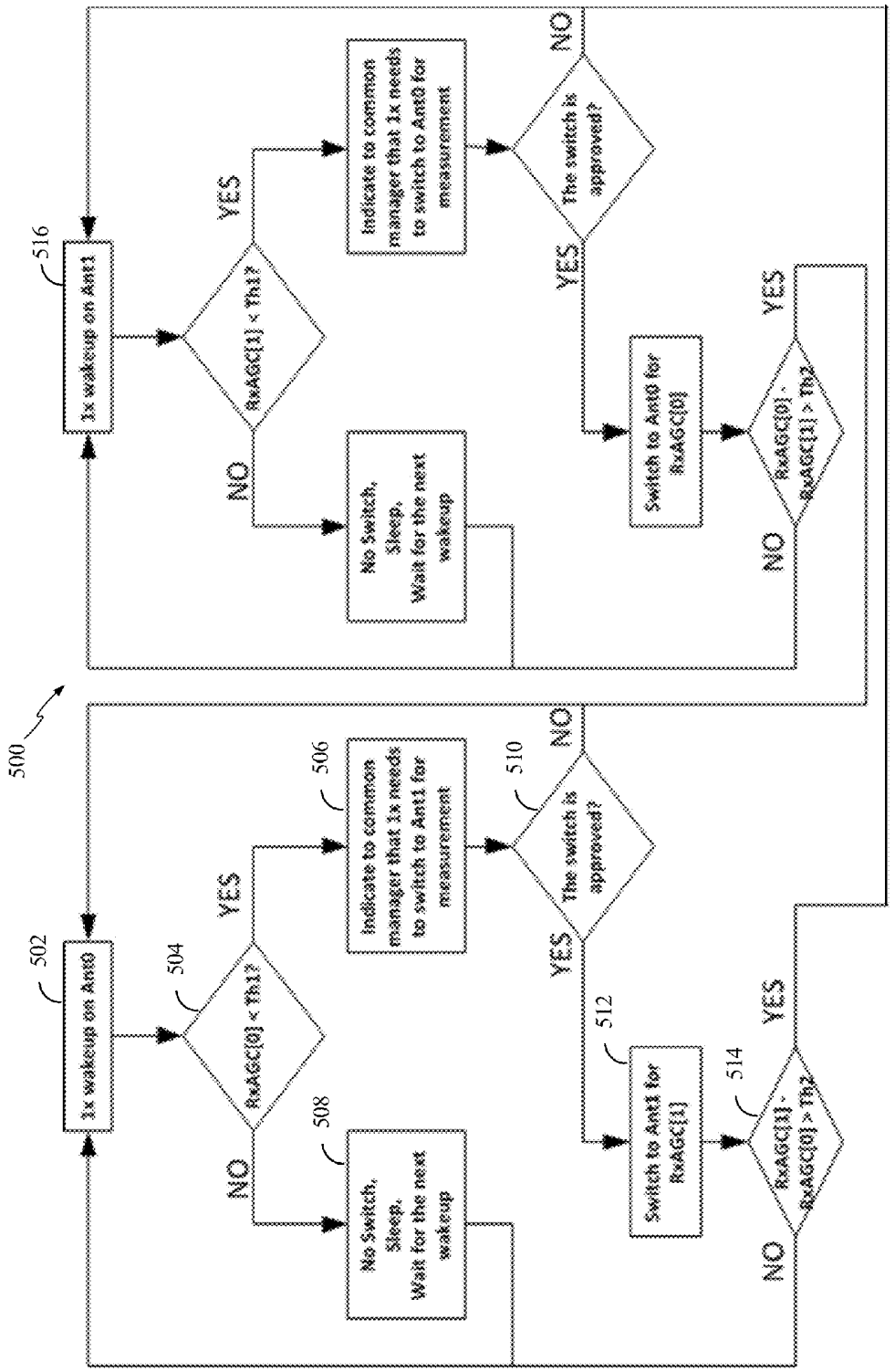

500
502
1x wakeup on Ant0
504
RxAGC[0] < Th1?
YES
NO
506
Indicate to common manager that 1x needs to switch to Ant1 for measurement
508
No Switch, Sleep, Wait for the next wakeup
510
The switch is approved?
YES
NO
512
Switch to Ant1 for RxAGC[1]
514
RxAGC[1] - RxAGC[0] > Th2
YES
NO
516
1x wakeup on Ant1
RxAGC[1] < Th1?
YES
NO
Indicate to common manager that 1x needs to switch to Ant0 for measurement
The switch is approved?
YES
NO
Switch to Ant0 for RxAGC[0]
RxAGC[0] - RxAGC[1] > Th2
YES
NO
No Switch, Sleep, Wait for the next wakeup

FIG. 5

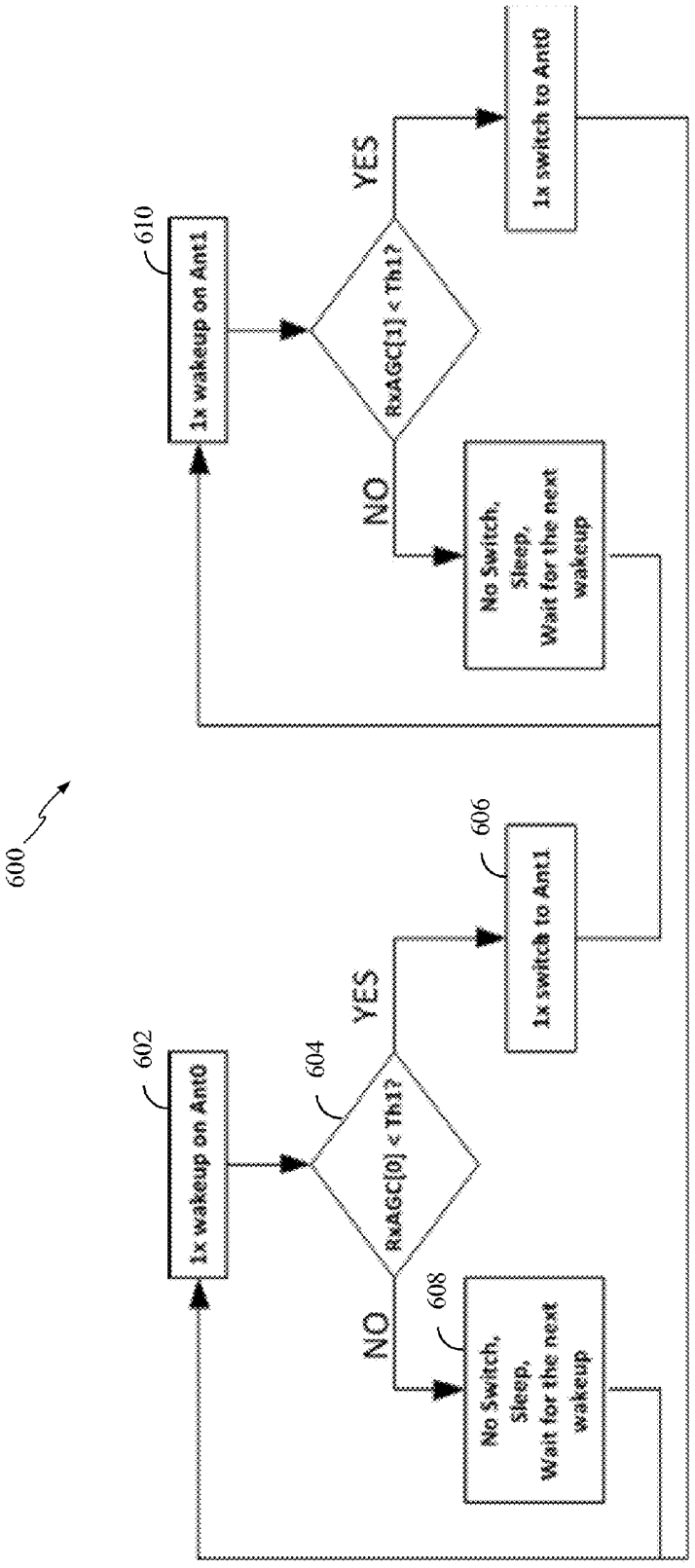

600
602
1x wakeup on Ant0
604
RxAGC[0] < Th1?
YES
NO
606
1x switch to Ant1
608
No Switch, Sleep, Wait for the next wakeup
610
1x wakeup on Ant1
RxAGC[1] < Th1?
YES
1x switch to Ant0
NO
No Switch, Sleep, Wait for the next wakeup

FIG. 6

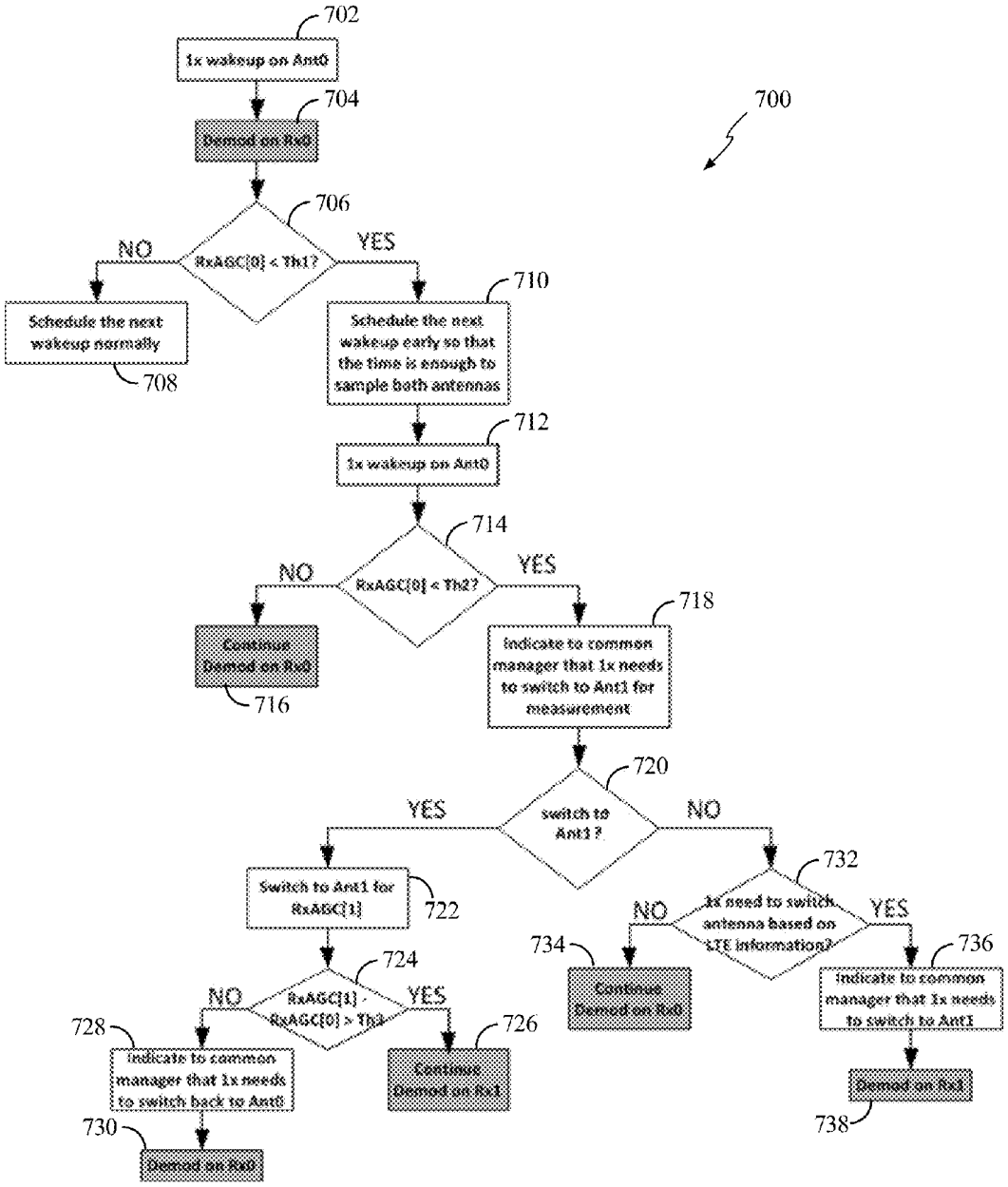

700
702
1x wakeup on Ant0
704
Demod on Rx0
706
RxAGC[0] < Th1?
NO
YES
708
Schedule the next wakeup normally
710
Schedule the next wakeup early so that the time is enough to sample both antennas
712
1x wakeup on Ant0
714
RxAGC[0] < Th2?
NO
YES
716
Continue Demod on Rx0
718
Indicate to common manager that 1x needs to switch to Ant1 for measurement
720
switch to Ant1 ?
YES
NO
722
Switch to Ant1 for RxAGC[1]
724
RxAGC[1] - RxAGC[0] > Th3
NO
YES
726
Continue Demod on Rx1
728
Indicate to common manager that 1x needs to switch back to Ant0
730
Demod on Rx0
732
1x need to switch antenna based on LTE information?
NO
YES
734
Continue Demod on Rx0
736
Indicate to common manager that 1x needs to switch to Ant1
738
Demod on Rx1

FIG. 7

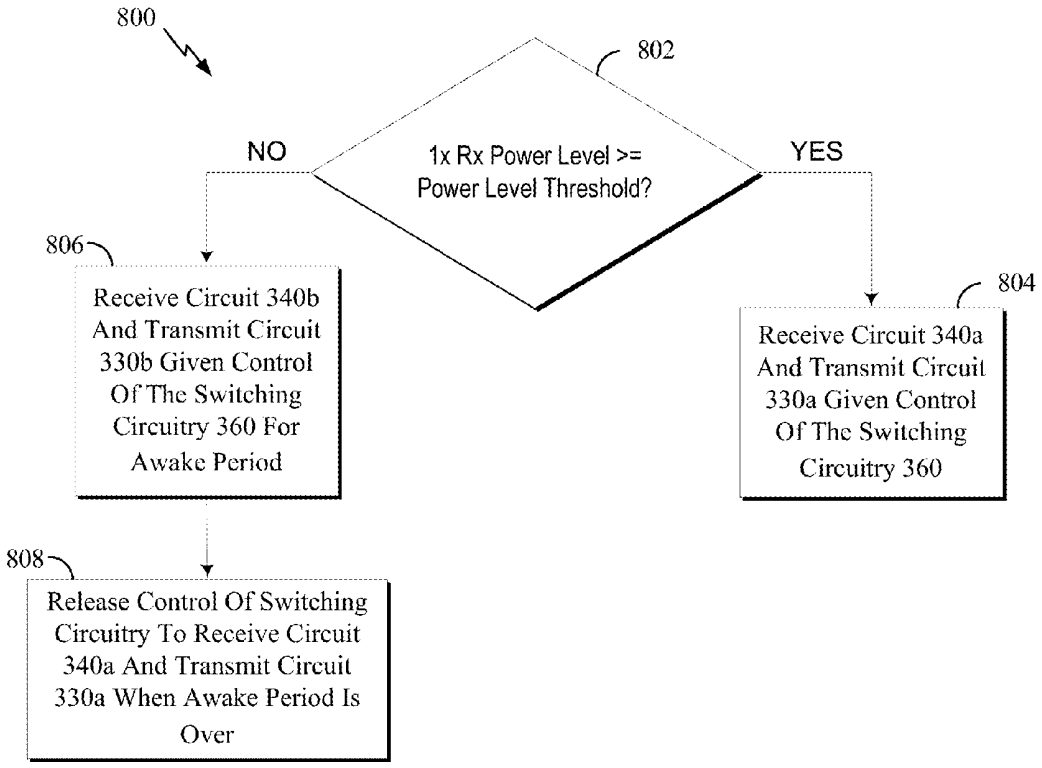

800
802
1x Rx Power Level >= Power Level Threshold?
NO
YES
806
Receive Circuit 340b And Transmit Circuit 330b Given Control Of The Switching Circuitry 360 For Awake Period
804
Receive Circuit 340a And Transmit Circuit 330a Given Control Of The Switching Circuitry 360
808
Release Control Of Switching Circuitry To Receive Circuit 340a And Transmit Circuit 330a When Awake Period Is Over

FIG. 8

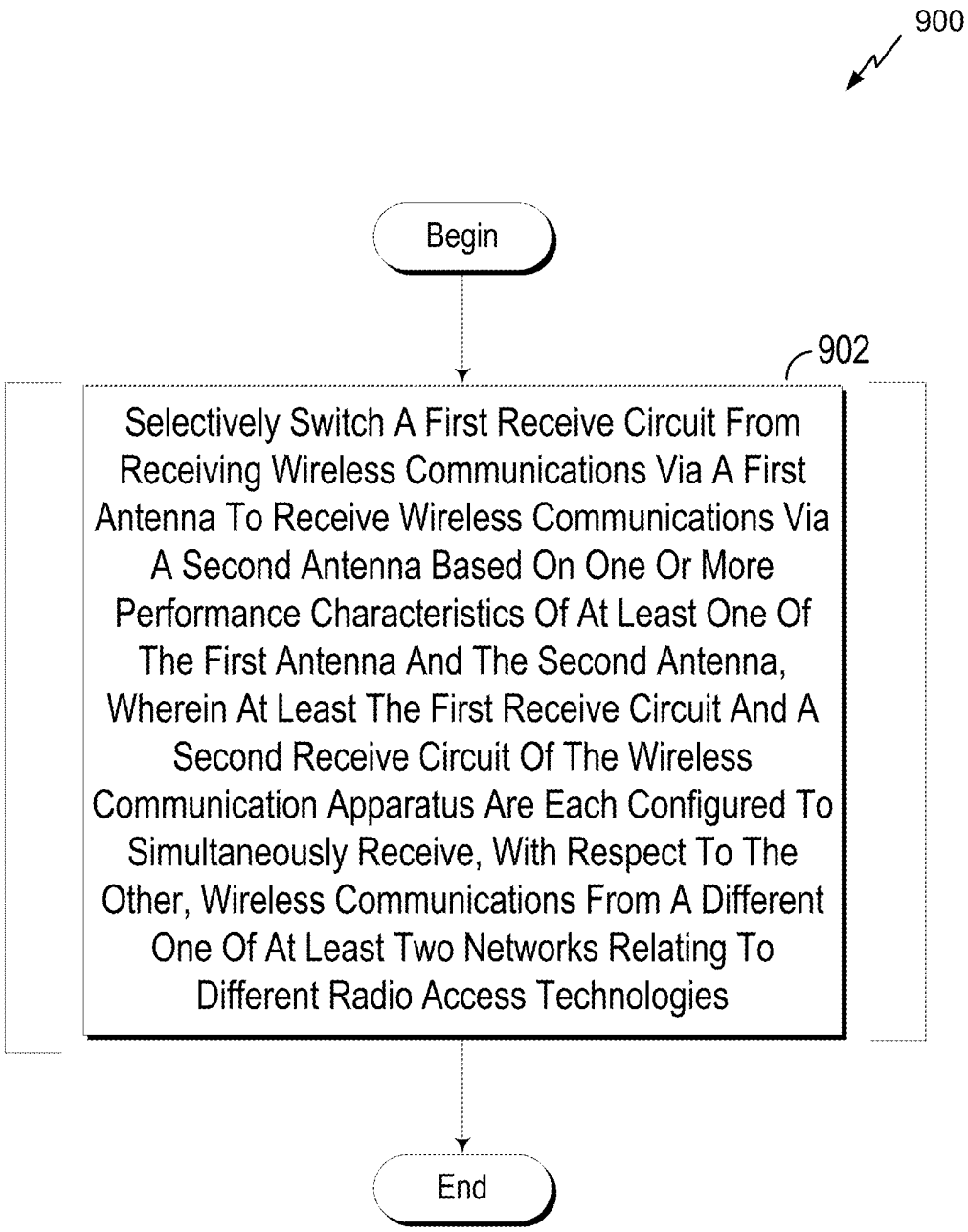

900
Begin
902
Selectively Switch A First Receive Circuit From Receiving Wireless Communications Via A First Antenna To Receive Wireless Communications Via A Second Antenna Based On One Or More Performance Characteristics Of At Least One Of The First Antenna And The Second Antenna, Wherein At Least The First Receive Circuit And A Second Receive Circuit Of The Wireless Communication Apparatus Are Each Configured To Simultaneously Receive, With Respect To The Other, Wireless Communications From A Different One Of At Least Two Networks Relating To Different Radio Access Technologies
End

FIG. 9A

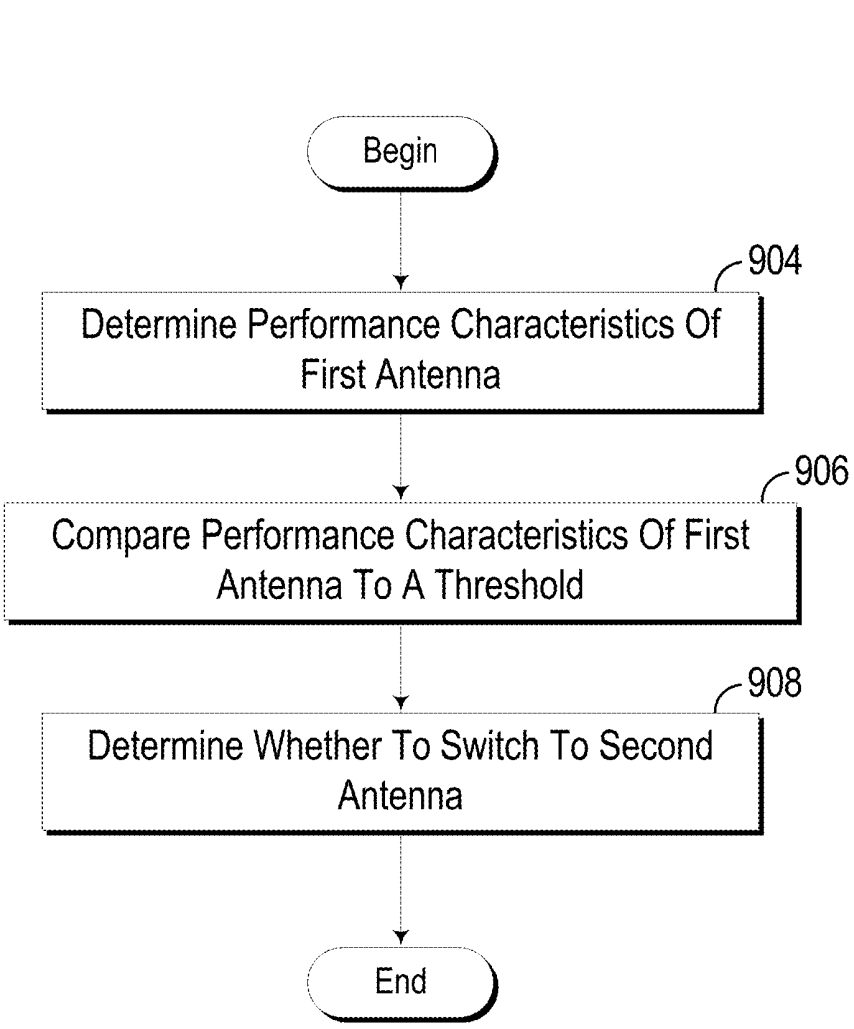

902
Begin
904
Determine Performance Characteristics Of First Antenna
906
Compare Performance Characteristics Of First Antenna To A Threshold
908
Determine Whether To Switch To Second Antenna
End

FIG. 9B

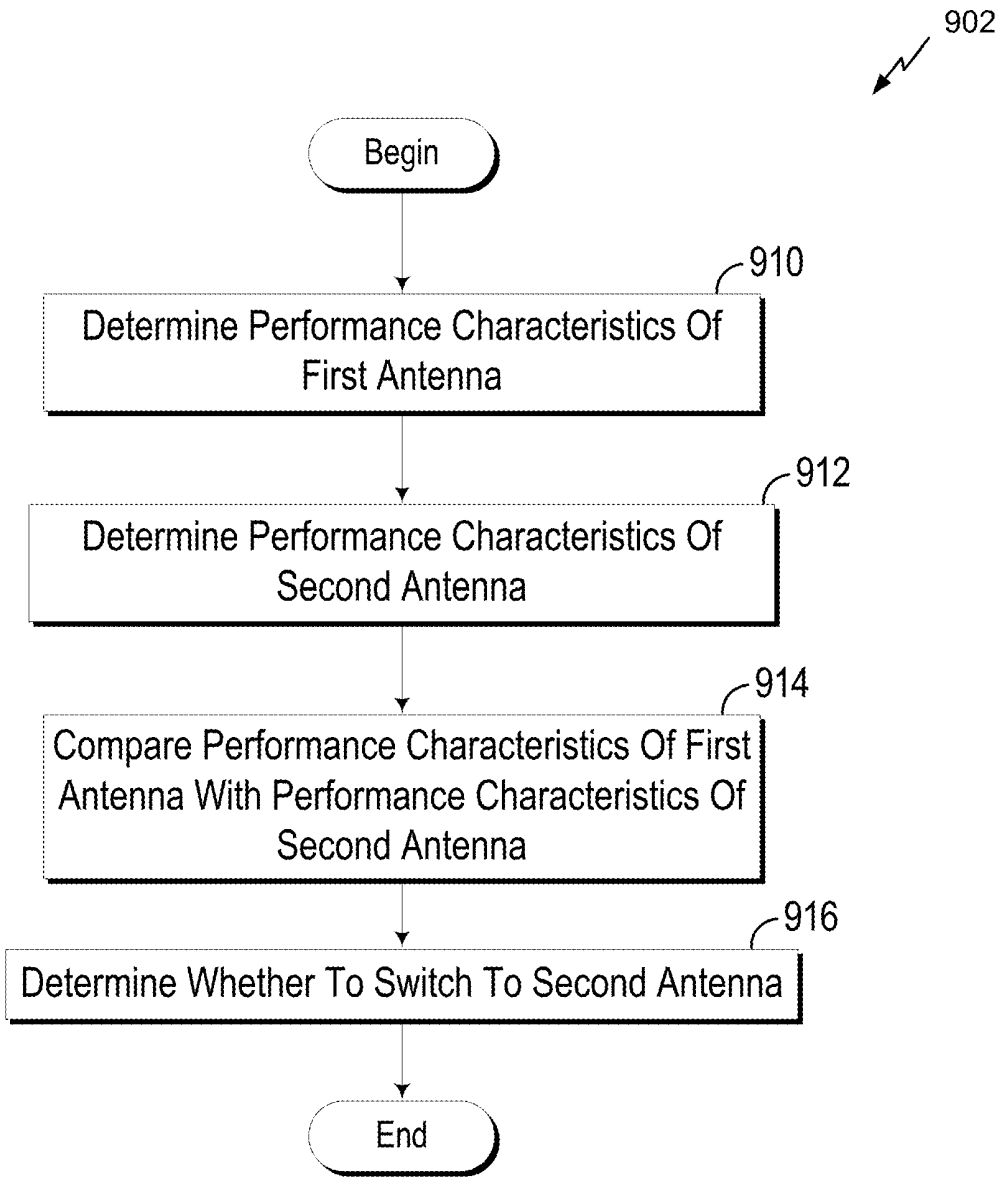

902
Begin
910
Determine Performance Characteristics Of First Antenna
912
Determine Performance Characteristics Of Second Antenna
914
Compare Performance Characteristics Of First Antenna With Performance Characteristics Of Second Antenna
916
Determine Whether To Switch To Second Antenna
End

FIG. 9C

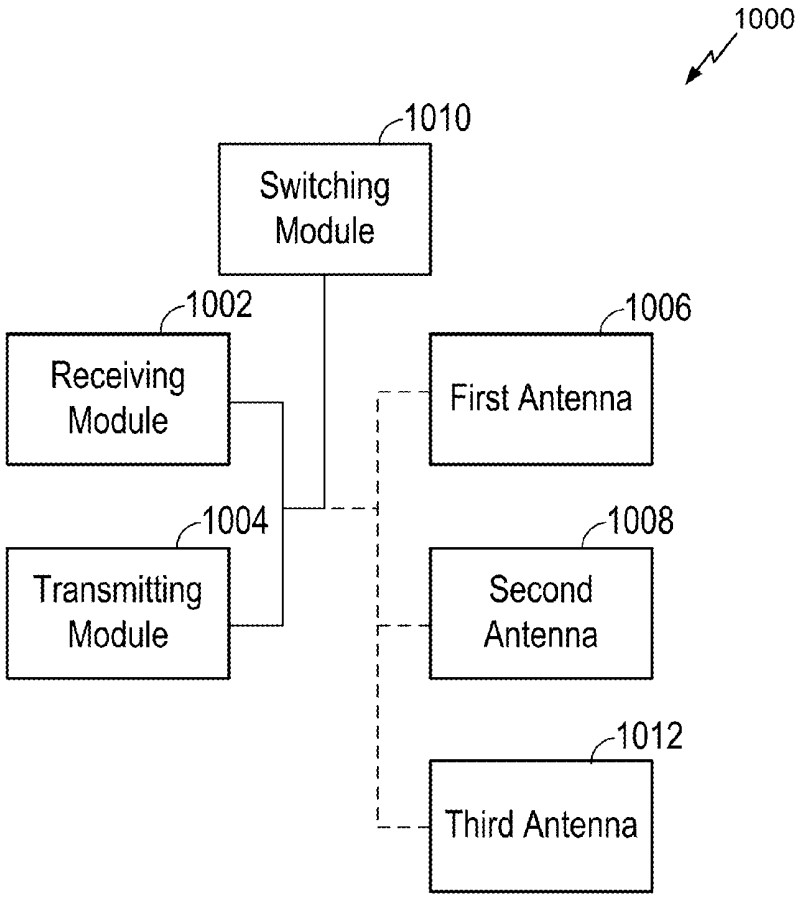

1000
1010
Switching Module
1002
Receiving Module
1006
First Antenna
1004
Transmitting Module
1008
Second Antenna
1012
Third Antenna

FIG. 10

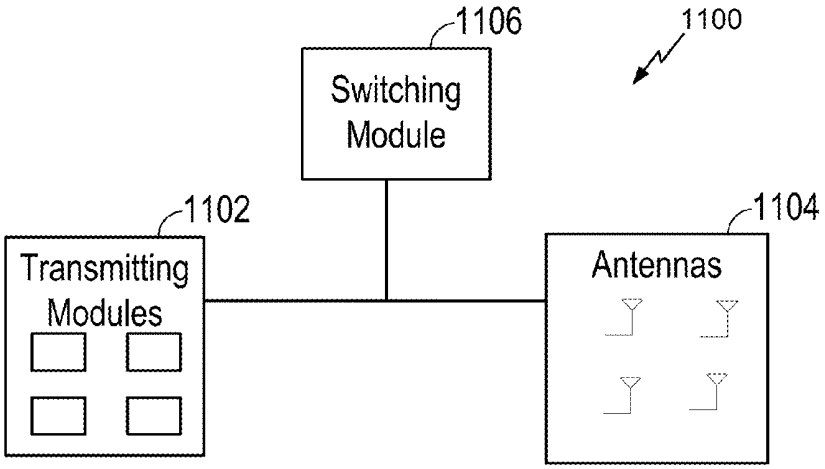

1106
1100
Switching Module
1102
Transmitting Modules
1104
Antennas

FIG. 11

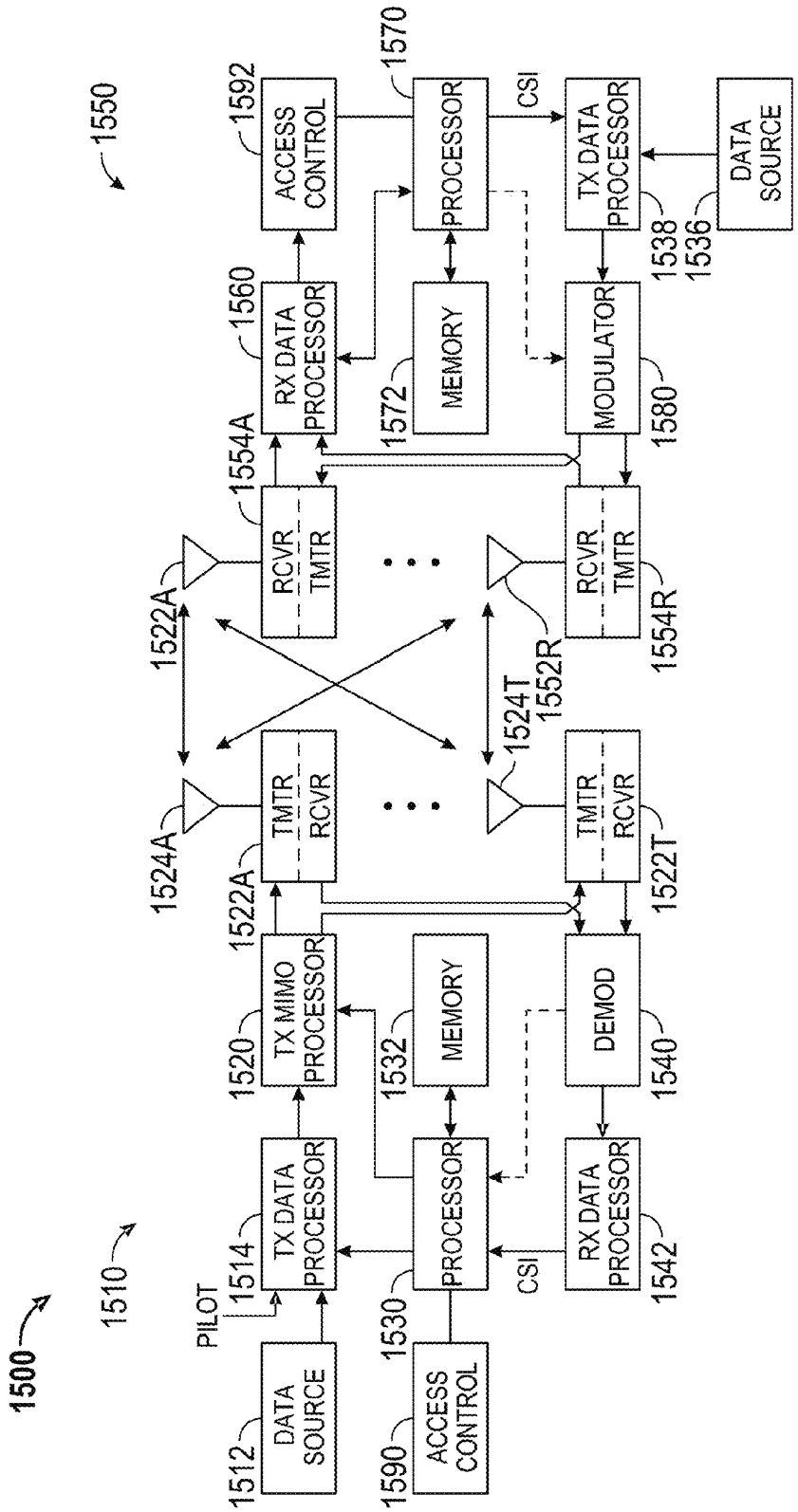

1500
1510
1512
DATA SOURCE
PILOT
1514
TX DATA PROCESSOR
1520
TX MIMO PROCESSOR
1522A
1524A
TMTR
RCVR
1530
ACCESS CONTROL
1532
MEMORY
PROCESSOR
CSI
1540
DEMOD
1542
RX DATA PROCESSOR
1522T
1524T
1552R
1554A
1554R
RCVR
TMTR
1560
RX DATA PROCESSOR
1570
PROCESSOR
1572
MEMORY
1580
MODULATOR
1592
ACCESS CONTROL
1536
DATA SOURCE
1538
TX DATA PROCESSOR
CSI
1550

FIG. 12

665

ANTENNA SWITCHING DEVICES, METHODS, AND SYSTEMS FOR SIMULTANEOUS COMMUNICATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present Application for Patent claims priority to and the benefit of U.S. Provisional Application Nos. (a) 61/649,704, filed 21 May 2012; (b) 61/716,582, filed 21 Oct. 2012; (c) 61/734,276, filed 6 Dec. 2012; (d) **61/737,715**, filed 14 Dec. 2012; (e) 61/716,586, filed 21 Oct. 2012; (f) 61/716,599, filed 21 Oct. 2012; (g) 61/716,902, filed 22 Oct. 2012; and (h) 61/736,541, filed 12 Dec. 2012. All of said applications are assigned to the assignee hereof and are hereby expressly incorporated by reference herein as if fully set forth fully below in their entireties for all applicable purposes.

TECHNICAL FIELD

[0002] The technology discussed below relates generally to wireless communications, and more specifically, to antenna selection for maximizing power transmit and receive levels.

BACKGROUND

[0003] Wireless communication systems are widely deployed to provide various types of communication content such as voice and data. Typical wireless communication systems may be multiple-access systems capable of supporting communication with multiple users by sharing available system resources (e.g., bandwidth, transmit power, and the like). Examples of such multiple-access systems may include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, and the like. Additionally, the systems can conform to specifications such as third generation partnership project (3GPP), 3GPP2, 3GPP long-term evolution (LTE), LTE Advanced (LTE-A), etc.

[0004] Generally, wireless multiple-access communication systems may simultaneously support communication for multiple mobile devices. Each mobile device may communicate with one or more base stations via transmissions on forward and reverse links. The forward link (or downlink) refers to the communication link from base stations to mobile devices, and the reverse link (or uplink) refers to the communication link from mobile devices to base stations.

[0005] Mobile devices may further simultaneously support communication using multiple radio access technologies. Different radio access technologies may be used to expand the scope of services offered by the communications as a mobile device moves through different regions supporting different radio access technologies. Furthermore, different radio access technologies may be used to simultaneously allow a user to engage in a variety of different forms of wireless communication activities.

BRIEF SUMMARY

[0006] The following summarizes some aspects of the present disclosure to provide a basic understanding of the discussed technology. This summary is not an extensive overview of all contemplated features of the disclosure, and is intended neither to identify key or critical elements of all aspects of the disclosure nor to delineate the scope of any or all aspects of the disclosure. Its sole purpose is to present some concepts of one or more aspects of the disclosure in summary form as a prelude to the more detailed description that is presented later.

[0007] Details of one or more embodiments of the subject matter described in this specification are set forth in the accompanying drawings and the description below. Other features, aspects, and advantages will become apparent from the description, the drawings, and the claims. Note that the relative dimensions of the following figures may not be drawn to scale.

[0008] One embodiment of the subject matter described in the disclosure provides a wireless communication apparatus. The wireless communication apparatus includes a plurality of antennas including a first antenna, a second antenna, and a third antenna. The wireless communication apparatus further includes a plurality of receive circuits including a first receive circuit, at least two of the plurality of receive circuits each configured to simultaneously receive, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies. The wireless communication apparatus further includes a controller configured to selectively switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on one or more performance characteristics of at least one of the first antenna and the second antenna.

[0009] Another aspect of the subject matter described in the disclosure provides an implementation of a method implemented in a wireless communication apparatus. The method includes selectively switching a first receive circuit from receiving wireless communications via a first antenna to receive wireless communications via a second antenna based on one or more performance characteristics of at least one of the first antenna and the second antenna, wherein at least the first receive circuit and a second receive circuit of the wireless communication apparatus are each configured to simultaneously receive, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies.

[0010] Yet another aspect of the subject matter described in the disclosure provides a wireless communication apparatus. The wireless communication apparatus includes a plurality of antennas including a first antenna, a second antenna, and a third antenna. The wireless communication apparatus further includes a plurality of receive circuits including a first receive circuit, at least two of the plurality of receive circuits each configured to simultaneously receive, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies. The wireless communication apparatus further includes means for selectively switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on one or more performance characteristics of at least one of the first antenna and the second antenna.

[0011] Another aspect of the subject matter described in the disclosure provides a computer program product. The computer program product includes a computer readable medium. The computer readable medium includes code, when executed by a computer, causes the computer to selectively switch a first receive circuit from receiving wireless communications via a first antenna to receive wireless communications via a second antenna based on one or more performance characteristics of at least one of the first antenna

and the second antenna, wherein at least the first receive circuit and a second receive circuit of the wireless communication apparatus are each configured to simultaneously receive, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies.

[0012] Other aspects, features, and embodiments will become apparent to those of ordinary skill in the art, upon reviewing the following description of specific, exemplary embodiments in conjunction with the accompanying figures. While features may be discussed relative to certain embodiments and figures below, all embodiments can include one or more of the advantageous features discussed herein. In other words, while one or more embodiments may be discussed as having certain advantageous features, one or more of such features may also be used in accordance with the various embodiments of the invention discussed herein. In similar fashion, while exemplary embodiments may be discussed below as device, system, or method embodiments it should be understood that such exemplary embodiments can be implemented in various devices, systems, and methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** shows an example of a simplified diagram of a wireless communication system in accordance with some embodiments.

[0014] FIG. **2** shows an example of a functional block diagram of an exemplary mobile device operating in a wireless communication network in accordance with some embodiments.

[0015] FIG. **3** shows an example of a functional block diagram of an exemplary access terminal shown in FIGS. **1** and **2** in accordance with some embodiments.

[0016] FIG. **4** is a functional block diagram of a portion of the access terminal shown in FIG. **3** in accordance with some embodiments.

[0017] FIG. **5** is a flowchart of an implementation of an exemplary method of determining whether to switch a transmit circuit and/or receive circuit from communicating using a first antenna to using a second antenna in accordance with some embodiments.

[0018] FIG. **6** is a flowchart of an implementation of another exemplary method of determining whether to switch a transmit circuit and/or receive circuit from communicating using a first antenna to using a second antenna in accordance with some embodiments.

[0019] FIG. **7** is a flowchart of an implementation of another exemplary method of determining whether to switch a transmit circuit and/or receive circuit from communicating using a first antenna to using a second antenna in accordance with some embodiments.

[0020] FIG. **8** is a flowchart of an implementation of provides an exemplary method of coordinating control of switching circuitry among various transmit and receive circuits.

[0021] FIG. **9**A is a flowchart of an implementation of an exemplary method implemented by a wireless communication apparatus in accordance with some embodiments.

[0022] FIG. **9**B is a flowchart of an implementation of another exemplary method implemented by a wireless communication apparatus in accordance with some embodiments.

[0023] FIG. **9**C is a flowchart of an implementation of another exemplary method implemented by a wireless communication apparatus in accordance with some embodiments.

[0024] FIG. **10** is a functional block diagram of an exemplary wireless communication apparatus that may be employed within the wireless communication system in accordance with some embodiments.

[0025] FIG. **11** is a functional block diagram of another exemplary wireless communication apparatus that may be employed within the wireless communication system in accordance with some embodiments.

[0026] FIG. **12** shows an example of a functional block diagram of various components in a communication system in accordance with some embodiments.

[0027] In accordance with common practice the various features illustrated in the drawings may not be drawn to scale. Accordingly, the dimensions of the various features may be arbitrarily expanded or reduced for clarity. In addition, some of the drawings may not depict all of the components of a given system, method, or device. Like reference numerals may be used to denote like features throughout the specification and figures.

DETAILED DESCRIPTION

[0028] Various aspects of embodiments within the scope of the appended claims are described below. It should be apparent that the aspects described herein may be implemented in a wide variety of forms and that any specific structure and/or function described herein is merely illustrative. Based on the present disclosure a person/one having ordinary skill in the art should appreciate that an aspect described herein may be implemented independently of any other aspects and that two or more of these aspects may be combined in various ways. For example, an apparatus may be implemented and/or a method may be practiced using any number of the aspects or embodiments set forth herein. In addition, such an apparatus may be implemented and/or such a method may be practiced using other structure and/or functionality in addition to or other than one or more of the aspects or embodiments set forth herein.

[0029] The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. The following description is presented to enable any person skilled in the art to make and use the invention. Details are set forth in the following description for purpose of explanation. It should be appreciated that one of ordinary skill in the art would realize that the invention may be practiced without the use of these specific details. In other instances, well known structures and processes are not elaborated in order not to obscure the description of the invention with unnecessary details. Thus, the present invention is not intended to be limited by the embodiments shown, but is to be accorded with the widest scope consistent with the principles and features disclosed herein.

[0030] The techniques described herein may be used for various wireless communication networks such as Code Division Multiple Access (CDMA) networks, Time Division Multiple Access (TDMA) networks, Frequency Division Multiple Access (FDMA) networks, Orthogonal FDMA (OFDMA) networks, Single-Carrier FDMA (SC-FDMA) networks, and the like. The terms "networks" and "systems"

are often used interchangeably. A CDMA network may implement a radio technology such as Universal Terrestrial Radio Access (UTRA), cdma2000, and the like. UTRA includes Wideband-CDMA (W-CDMA) and Low Chip Rate (LCR). A cdma2000 network may include IS-2000, IS-95, and IS-856 standards. A TDMA network may implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA network may implement a radio technology such as Evolved UTRA (E-UTRA), IEEE 802.11, IEEE 802.16, IEEE 802.20, Flash-OFDM", etc. UTRA, E-UTRA, and GSM are part of Universal Mobile Telecommunication System (UMTS). Long Term Evolution (LTE) is a release of UMTS that uses E-UTRA. UTRA, E-UTRA, GSM, UMTS, and LTE are described in documents from an organization named "3rd Generation Partnership Project" (3GPP). The cdma2000 and EV-DO standards are described in documents from an organization named "3rd Generation Partnership Project 2" (3GPP2). These various radio technologies and standards are known in the art.

[0031] Single carrier frequency division multiple access (SC-FDMA), which utilizes single carrier modulation and frequency domain equalization is one technique used in a wireless communication system. SC-FDMA has similar performance and essentially the same overall complexity as those of OFDMA system. SC-FDMA signal has lower peak-to-average power ratio (PAPR) because of its inherent single carrier structure. SC-FDMA may be useful especially for use in uplink communications where lower PAPR greatly benefits the mobile terminal in terms of transmit power efficiency. For example, SC-FDMA has been adopted as an option for the uplink multiple access method in LTE networks.

[0032] FIG. **1** illustrates an exemplary wireless communication network **100** in accordance with some embodiments. The wireless communication network **100** is configured to support communication between a number of users. The wireless communication network **100** may be divided into one or more cells **102**, such as, for example, cells **102***a*-**102***g*. Communication coverage in cells **102***a*-**102***g* may be provided by one or more nodes **104** (e.g., base stations, access points, and the like), such as, for example, nodes **104***a*-**104***g*. Each node **104** may provide communication coverage to a corresponding cell **102**. The nodes **104** may interact with a plurality of access terminals (ATs), such as, for example, ATs **106***a*-**106***l*. For ease of reference, each of the ATs **106***a*-**106***l* may be referred to hereinafter as an access terminal **106**.

[0033] Each AT **106** may communicate with one or more nodes **104** on a forward link (FL) and/or a reverse link (RL) at a given moment. A FL is a communication link from a node to an AT. A RL is a communication link from an AT to a node. The FL may also be referred to as the downlink. Further, the RL may also be referred to as the uplink. The nodes **104** may be interconnected, for example, by appropriate wired or wireless interfaces and may be able to communicate with each other. Accordingly, each AT **106** may communicate with another AT **106** through one or more nodes **104**.

[0034] The wireless communication network **100** may provide service over a large geographic region. For example, the cells **102***a*-**102***g* may cover only a few blocks within a neighborhood or several square miles in a rural environment. In one embodiment, each cell may be further divided into one or more sectors (not shown).

[0035] As described above, a node **104** may provide an access terminal (AT) **106** access within its coverage area to another communications network, such as, for example the internet or another cellular network.

[0036] An AT **106** may be a wireless communication device (e.g., a mobile phone, router, personal computer, server, etc.) used by a user to send and receive voice or data communications over a communications network. An AT **106** may also be referred to herein as user equipment (UE), mobile station (MS), or a terminal device. As shown, ATs **106***a*, **106***h*, and **106***j* comprise routers. ATs **106***b*-**106***g*, **106***i*, **106***k*, and **106***l* comprise mobile phones. However, each of ATs **106***a*-**106***l* may comprise any suitable communication device.

[0037] An access terminal **106** may be multimode, capable of operating using different radio access technologies (RATs). For example, AT **106** may be capable of operating using one or more RATs defined by standards such as cdma2000 lx, lx-EV-DO, LTE, eHRPD, 802.11, and the like. An AT **106** may perform a plurality of tasks across various communication systems using these different RATs. The communication may be accomplished using a plurality of collocated transmitters and/or receivers, or may be communicated using one single transmitter and/or receiver.

[0038] The techniques described herein may further be used with various modes associated with the different RATs, such as simultaneous voice and data modes that allow simultaneously sending and receiving voice and non-voice data. For example, Simultaneous 1× Voice and EV-DO Data (SVDO) and Simultaneous 1× and LTE (SVLTE) modes may be employed in various embodiments.

[0039] FIG. **2** shows an example of a functional block diagram of an exemplary access terminal (AT) **106** operating in a wireless communication network **200** in accordance with some embodiments. The wireless communication network **200** comprises the AT **106**, a second wireless communications device **210**, a third wireless communications device **220**, a fourth wireless communications device **230**, and a cellular tower **240**. The wireless communication network **200** may be configured to support communication between a multitude of devices, such as the wireless communications devices **106***a*, **210**, **220**, **230**, and tower **240**. The mobile wireless communications devices (e.g., **106***a*, **210**, and **220**) may comprise, for example, personal computers, PDAs, music players, video players, multimedia players, televisions, electronic game systems, digital cameras, video camcorders, watches, remote controls, headsets, and so on. The AT **106** may be simultaneously in communication with each of devices **210**, **220**, **230**, and **240** via one or more transmitters and/or receivers collocated on access terminal **106**.

[0040] With continuing reference to FIG. **2**, the AT **106** may communicate with other wireless communications devices (e.g., **210**, **220**) over a variety of communication channels. The communication channels may comprise Ultra-Wide Band (UWB) channels, Bluetooth channels, 802.11 channels (e.g., 802.11a, 802.11b, 802.11g, 802.11n, etc.), infrared (IR) channels, ZigBee (802.15) channels, or a variety of other channels, as is well known in the art. In one embodiment, the channel may be a UWB channel conforming to the ECMA-368 standard. Other channels would be readily recognized as possible as well.

[0041] The wireless communications network **200** may comprise a wireless local area network (WLAN) covering a physical area, such as a home, office, a group of buildings, or the like. A WLAN may use standards, such as an 802.11 standard and/or other standards, for wireless communications. In some embodiments, a WLAN may use peer-to-peer

communication in which the wireless communication devices directly communicate with each other.

[0042] The wireless communications network **200** may also comprise a wireless personal area network (WPAN), spanning, for example, an area of a few meters. A WPAN may use standards such as infrared, Bluetooth, a WiMedia based UWB standard (e.g., ECMA-368), a ZigBee standard, and/or other standards for wireless communications. A WPAN may use peer-to-peer communication in which the wireless communication devices directly communicate with each other.

[0043] The wireless communications network **200** may also comprise a wide wireless area network (WWAN). The WWAN may use standards such as cdma2000 1×, 1×-EV-DO, LTE, eHRPD and the like. The access terminal **106** may connect to another network, such as a wireless communications network or the Internet, through network **200**. The messages sent across the wireless communications network **200** may comprise information related to various types of communication (e.g., voice, data, multimedia services, and the like) and may be of varied degrees of importance to the user of access terminal **106**, as described in greater detail below.

[0044] Although the following embodiments may refer to FIG. **1** or **2**, one will recognize that they are readily applicable to other communication standards. For example, some embodiments may be applicable in a UMTS communication system. Some embodiments may be applicable in an OFDMA communication system. The communication system **200** may further comprise any type of communication system including, but not limited to, a CDMA system, a GSM system, a wideband code division multiple access (WCDMA), and an OFDM system.

[0045] FIG. **3** shows an example of a functional block diagram of an exemplary access terminal **106** shown in FIGS. **1** and **2** in accordance with some embodiments. The access terminal **106** may be multimode, capable of operating using different radio access technologies (RATs) such as any of the radio technologies mentioned above with reference to FIGS. **1** and **2**. The access terminal **106** is an example of a device that may be configured to implement the various methods described herein. The access terminal **106** may implement any of the devices illustrated in FIGS. **1-2**.

[0046] The access terminal **106** may include a central data bus **317** linking several circuits together. The circuits include a controller/processor **320**, a memory unit **308**, and RAT circuitry **304**, which may include various RAT modules such as modules **302***a*, **302***b*, **302***c*, and **302***d*. The processor/controller **320** may comprise or be a component of a processing system implemented with one or more processors. The processor/controller **320** may be configured as or referred to as an application processor **320** in some embodiments. The one or more processors of the processor/controller **320** may be implemented with any combination of general-purpose microprocessors, microcontrollers, digital signal processors (DSPs), field programmable gate array (FPGAs), programmable logic devices (PLDs), controllers, state machines, gated logic, discrete hardware components, dedicated hardware finite state machines, or any other suitable entities that can perform calculations or other manipulations of information.

[0047] In addition, the processor/controller **320** may be configured to communicate with and control the operation of various modules configured for different RATs. Each of the RAT modules **302***a*, **302***b*, **302***c*, and **302***d* may implement a specific RAT and may each individually include additional memory modules, communication components and functions which are applicable to the RAT type implemented by the module. Each RAT module **302***a*, **302***b*, **302***c*, and **302***d* may further include a controller **306***a*, **306***b*, **306***c*, and **306***d*, each of which may be referred to herein as a modem processor **306***a*, **306***b*, **306***c*, and **306***d* that may be used to control the operation of each RAT. For ease of reference, controllers **306***a*, **306***b*, **306***c*, and **306***d* may hereinafter be referred to as a RAT controller **306**. Furthermore, RAT controllers **306***a*, **306***b*, **306***c*, and **306***d* may be provided independently of each module **302***a*, **302***b*, **302***c*, and **302***d* for controlling the modules. In some embodiments, the processor **320** may be configured to perform the functions of the RAT controller **306**. Furthermore, each RAT module may include its own transceiver(s), including one or more antennas (not shown). The RAT modules may implement any of the RAT types discussed above with reference to FIGS. **1-2**, or any other readily recognizable RAT types.

[0048] The access terminal **106** further comprises one or more transmit circuits **330***a*, **330***b*, and **330***n*. Transmit circuits **330***a*, **330***b*, and **330***n* may also be referred to as transmit chains having one or more components configured to transmit wireless communications signals via antennas **370***a*, **370***b*, and/or **370***n*. For example, transmit circuit **330***a* may include a modulator (not shown), a digital-to-analog (D/A) converter (not shown), an amplifier (not shown), as well as other circuitry for modulating and preparing wireless communications signals for transmission via antennas **370***a*, **370***b*, and/or **370***n*. In some cases, the RAT circuitry **304** may include transmit circuits **330***a*, **330***b*, and **330***n* where each RAT module **302***a*, **302***b*, **302***c*, and **302***d* may include one of the transmit circuits **330***a*, **330***b*, and **330***n*. As such, transmit circuits **330***a*, **330***b*, and **330***n* may be configured to transmit according to one or more radio access technologies associated with one of RAT modules **302***a*, **302***b*, **302***c*, and **302***d*. In some cases, the access terminal **106** may have one transmit circuit **330***a*. In other cases, one or more of transmit circuits **330***a*, **330***b*, and **330***n* may be activated or deactivated. In one aspect, the transmit circuits **330***a* may include components particular to one of the RAT modules **302***a*, **302***b*, **302***c*, and **302***d*. For example, a RAT module **302***a* may implement wireless communications using OFDM, while a second RAT module **302***b* may implement a wireless communications using CDMA. As such, one transmit circuit **330***a* may include components configured for OFDM communications while a second transmit circuit **330***b* may include components configured CDMA communications.

[0049] The access terminal **106** further comprises one or more receive circuits **340***a*, **340***b*, and **340***n*. Receive circuits **340***a*, **340***b*, and **340***n* may also be referred to as receive chains having one or more components configured to receive wireless communications signals via antennas **370***a*, **370***b*, and/or **370***n*. For example, receive circuit **340***a* may include an amplifier (not shown), an analog-to-digital converter (not shown), a demodulator (not shown), as well as other circuitry for receiving and demodulating wireless communications signals received via antennas **370***a*, **370***b*, and/or **370***n*. In some cases, the RAT circuitry **304** may include receive circuits **340***a*, **340***b*, and **340***n* where each RAT module **302***a*, **302***b*, **302***c*, and **302***d* may include one or more of the receive circuits **340***a*, **340***b*, and **340***n*. As such, each of receive circuits **340***a*, **340***b*, and **340***n* may be configured to receive according to a radio access technology associated with one of the RAT modules **302***a*, **302***b*, **302***c*, and **302***d*. In some cases,

the access terminal **106** may have one receive circuit **340***a*. In other cases, one or more of the receive circuits **340***a*, **340***b*, and **340***n* may be activated or deactivated.

[0050] Transmit circuits **330***a*, **330***b*, and **330***n* may process and convert base-band signals to high-frequency (HF) signals to for transmission. Receive circuits **340***a*, **340***b*, and **340***n* in turn may process and buffer received signals before sending the signals to the data bus **317**. Transmit circuits **330***a*, **330***b*, and **330***n* may process and buffer the data from the data bus **317** before transmitting the signals from the access terminal **106**. The processor/controller **320** controls the proper timing of the various components of the access terminal **106**. For example, the processor/controller **320** may allocate time slots for the data sensing and processing for the different frequency bands for transmit circuits **330***a*, **330***b*, and **330***n* and receive circuits **340***a*, **340***b*, and **340***n*.

[0051] Each of transmit circuits **330***a*, **330***b*, and **330***n* and receive circuits **340***a*, **340***b*, and **340***n* may be configured to respectively transmit and receive via one or more of the antennas **370***a*, **370***b*, and **370***n*. Individual transmit circuits **330***a*, **330***b*, and **330***n* and receive circuits **340***a*, **340***b*, and **340***n* may transmit and receive information associated with a different radio access technology via a particular antenna **370***a*, **370***b*, or **370***n*. For example, for simultaneous voice and data modes, one transmit circuit **330***a* may be used for transmitting voice communications via antenna **370***a* while another transmit circuit **330***b* may be used for transmitting non-voice data via antenna **370***b*. Stated another way, a first transmit circuit **330***a* may be used for transmitting and receiving voice communications (e.g., cdma2000 1×, and the like) via antenna **370***a* while a second transmit circuit **330***b* may be used for data only communications (e.g., LTE, EV-DO, and the like) via antenna **370***b*. As a result, at least two of the plurality of receive circuits **340***a*, **340***b* and/or transmit circuits **330***a*, **330***b* may each be configured to simultaneously receive and/or transmit, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies. One of skill in the art will understand that any of the transmit circuits **340***a*, **340***b*, **340***n* and the receive circuits **340***a*, **340***b*, **340***c* may be configured to simultaneously transmit and receive using any suitable radio access technology.

[0052] The processor/controller **320** directs the multiple transmit circuits **330***a*, **330***b*, and **330***n* and receive circuits **340***a*, **340***b*, and **340***n* for detecting and/or processing of signals from the different frequency bands via antennas **370***a*, **370***b*, and **370***n*. Antennas **370***a*, **370***b*, and **370***n* may be placed in different physical locations within the access terminal **106**. For example, antennas **370***a*, **370***b*, and **370***n* may be at opposite (e.g., distal or lateral) ends or corners of the access terminal **106** or adjacent to each other. Generally, antennas **370***a*, **370***b*, and **370***n* can be located at similar or distinct places as desired or in accordance with device design.

[0053] A switching circuit **360** may be provided to allow a processor/controller **320** to select the antennas **370***a*, **370***b*, and **370***n* for which transmit circuits **330***a*, **330***b*, and **330***n* or receive circuits **340***a*, **340***b*, and **340***n* are configured to transmit and receive. The switching circuit **360** may include circuitry configured to switch M inputs corresponding to transmit circuits **330***a*, **330***b*, and **330***n* and receive circuits **340***a*, **340***b*, and **340***n* to N outputs corresponding to antennas **370***a*, **370***b*, and **370***n*. As shown in FIG. **3**, there may be more or less than three transmit circuits **330***a*, **330***b*, and **330***n*, three receive circuits **340***a*, **340***b*, and **340***n*, and three antennas **370***a*, **370***b*, and **370***n*. As one example, the switching circuit **360** may be configured as a crossbar switch or other suitable switching circuitry. The processor/controller **320** may be configured to switch transmit circuits **330***a*, **330***b*, and **330***n* and receive circuits **340***a*, **340***b*, and **340***n* to respectively transmit and receive via any combination of antennas **370***a*, **370***b*, and **370***n*.

[0054] The processor/controller **320** performs the function of data management of the data bus **317** and the function of general data processing, including executing the instructional contents of the memory unit **308**. The memory unit **308** may include a set of modules and/or instructions. Instructions particular to the process steps of the access terminal **106** as shown and described in the embodiments described below can be coded in the various functions included in the contents of the memory unit **308**. In one embodiment, the memory unit **308** is a RAM (Random Access Memory) circuit. Some communication device functions, such as the handoff functions, are software routines, modules, and/or data sets. The memory unit **308** can be tied to another memory circuit (not shown), which may be of the volatile or nonvolatile type. As an alternative, the memory unit **308** can be made of other circuit types, such as an EEPROM (Electrically Erasable Programmable Read Only Memory), an EPROM (Electrical Programmable Read Only Memory), a ROM (Read Only Memory), an ASIC (Application Specific Integrated Circuit), a magnetic disk, an optical disk, and others well known in the art. In addition, the memory unit **308** can be a combination of ASIC and memory circuitry of the volatile type and/or non-volatile type.

[0055] The access terminal **106** may further include a device state sensor **350**. The device state sensor may be configured to detect one or more states or modes of a device according to how the device is being used, handled, and/or positioned. For example, the device state sensor **350** may be configured as a proximity sensor that may be configured to detect a proximity of the user or other object with respect to the access terminal **106**. In one embodiment, the device state sensor **350** includes multiple proximity sensors. Each of the multiple proximity sensors may be placed next to the antennas **370***a*, **370***b*, and **370***n*. Each of the multiple proximity sensors is configured to detect whether an object is in proximity (e.g., blocking) a respective antenna **370***a*, **370***b*, and **370***n*. The device state sensor **350** may further include and/or be configured as an orientation sensor that may be configured to detect the orientation of the access terminal **106** with respect to the user of the access terminal **106**. For example, the orientation sensor may include any suitable sensor, such as an accelerometer, a gyroscope, or the like. The device state sensor **350** may further include and/or be configured as other types of sensors for detecting a temporary condition or state of the access terminal **106**. While shown as one functional block, multiple device state sensors of different types may be included. For example, the access terminal **106** may include both a separate proximity sensor and a separate orientation sensor.

[0056] In this specification and the appended claims, it should be clear that the term "circuitry" is construed as a structural term and not as a functional term. For example, circuitry can be an aggregate of circuit components, such as a multiplicity of integrated circuit components, in the form of processing and/or memory cells, modules, units, blocks, and the like, such as shown and described in FIG. **3**.

[0057] Although described separately, it is to be appreciated that functional blocks described with respect to the access terminal **106** need not be separate structural elements. For example, the processor **320**, the memory unit **308**, and RAT modules **302***a*, **302***b*, **302***c*, and **302***d* may be embodied on a single chip. The processor **320** may additionally, or in the alternative, contain memory, such as processor registers. Similarly, one or more of the functional blocks or portions of the functionality of various blocks may be embodied on a single chip. Alternatively, the functionality of a particular block may be implemented on two or more chips.

[0058] Access terminal **106** performance may be affected by blockage of receive and transmit signals to and from the access terminal **106**. For example, due to an object (e.g., a hand or body) blocking an antenna, device performance may be severely impacted. In some scenarios, the impact may lead to dropped calls or paging failure. Also, blocking may in some instances cause higher transmit power, which may lead to increased interference to the communication network and high power consumption. Accordingly, systems, apparatus, and methods are needed for selection of antennas for signal reception and/or transmission based on various performance characteristics of the antennas. The selection may depend on several factors, which will be described in detail below. Depending on these factors, one or more of the antennas may be selected in a manner to improve signal reception/transmission.

[0059] FIG. **4** is a functional block diagram of a portion of the access terminal **106** shown in FIG. **3** in accordance with some embodiments. In some cases, the access terminal **106** may include three antennas **370***a*, **370***b*, and **370***c*. The access terminal may further include two transmit circuits **330***a*, **330***b*, three receive circuits **340***a*, **340***b*, **340***c*, switching circuitry **360**, and a processor/controller **320**. Antenna **370***c* may be dedicated for communications using only receive circuit **340***c*, while antennas **370***a* and **370***b* may be used by any of the transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b*. In some embodiments, transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b*, **340***c* may each transmit and receive information associated with a particular radio access technology. For example, transmit circuit **330***a* and receive circuits **340***a*, **340***c* may be used for transmitting and receiving data only communications, and transmit circuit **330***b* and receive circuit **340***b* may be used for transmitting and receiving voice communications. Accordingly, antenna **370***c* may be dedicated for receiving data only communications for receive circuit **340***c*, while antennas **370***a* and **370***b* may be used for communicating either data only communications to and from receive circuit **340***a* and transmit circuit **330***a* or voice communications to and from receive circuit **340***b* and transmit circuit **330***b*.

[0060] As described above, the transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b*, **340***c* may simultaneously transmit and receive using the multiple antennas **370***a*, **370***b*, and **370***c*. However, as described above, the performance of one antenna (e.g., antenna **370***b*) may be better than another antenna (e.g., antenna **370***a*) based on any one of a number of factors that may be related to, but not limited to, the arrangements of the antennas on the access terminal **106**, the proximity of external objects to the antennas **370***a*, **370***b*, and **370***c*, or inherent antenna characteristics. Furthermore, during operation, certain transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b*, **340***c* may have different data transmission priorities or transmit power preferences. For example, the preferences may be based on priority levels assigned to different radio access technologies associated with each of the plurality of receive circuits. As an example, higher priority communications may include voice communications and the lower priority communications may include data only communications. In some embodiments, the preferences may be assigned to and/or and adjusted for each of the receive circuits **340***a*, **340***b*, **340***c* and/or transmit circuits **330***a*, **330***b*, **330***c* based on a state of each of the plurality of receive circuits. For example, depending on the state of the transmit or receive circuit (initialization, connected, idle, access or traffic, acquisition, etc.), the priority of the transmit or receive circuits may change.

[0061] The various factors affecting antenna performance may include certain operating conditions that result in one or more of the antennas **370***a*, **370***b*, and **370***c* being de-sensed or otherwise resulting in one or more performance characteristics of the antennas **370***a*, **370***b*, and/or **370***c* being reduced. For example, the hand of a user may be wrapped around the access terminal **106**, effectively blocking one or more of the antennas **370***a*, **370***b*, and **370***c*. As another example, the access terminal **106** may be positioned such that antennas **370***a*, **370***b*, and/or **370***c* may operate with less than ideal receive and/or transmit conditions. These scenarios may reduce power levels of received signals, thus making it more difficult to receive and demodulate signals. These scenarios may also make it difficult to effectively transmit signals. For example, blocking one or more of antennas **370***a*, **370***b* may reduce the total signal strength such that transmit circuits **330***a*, **330***b* may need to increase power levels. However, with respect to increased transmit power levels, an access terminal **106** may be subject to regulatory radio frequency (RF) safety requirements and may be required to operate within specific guidelines before entering the market. For example, devices operating near the human body are evaluated to determine the Specific Absorption Rate ("SAR") their electromagnetic waves produce. SAR is the time-rate of electromagnetic energy absorption per unit of mass in a lossy media, and may be expressed as:

$$SAR(r) = \frac{\sigma(r)}{\rho(r)}|E(r)|^2_{rms} \qquad \text{(Equation 1)}$$

Where E(r) is the exogenous electric field at point r, while $\sigma(r)$ and $\rho(r)$ are the corresponding equivalent electrical conductivity and mass density, respectively. In one aspect, these safety guidelines may limit the amount of allowed transmit power levels. As such, when one or more of the antennas **370***a*, **370***b* are blocked, the maximum transmit power level allowed may be significantly reduced in order to avoid exceeding SAR limits.

[0062] As operation of the access terminal **106** may affect performance of the antennas **370***a*, **370***b*, and/or **370***c*, it may be desirable to have dynamic systems and methods for coupling receive circuits **340***a*, **340***b*, **340***c* and transmit circuits **330***a*, **330***b* to antennas **370***a*, **370***b*, and/or **370***c*, as provided by embodiments described herein. Accordingly, certain aspects of various embodiments described herein are directed to switching transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b* for transmitting and receiving via the different antennas **370***a* and **370***b* to improve performance of the access terminal **106**. For example, it may be desirable for the receive circuit **340***b* receiving the highest priority communi-

cations to receive via the antenna **370***b* having better performance characteristics than antenna **370***a*. In addition, other receive and/or transmit circuit power requirements may result in improved performance if a receive circuit **340***b* and/or transmit circuit **330***b* is coupled to the highest performing antenna **370***b*. In one embodiment, the dynamic switching of the transmit and receive circuits may mitigate hand/body blocking and may allow for selecting antennas in such a way to meet regulatory limits at the least cost to performance and/or to enable good transmit and receive conditions. Furthermore, in one aspect, transmit antenna selection may allow the mitigation of interference and may provide a target quality of service using the least amount of transmit power.

[0063] Referring to FIG. **4**, the processor/controller **320** may be configured to switch the transmit circuit **330***b* and the receive circuit **340***b* to communicate via either the antenna **370***a* or the antenna **370***b*. The receive circuit **340***b* may be associated with the transmit circuit **330***b* in that the receive circuit **340***b* is configured to communicate via the same antenna **370***a* or **370***b* as that used by the transmit circuit **330***b*. As such, the processor/controller **320** may be configured to switch the transmit circuit **330***b* and receive circuit **340***b* to respectively transmit and receive via the antenna **370***a* or the antenna **370***b*. Stated another way, the first receive circuit **340***b* may be configured to be switched alongside the transmit circuit **330***b*. In some embodiments, the transmit circuit **330***b* and the receive circuit **340***b* may be configured to transmit and receive communications having higher priority than communications that are transmitted and received using transmit circuit **330***a* and receive circuit **340***a*. For example, the higher priority communications may include voice communications and the lower priority communications may include data only communications. In addition, the transmit circuit **330***a* and the receive circuit **340***a* may be configured to communicate via either of the antennas **370***a* or **370***b* that is not being used by the transmit circuit **330***b* and the receive circuit **340***b*. Accordingly, the processor/controller **320** may be configured to switch the transmit circuit **330***a* and the receive circuit **340***a* to communicate via the antenna **370***a* and switch the transmit circuit **330***b* and the receive circuit **340***b* to communicate via the antenna **370***b*, which has better performance characteristics than antenna **370***a*. In some embodiments, the switch may occur due to the higher priority of the communications communicated by the transmit circuit **330***b* and the receive circuit **340***b* compared to that communicated by the transmit circuit **330***a* and the receive circuit **340***a*.

[0064] The transmit circuits **330***a*, **330***b* and the receive circuits **340***a*, **340***b*, **340***c* may include measurement circuitry **342***a*-**342***e*, respectively. Measurement circuitry **342***a*-**342***e* may be configured to measure performance characteristic metrics. Performance characteristic metrics may include receive and transmit power levels, automatic gain control (AGC) measurements, signal to interference plus noise ratio (SINR), signal to noise ratio (SNR), and the like. As one example, the measurement circuitry **342***b*, **342***d*, **342***e* may be configured to gather receive AGC measurements. As another example, the measurement circuitry **342***a* and **342***c* may be configured to gather transmit AGC measurements.

[0065] In some embodiments, factors affecting performance characteristics of the antennas **370***a*, **370***b*, and **370***c* may correspond to, for example, the proximity of a user or other object to the access terminal **106**. For example, as described above, the device state sensor **350**, such as a plurality of proximity sensors, may be configured to detect a proximity of the user or other objects with respect to the access terminal **106** (e.g., antennas **370***a* and **370***b*). Based on state information of the device state sensor **350** indicating the proximity of an object relative to the antennas **370***a* and **370***b*, the processor/controller **320** may determine performance characteristics of the antennas. Based on the performance characteristics, the processor/controller **320** may determine whether the current antenna **370***a* or **370***b* being used by each of the transmit circuits **330***a* and **330***b* and/or receive circuits **340***a* and **340***b* is blocked, and whether to switch one or more of the circuits to a non-blocked antenna. For example, for an access terminal **106** in an idle state, the processor/controller **320** may choose a non-blocked antenna for voice wakeup so that, upon wakeup, the access terminal **106** may transmit voice communications using the non-blocked antenna. In some aspects, if the processor/controller **320** determines that all possible antennas are blocked, the processor/controller **320** may choose a default antenna configuration. For example, the default antenna configuration may be the transmit circuit **330***a* and the receive circuit **340***a* transmitting and receiving using antenna **370***a*, and the transmit circuit **330***b* and the receive circuit **340***b* transmitting and receiving using antenna **370***b*. In some embodiments, a default antenna may be pre-selected for each of the transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b* when one of the other transmit and receive circuits is active in order to reduce impact to the transmit and receive circuits.

[0066] In some embodiments, other factors affecting performance characteristics of the antennas **370***a*, **370***b*, and **370***c* may correspond to the detected orientation of the access terminal **106**. For example, the processor/controller **320** may detect whether the access terminal **106** is in a portrait or landscape mode. An accelerometer or gyroscope may be used to detect and indicate the orientation of the access terminal **106**. The processor/controller **320** may determine performance characteristics based on the orientation of the access terminal **106**. For example, if the access terminal **106** in landscape mode, the processor/controller **320** may determine that antenna **370***a* is blocked and may cause the switching circuitry to switch the transmit circuit **330***b* and receive circuit **340***b* to transmit communications using a non-blocked antenna **370***b*. In addition, the top-left location of the display of the access terminal **106** may be used to determine whether a particular antenna **370***a*, **370***b*, or **370***c* is blocked. For example, depending on which way a user rotates the access terminal **106** to place it in portrait or landscape mode, a different physical portion of the access terminal **106** will be in the top-left corner relative to the user. The physical portion that is located in the top-left corner may be used in addition to the portrait or landscape orientation to determine which antenna is likely blocked by the user. In some aspects, a look-up table may be created with the phone orientation and/or top-left location as input in order to choose the best antenna for communication. For example, the processor/controller **320** may refer to the look-up table to determine the proper antenna to choose for a particular transmit and/or receive circuit based on the particular orientation and top-left location of the access terminal **106**. In some aspects, the processor/controller **320** may choose non-blocked antenna **370***b* for voice wakeup based on the orientation of the access terminal **106** and/or the portion of the access terminal that is located in the top-left corner. The non-blocked antenna **370***b* may be chosen for voice wakeup by referring to a look-up table. Upon wakeup, the access terminal **106** may transmit and receive

voice communications via transmit circuit **330***b* and receive circuit **340***b* using the non-blocked antenna **370***b*.

[0067] In some embodiments, the different transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b*, **340***c* of the access terminal **106** may be in different states at different points in time. For example, any of the receive and transmit circuits may be in an initialization state, an idle state, an access state, or a traffic or active state.

[0068] Upon power up, the receive and transmit circuits of the access terminal begin the initialization state. During the initialization state, the circuits may conduct system acquisition (ACQ) and synchronization. The receive and transmit circuits may then enter an idle state. While in the idle state, the access terminal **106** may periodically wake up from a sleep state to receive and monitor pages or other overhead information received over, for example, signaling and control channels. No data is transmitted by the access terminal during the idle state. During the access state, the receive and transmit circuits may attempt to access the system by sending messages or responding to requests from an access point **104**. In the traffic or active state, a communications link is established between the access terminal **106** and the access point **104**, and data is actively transmitted and received by the corresponding transmit circuit and receive circuit.

[0069] In some embodiments, the priority of the transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b* may change depending on the state (e.g., connected, idle, sleep, access, acquisition, and the like) of particular transmit and receive circuit. For example, if transmit circuit **330***b* and receive circuit **340***b* are in a sleep mode, the transmit circuit **330***a* and receive circuit **340***a* may have priority for the use of a particular antenna **370***a*, **370***b* and/or the switching circuitry **360** during the period in which the transmit circuit **330***b* and receive circuit **340***b* are asleep.

[0070] While the transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b* of the access terminal **106** are in the idle state, the processor/controller **320** may determine whether to switch antennas so that the access terminal **106** may use the antenna chosen by the processor/controller **320** upon waking up from the idle state. For example, the processor/controller **320** may choose a non-blocked antenna **370***b* for voice wakeup based upon an analysis of the performance characteristics of the antennas **370***a* and **370***b*. Upon wakeup, the access terminal **106** may receive voice communications using the non-blocked antenna **370***b* and the corresponding voice communications receive circuit **340***b*. In some embodiments, processor/controller **320** may be configured to determine the performance characteristics of the antennas **370***a* and/or **370***b* based on the receive power levels of the antennas **370***a* and/or **370***b* as detected by the receive circuits **340***a* and/or **340***b*. For example, the measurement circuitry **342***b* and **342***d* may be used to detect the receive power levels of antennas **370***a* and/or **370***b*. In one embodiment, the receive power levels may be obtained using receive automatic gain control (AGC) measurements from the receive circuits **340***a* and **340***b*. A determination may be made whether to switch one or more of the transmit circuits **330***a*, **330***b* and/or receive circuits **340***a*, **340***b* from transmitting/receiving via one of the antennas **370***a*, **370***b* to transmitting/receiving via the other one of the antennas **370***a*, **370***b*, based on the receive power levels of the antennas.

[0071] As described above, the transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b*, **340***c* may have different data transmission priorities or transmit power preferences. The preferences may be based on priority levels assigned to different radio access technologies associated with each of the plurality of receive circuits. For example, voice communications may have a higher priority than data only communications. The preferences may be assigned to and/or and adjusted for each of the receive circuits **340***a*, **340***b*, **340***c* and/or transmit circuits **330***a*, **330***b*, **330***c* based on a state of each of the plurality of receive circuits. For example, depending on the state of the transmit or receive circuit (initialization, connected, idle, access or traffic, acquisition, etc.), the priority of the transmit or receive circuits may change. As one example, the receive circuit **340***b* and the transmit circuit **330***b* may be configured to receive and transmit higher priority voice communications and thus may generally be preferred over the receive circuit **340***a* and transmit circuit **330***a*, which are configured to communicate according to a lower priority data only communications. If the receive circuit **340***b* and the transmit circuit **330***b* change to an idle state and the receive circuit **340***a* and transmit circuit **330***a* are in an active state, the data only receive circuit **340***a* and transmit circuit **330***a* may be preferred over the voice receive circuit **340***b* and transmit circuit **330***b*.

[0072] In some embodiments, if the processor/controller **320** determines that performance characteristics of antenna **370***a* (e.g., power level, receive AGC, SINR, SNR, and the like) indicate that antenna **370***a* reception of voice communications are weak, an antenna switching algorithm may be turned on so that the voice receive circuit **340***b* have use of a primary antenna **370***a* and a secondary antenna **370***b*. Accordingly, the transmit circuit **330***b* and receive circuit **340***b* that are configured to transmit and receive voice communications may take control of both antennas **370***a* and **370***b* in order to determine whether to switch from antenna **370***a* to **370***b*.

[0073] In some embodiments, the transmit or receive circuit according to the highest preference level may be granted use of the antenna switching algorithm. For example, the transmit or receive circuit according to the highest preference level may be switched to the second antenna **370***b* that has better performance characteristics. In this example, if the receive circuit **340***a* has a lower preference level than the first receive circuit (e.g., it has a lower priority RAT, it is in an idle state, etc.), the receive circuit **340***a* may be denied a request to switch to the second antenna **370***b* based on the lower preference level.

[0074] In some embodiments, the transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b* may share with each other information relating to the one or more performance characteristic of the antennas **370***a*, **370***b*. As one example, a voice communications receive circuit **340***b* may receive information from data only communications receive circuit **340***a* relating to a performance characteristic of antenna **370***b* as measured by the receive circuit **340***a*. The voice communications receive circuit **340***b* may use the information from the receive circuit **340***a* to determine whether to switch to antenna **370***b*.

[0075] In some embodiments, the antenna switching algorithm may include a fast switch-back mechanism may be used. For example, the processor/controller **320** may execute the antenna switching algorithm to cause the switching circuitry **360** to switch the second antenna **370***b* from the first receive circuit **340***a* to the receive circuit **340***b*. The processor/controller **320** may execute the fast switch-back mechanism of the antenna switching algorithm to cause the switching circuitry **360** to switch the antenna **370***a* back to receive

circuit **340***b* upon determining that performance of first receive circuit **340***b* is lower after the switch to antenna **370***b*.

[0076] In some embodiments, the switching of a transmit or receive circuit from one antenna to a second antenna may be scheduled in advance to avoid adversely affecting the communication of another transmit or receive circuit. For example, receive circuit **340***a* may be receiving critical information (e.g., packets, control information, synchronization information, etc.) via antenna **370***b*. The controller/processor **320** may schedule the switch of the receive circuit **340***b* to antenna **370***b* in advance so that the receive circuit **340***a* can complete reception of the critical information prior to the switch.

[0077] In some embodiments, when a transmit or receive circuit takes control of the switching circuitry **360** or algorithm, the transmit or receive circuit may start with a default antenna configuration or may use an existing antenna configuration. For example, a receive circuit **340***b* may be running the antenna switching algorithm (e.g., because it is active, it has preference or priority, etc.) and may select a particular antenna configuration, such as antenna **370***b* switched to receive circuit **340***b* and antenna **370***a* switched to receive circuit **340***a*. If the receive circuit **340***a* takes control of the antenna switching circuitry **360** or algorithm, it may start with a default antenna configuration (antenna **370***a* switched to receive circuit **340***b* and antenna **370***b* switched to receive circuit **340***a*), or it may continue to use the previous antenna configuration selected by receive circuit **340***b*.

[0078] FIG. **5** illustrates an example of a process **500** for determining whether to switch a transmit circuit and/or receive circuit in an idle state from communicating using a first antenna to using a second antenna. While the discussion below relates to receiving and transmitting voice communications, a person of skill in the art will recognize that the process **700** applies to receiving and transmitting other types of signals, such as data only communications. For example, transmit circuit **330***b* and receive circuit **340***b* may be configured to transmit and receive voice communications, and the processor/controller **320** may determine whether to switch from antenna **370***a* to antenna **370***b* for voice transmission and reception using transmit circuit **330***b* and receive circuit **340***b* upon wakeup of the access terminal **106**.

[0079] At block **502**, the transmit circuit **330***b* and/or receive circuit **340***b* that are configured to communicate according to a voice radio access technology are configured to initially wake up from an idle state and receive using the antenna **370***a*. No transmission takes place during the idle state. Antenna **370***a* may be referred to herein and in FIG. **5** as Ant**0**. At block **504**, the processor/controller **320**, for example, may determine whether a performance characteristic of a signal received using antenna **370***a* is below a threshold performance characteristic level. For example, as described above, performance characteristic metrics may include receive power levels, receive automatic gain control (AGC) measurements, signal to interference plus noise ratio (SINR), signal to noise ratio (SNR), and the like. The performance characteristic of the signal received using antenna **370***a* may be detected using the receive circuit **340***b* that is currently switched to antenna **370***a*. For example, the performance characteristic may include a power level measured using the receive circuit **340***b*. The measurement circuitry **342***d* may be used to detect the performance characteristic of the signal received using antennas **370***a*. The threshold performance characteristic level may be determined based on a level needed to support voice communications. For example, a threshold power level may be determined based on a power level that is sufficient to support voice communications. In this example, the threshold power level may be set to a level required to support reception of a page, such as from an AP.

[0080] At block **508**, if the determined performance characteristic of the signal received using antenna **370***a*, as detected by the receive circuit **340***b*, is not worse than the threshold level, the processor/controller **320** may determine that a switch is not required and may cause the access terminal **106** to remain asleep and wait for the next wakeup period to determine whether the receive performance characteristic level of a next signal using antenna **370***a* is worse than the threshold performance characteristic level.

[0081] At block **506**, if the processor/controller **320** determines that the performance characteristic level of the signal received using antenna **370***a*, as detected by the receive circuit **340***b*, is worse than the threshold performance characteristic level, the processor/controller **320** may consider the antenna **370***a* as being blocked. In response, the processor/controller **320** indicates that the voice communications receive circuit **340***b* needs to switch to antenna **370***b* for measurement of the performance characteristic level of the signal received by antenna **370***b*. Antenna **370***b* may be referred to herein and in FIG. **5** as Ant1.

[0082] At block **510**, a common manager determines whether to approve the switch. In some embodiments, the common manager is implemented using the processor/controller **320**. The common manager may determine whether a switch can occur based on the current configuration and/or operation of the access terminal **106**. For example, if the transmit circuit **330***a* and/or receive circuit **340***a* are performing a critical function using antenna **370***b*, such as currently receiving data via antenna **370***b*, the common manager may not allow the transmit circuit **330***b* and/or receive circuit **340***b* to be switched from antenna **370***a* to antenna **370***b* for measurement. If the switch to antenna **370***b* is not approved, the process returns to block **502** and no switch occurs. Upon approval of the switch to antenna **370***b*, the processor/controller **320** causes the switching circuitry **360** to switch the receive circuit **340***b* and/or transmit circuit **330***b* to antenna **370***b* so that the receive circuit **340***b* can measure the performance characteristic level of the signal received by antenna **370***b* at block **512**. For example, the measurement circuitry **342***d* may be used to detect the power level or interference level of the signal received using antennas **370***b*.

[0083] At block **514**, the processor/controller **320** determines whether the difference between the two performance characteristic levels of antenna **370***a* and **370***b* is greater than a threshold difference. The threshold difference may be provided to ensure switching is not done unnecessarily. For example, it may only be necessary to switch the transmit circuit **330***b* and/or receive circuit **340***b* from antenna **370***a* to antenna **370***b* if the difference between the two performance characteristic levels is large enough. For example, the processor/controller **320** may be configured to switch only if the difference between two power levels of the antennas **370***a* and **370***b* is greater than, for example, 10 dB. In some embodiments, the threshold difference may depend on a variety of factors for an imbalance in receive performance characteristic. The threshold may be a function of various receive or transmit characteristics. For example, as the lower of two receive power levels approaches a receive power floor, the threshold to switch may be decreased (less difference

between the two power levels is required to trigger a switch to the other antenna). In one aspect, the receive power floor may correspond to a thermal noise limit. The threshold difference may be further based on interference levels and thermal levels. A person of skill in the art will recognize that any other threshold difference may be used to determine whether to switch antennas.

[0084] If the difference between the performance characteristic levels is above the threshold difference as determined at block **514**, the processor/controller **320** causes the transmit circuit **330***b* and/or receive circuit **340***b* to remain switched to antenna **370***b* so that the transmit circuit **330***b* and/or receive circuit **340***b* are configured to use antenna **370***b* upon wakeup from the idle state, upon which the process **500** continues to block **516**. On the other hand, if the difference between the performance characteristic levels is not above the threshold difference as determined at block **514**, the processor/controller **320** causes the transmit circuit **330***b* and/or receive circuit **340***b* to switch back to antenna **370***a* so that antenna **370***a* is used upon wakeup from the idle state, and the process **500** returns to block **502**.

[0085] In the event the transmit circuit **330***b* and/or the receive circuit **340***b* remain switched to antenna **370***b*, the process **500** continues to block **516** in order to determine whether to switch from antenna **370***b* to antenna **370***a* in the event the transmit circuit **330***b* and/or receive circuit **340***b* are configured to wake up from an idle state and transmit and/or receive using the antenna **370***b*.

[0086] FIG. **6** illustrates another example of a process **600** for determining whether to switch a transmit circuit and/or receive circuit from using a first antenna for communications to using a second antenna. While the discussion below relates to receiving and transmitting voice communications, a person of skill in the art will recognize that the process **700** applies to receiving and transmitting other types of signals, such as data only communications. For example, upon wakeup of the access terminal **106**, the processor/controller **320** may determine whether to switch transmit circuit **330***b* and receive circuit **340***b* from antenna **370***a* to antenna **370***b* for voice transmission and reception. At block **602**, a transmit circuit **330***b* and/or receive circuit **340***b*, which are configured to communicate according to a voice radio access technology, are configured to initially wake up from an idle state and receive using antenna **370***a*. Antenna **370***a* may be referred to herein and in FIG. **6** as AntO.

[0087] At block **604**, the processor/controller **320** may determine whether a performance characteristic level (e.g., power level, AGC level, SINR, SNR, and the like) of a signal received using antenna **370***a* is below a threshold performance characteristic level. The performance characteristic level of the signal received using antenna **370***a* may be detected using the receive circuit **340***b* that is currently switched to antenna **370***a*. For example, the measurement circuitry **342***d* may be used to detect the performance characteristic level of the signal received using antennas **370***a*. As described above, the threshold performance characteristic level may be determined based on a performance characteristic level that is sufficient to support voice communications. At block **608**, if it is determined that the performance characteristic level of the received signal, as detected by the receive circuit **340***b*, is not worse than the threshold, the processor/controller **320** determines that a switch is not required. The processor/controller **320** instructs the access terminal **106** to remain asleep and wait for the next wakeup period to determine whether the receive performance characteristic level is worse than the threshold performance characteristic level.

[0088] At block **606**, if the processor/controller **320** determines that the performance characteristic level of the received signal using antenna **370***a*, as detected by the receive circuit **340***b*, is worse than the threshold performance characteristic level, the processor/controller **320** may consider the antenna **370***a* as being blocked. As a result, the processor/controller **320** causes the switching circuitry **360** to switch transmit circuit **330***b* and/or receive circuit **340***b* to antenna **370***b*. Upon being switched to antenna **370***b*, the transmit circuit **330***b* and/or receive circuit **340***b* are configured to transmit and/or receive voice communications using antenna **370***b* upon wakeup from the idle state. Antenna **370***b* may be referred to herein and in FIG. **6** as ANTI.

[0089] As illustrated in FIG. **6**, the process may be repeated, starting at block **610**, in order to determine whether to switch from antenna **370***b* to antenna **370***a* in the event the transmit circuit **330***b* and/or receive circuit **340***b* are configured to transmit and/or receive using the antenna **370***b* upon waking up from an idle state.

[0090] FIG. **7** illustrates an example of a process **700** for determining whether to switch a first receive circuit from demodulating received signals using a first antenna to demodulating received signals using a second antenna. While the discussion below relates to demodulation of voice communications using receive circuit **340***b* and the antenna **370***a* or **370***b*, a person of skill in the art will recognize that the process **700** applies to demodulating other types of signals, such as data only communications. At block **702**, the receive circuit **340***b*, which is configured to communicate according to a voice radio access technology, is configured to initially wake up from an idle state and receive using antenna **370***a*. Antenna **370***a* may be referred to herein and in FIG. **7** as Ant**0**. At block **704**, the receive circuit **340***b*, which may be referred to herein an in FIG. **7** as Rx**0**, is configured to demodulate voice communication signals using antenna **370***a*.

[0091] At block **706**, the processor/controller **320**, for example, may determine whether a performance characteristic level (e.g., power level, AGC level, SINR, SNR, and the like) of a signal received using antenna **370***a* is below a first threshold performance characteristic level. The performance characteristic level of the signal received using antenna **370***a* may be detected using the receive circuit **340***b* that is currently switched to antenna **370***a*. For example, the measurement circuitry **342***d* may be used to detect the performance characteristic level of the signal received using antennas **370***a*. The first threshold performance characteristic level may be determined based on a performance characteristic level that is sufficient to support voice communications. At block **708**, if the determined performance characteristic level of the signal received using antenna **370***a*, as detected by the receive circuit **340***b*, is not below the first threshold, the processor/controller **320** may determine that a switch to a different antenna is not required. As a result, the processor/controller **320** may cause the access terminal **106** to remain asleep and may schedule the next wakeup time according to a normal predetermined wakeup schedule.

[0092] At block **710**, if the processor/controller **320** determines that the performance characteristic level of the signal received using antenna **370***a*, as detected by the receive circuit **340***b*, is below the first threshold performance characteristic level, the processor/controller **320** may schedule the next

wakeup time of the access terminal **106** at an earlier time than the next normal wakeup time according to the normal predetermined wakeup schedule. Scheduling the next wakeup time to be earlier than the scheduled wakeup time may help to ensure that the amount of time for which the access terminal **106** is awake is long enough for the access terminal **106** to sample the performance characteristic measurements from both antennas **370***a* and **370***b*.

[0093] At block **712**, receive circuit **340***b* wakes up from an idle state at the earlier wake up time scheduled at block **710**. At block **714**, the processor/controller **320** may determine whether a performance characteristic level of a received signal using antenna **370***a* is below a second threshold performance characteristic level. The receive circuit **340***b*, which continues to be switched to antenna **370***a*, may be used to detect the performance characteristic level of the signal received using antenna **370***a*. In some embodiments, the second threshold performance characteristic level may be determined based on a performance characteristic level that is sufficient to support voice communications, similar to the first threshold performance characteristic level. In some embodiments, the first threshold performance characteristic level is the same as the second threshold performance characteristic level. In some embodiments, the second threshold performance characteristic level may be set at a higher or lower performance characteristic level relative to the first threshold performance characteristic level. For example, the first threshold may be a higher performance characteristic level relative to the second threshold, and may be set to indicate that the performance characteristic level of the received signal is approaching levels that may require an antenna switch from antenna **370***a* to antenna **370***b*. In this example, the second threshold may be lower (e.g., a lower power level) and may be set to indicate that the antenna **370***a* is blocked and a switch to antenna **370***b* is needed. In some embodiments, the performance characteristic may include interference or noise levels (SINR, SNR, and the like), and the second threshold may be higher and set to indicate that the antenna **370***a* is experiencing high levels of interference that require a switch to antenna **370***b*.

[0094] At block **716**, if the determined performance characteristic level of the signal received using antenna **370***a*, as detected by the receive circuit **340***b*, is not below the second threshold, the processor/controller **320** may determine that a switch is not required and may cause the receive circuit **340***b* to continue demodulating the received voice communication signals using antenna **370***a*.

[0095] At block **718**, if the processor/controller **320** determines that the performance characteristic level of the signal received using antenna **370***a*, as detected by the receive circuit **340***b*, is worse than the threshold performance characteristic level, the processor/controller **320** may consider the antenna **370***a* as being blocked. In response, the processor/controller **320** indicates that the voice communications transmit circuit **330***b* and/or receive circuit **340***b* needs to switch to antenna **370***b* for measurement of the performance characteristic level of the signal received by antenna **370***b*. Antenna **370***b* may be referred to herein and in FIG. **5** as Antl. At block **720**, the processor/controller **320** may determine whether to switch to antenna **370***b*. For example, a common manager may be used to determine whether to approve the switch. In some embodiments, the common manager is implemented using the processor/controller **320**. The common manager may determine whether a switch can occur based on the current configuration and/or operation of the access terminal **106**. For example, if the transmit circuit **330***a* and/or receive circuit **340***a* are performing a critical function using antenna **370***b*, such as currently receiving data via antenna **370***b*, the common manager may not allow the transmit circuit **330***b* and/or receive circuit **340***b* to be switched from antenna **370***a* to antenna **370***b* for measurement. In some embodiments, if the switch to antenna **370***b* is not approved, the process may not perform a switch and the receive circuit **340***b* continues to demodulate the received signals using antenna **370***a*.

[0096] In some embodiments, if the switch to antenna **370***b* is not approved or is not needed, the transmit circuit **330***b* and/or receive circuit **340***b* may use information regarding the use of antenna **370***b* as used by the other transmit circuit **330***a* and receive circuit **340***a* using a different radio access technology than that used by transmit circuit **330***b* and receive circuit **304***b*. For example, details regarding data only communications received by receive circuit **340***a* using antenna **370***b* may be analyzed by transmit circuit **330***b* and/or receive circuit **340***b*, in addition to the information collected by the receive circuit **340***b* regarding signals received using antenna **370***a*, to determine whether the transmit circuit **330***b* and/or receive circuit **340***b* will switch to antenna **370***b*. At block **732**, the processor/controller **320** and/or the transmitter **330***b* and receiver **340***b* determines whether the transmitter **330***b* and receiver **340***b* will be switched to antenna **370***b* based on the information received from the transmitter **330***a* and/or receiver **340***a*.

[0097] At block **734**, the processor/controller **320** and/or the transmitter **330***b* and receiver **340***b* determines that a switch is not needed and the receiver **340***b* continues to demodulate received signals using antenna **370***a*. For example, the performance characteristics of antenna **370***b* as used by the transmit circuit **330***a* and/or receive circuit **340***a* may be worse than the performance characteristics of antenna **370***a* as used by the transmit circuit **330***b* and/or receive circuit **340***b*. As a result, a switch of the transmit circuit **330***b* and/or receive circuit **340***b* to antenna **370***b* for demodulation of the received signals is not beneficial for operation of the access terminal **106**. At block **736**, the processor/controller **320** and/or the transmitter **330***b* and receiver **340***b* determines that a switch is needed based on the information regarding antenna **370***b* received from the transmitter **330***a* and/or receiver **340***a*. For example, the processor/controller **320** and/or the transmitter **330***b* and receiver **340***b* may indicate to the switching circuitry **360** and/or the common manager that a switch of the transmitter **330***b* and/or receiver **340***b* from antenna **370***a* is needed to antenna **370***b*. After the switch from antenna **370***a* to **370***b* occurs, the receive circuit **340***b* begins demodulating received signals using antenna **370***b* at block **738**.

[0098] Returning to block **720**, upon approval of the switch to antenna **370***b*, the processor/controller **320** and/or the common manager causes the switching circuitry **360** to switch the receive circuit **340***b* and/or transmit circuit **330***b* to antenna **370***b* so that the receive circuit **340***b* can measure the performance characteristic level of the signal received by antenna **370***b* at block **722**. For example, the measurement circuitry **342***d* may be used to detect a power level or interference level of the signal received using antennas **370***b*.

[0099] At block **724**, the processor/controller **320** determines whether the difference between the two performance characteristic levels of antenna **370***a* and **370***b* is greater than a threshold difference. The threshold difference may be pro-

vided to ensure switching is not done unnecessarily. For example, it may only be necessary to switch the transmit circuit **330***b* and/or receive circuit **340***b* from antenna **370***a* to antenna **370***b* if the difference between the two performance characteristic levels is large enough. In some embodiments, the threshold difference may depend on a variety of factors for an imbalance in receive performance characteristic. The threshold may be a function of various receive or transmit characteristics. For example, as the lower of two receive power levels approaches a receive power floor, the threshold to switch may be decreased (less difference between the two power levels is required to trigger a switch to the other antenna). In one aspect, the receive power floor may correspond to a thermal noise limit. The threshold difference may be further based on interference levels and thermal levels. A person of skill in the art will recognize that any other threshold difference may be used to determine whether to switch antennas.

[0100] At block **726**, if the difference between the performance characteristic levels is above the threshold difference (as determined at block **724**), the processor/controller **320** causes the transmit circuit **330***b* and/or receive circuit **340***b* to remain switched to antenna **370***b* so that the receive circuit **340***b* is configured to use antenna **370***b* for demodulating the received signals. On the other hand, at block **728**, if the difference between the performance characteristic levels is not above the threshold difference (as determined at block **724**), the processor/controller **320** causes the transmit circuit **330***b* and/or receive circuit **340***b* to switch back to antenna **370***a*. For example, the processor/controller **320** and/or the transmitter **330***b* and receiver **340***b* may indicate to the switching circuitry **360** and/or the common manager that the transmitter **330***b* and/or receiver **340***b* needs to be switched back from the antenna **370***b* to the antenna **370***a*. After the switch from antenna **370***b* to **370***a* occurs, the receive circuit **340***b* begins demodulating received signals using antenna **370***a* at block **730**.

[0101] In some embodiments, transmit circuit **330***a* and/or receive circuit **340***a* configured to communicate using a first radio access technology (e.g., voice communications) may be configured to switch antennas based on communications from transmit circuit **330***b* and/or receive circuit **340***b* configured to communicate using a second radio access technology (e.g., data only communications). The transmit circuit **330***a* and/or receive circuit **340***a* may be in an idle state, during which no data is transmitted, while transmit circuit **330***b* and/or receive circuit **340***b* may be in an active state. Because the transmit circuit **330***b* and/or receive circuit **340***b* are in an active state, data is being transmitted and received, resulting in more information being available for determining antenna performance. This additional information may be used to determine the configuration of the switching circuitry **360**. For example, details regarding data only communications using transmit circuit **330***b* and/or receive circuit **340***b* may be used by transmit circuit **330***a* and/or receive circuit **340***a* in addition to the voice communications information determined above with respect to FIGS. **5-7** to determine whether the transmit circuit **330***a* and/or receive circuit **340***a* will switch to another antenna.

[0102] For example, transmit circuit **330***b* and/or receive circuit **340***b*, which are in an active state, may be configured to communicate according to a data only radio access technology and may include a primary radio frequency chain (RF chain) and a secondary RF chain. One or more antennas in the primary or secondary RF chain may also be shared by the transmit circuit **330***a* and/or receive circuit **340***a*, which are in an idle state and are configured to communicate according to the voice communications radio access technology. The processor/controller **320** may detect performance characteristics of a shared antenna based on the communications being transmitted and received via the shared antenna by the active data only communications transmit circuit **330***b* and receive circuit **340***b*. The performance characteristics detected by the processor/controller **320** may be used to determine whether or not the shared antenna is blocked, and thus may be used to determine whether to switch the transmit circuit **330***a* and/or receive circuit **340***a* to a different circuit for when the circuits wake up from the idle state.

[0103] In some embodiments, the performance characteristics of the shared antenna may include a power differential between the primary RF chain and the secondary RF chain. For example, if the power differential between the primary RF chain and the secondary RF chain is large (indicating that the receive or transmit power level of one of the RF chains is higher than the other), it may be determined that the antenna mapped to the RF chain with the lower receive or transmit power level is blocked, or at least has a lower performance level. In some embodiments, the performance characteristics of the shared antenna may include past power level measurements of each of the primary RF chain and secondary RF chain. In some embodiments, the performance characteristics may include automatic gain control (AGC) measurements, signal to interference plus noise ratio (SINR), signal to noise ratio (SNR), and the like. For example, a difference in interference levels between the primary RF chain and the secondary RF chain may be monitored in order to determine whether to switch antennas.

[0104] Based on the detected performance characteristics of the shared antenna, the voice communications transmit circuit **330***b* and/or receive circuit **340***b* may determine (e.g., under the control of the processor/controller **320**) that a switch from the shared antenna to a different antenna is necessary because, for example, the shared antenna is blocked or the performance level is too low. Accordingly, the transmit circuit **330***b* and/or receive circuit **340***b*, upon wakeup, may use the new antenna with better transmission and/or reception performance. In some aspects, the transmit circuit **330***b* and/or receive circuit **340***b* communicating according to a voice communications radio access technology may also be in an active state and may switch antennas so that the circuits can actively transmit and/or receive using the new antenna.

[0105] In some embodiments, one of the pairs of receive circuits and transmit circuits may have control of the switching circuitry **360** based on the performance characteristics (e.g., power level, AGC level, SINR, SNR, and the like) determined at the various antennas **370***a* and **370***b*. FIG. **8** illustrates an example of coordinating control of the switching circuitry **360** among the various transmit and receive circuits. At block **802**, the processor/controller **320** may determine whether the performance characteristic level of a signal received by voice communications receive circuit **340***b* via antenna **370***a* is equal to or above a threshold performance characteristic level. At block **804**, if the performance characteristic level of a received signal is equal to or above a threshold performance characteristic level, the receive circuit **340***a* and transmit circuit **330***a* may be given control of the switching circuitry **360** for controlling which antennas are used by the receive circuit **340***a* and the transmit circuit **330***a*. As a

result, the data only communications receive circuit **340***a* and transmit circuit **330***a* can operate using an antenna switching algorithm by using two of the three available antennas **370***a*, **370***b*, or **370***c*. In this example, if the performance characteristic level of the signal is above the threshold performance characteristic level, the voice communications receive circuit **340***b* and/or transmit circuit **330***b* will wake up from the idle sleep state using the secondary antenna being used by the data only communications receive circuit **340***a* and transmit circuit **330***a*.

[0106] At block **806**, if the performance characteristic level of a signal received using antenna **370***a* and voice communications receive circuit **340***b* is worse than the threshold performance characteristic level, the voice communications receive circuit **340***b* and/or transmit circuit **330***b* may be given control of the switching circuitry **360** for the duration of a hold period. For example, the hold period may be a longer duration than the period for which the receive circuit **340***b* and/or the transmit circuit **330***b* are awake. In this example, the voice communications receive circuit **340***b* and/or transmit circuit **330***b* may wake up from the idle sleep state using the primary antenna being used by the data only communications receive circuit **340***a* and transmit circuit **330***a*. At block **808**, when the hold period is over and the voice communications receive circuit **340***b* and/or transmit circuit **330***b* go back to the idle sleep state, control of the switching circuitry **360** may be released to the data only communications receive circuit **340***a* and transmit circuit **330***a*. When the performance characteristic level of a signal received using antenna **370***a* and voice communications receive circuit **340***b* is worse than the threshold performance characteristic level, the data only communications receive circuit **340***a* and/or transmit circuit **330***a* do not use the antenna switching algorithm and thus do not switch between use of the antennas **370***a* and/or **370***b*. In order to avoid affecting the voice communications idle sleep and awake timeline, when the voice communications receive circuit **340***b* and/or transmit circuit **330***b* determines that a switch to another antenna is needed at a particular wakeup time n+1, the voice communications circuits may make the switch request at the end of the prior wakeup time n, and then may go to sleep until the wakeup time n+1. In some embodiments, when the voice communications receive circuit **340***b* and/or transmit circuit **330***b* release control of the switching circuitry **360**, the voice communications circuits may allow the data only communications receive circuit **340***a* and transmit circuit **330***a* take control for at least one wakeup cycle so that data only communications circuits can operate using the antenna switching algorithm and thus may select the proper antenna **370***a* and/or **370***b*.

[0107] In some embodiments, a first transmitter and/or first receiver in traffic or active state communicating using a first radio access technology may be configured to compare performance characteristics of a first antenna used by the first transmitter and/or first receiver to performance characteristics of a second antenna used by a second transmitter and/or second receiver in an active state communicating using a second radio access technology. For example, a transmit circuit **330***a* and/or receive circuit **340***a* may be in an active state and may be configured to communicate using antenna **370***a* according to a voice communications radio access technology. Further, transmit circuit **330***b* and/or receive circuit **340***b*, **340***c* may be in an active state and may be configured to communicate according to a data only radio access technology using a primary and secondary antenna. The transmit circuit **330***a* and/or receive circuit **340***a* may periodically detect (e.g., using measurement circuitry **342***a* and **342***b* and/or the processor/controller **320**) performance characteristics of antenna **370***b* and/or **370***c* used by the transmit circuit **330***b* and/or receive circuits **340***b*, **340***c*. For example, the antenna **370***b* may be the primary antenna used by the data only communications transmit circuit **330***b* and receive circuit **340***b*, and the voice communications transmit circuit **330***a* and/or receive circuit **340***a* may periodically detect the performance characteristics of the primary antenna **370***b*. The detected performance characteristics of the primary antenna **370***b* may be compared to performance characteristics of the antenna **370***a* in order to determine whether to switch the voice communications transmit circuit **330***a* and/or receive circuit **340***a* to the antenna **370***b*. In some aspects, the performance characteristics may include a power level (e.g., obtained using received AGC), signal to interference plus noise ratio (SINR), signal to noise ratio (SNR), and the like. The performance characteristics of the antennas **370***a* and **370***b* may be compared to a threshold in order to determine whether a switch is necessary. For example, if the difference in receive or transmit power levels between the antenna **370***a* and antenna **370***b* is above a threshold, the processor/controller **320** may instruct the voice communications transmit circuit **330***a* and/or receive circuit **340***a* to switch to the antenna **370***b*. The threshold may be determined to ensure switching is not done unnecessarily. For example, it may only be necessary to switch the first transmitter and/or receiver if the difference between the two power levels is large enough.

[0108] In some embodiments, the voice communications receive circuit **340***a* may be configured to detect (e.g., using measurement circuitry **342***b* and/or the processor/controller **320**) one or more forward link (FL) performance metrics of a forward link channel being received by the antenna **370***a* for which the receive circuit **340***a* is currently switched. In some embodiments, the FL performance metrics may include a setpoint, frame erasures, and the like. If the FL performance metrics indicate that the performance of the antenna **370***a* is below an acceptable performance limit, the receive circuit **340***a* may be switched to a second antenna. For example, if the setpoint is close to a maximum setpoint threshold, or the frame erasure rate is above a maximum frame erasure threshold, the receive circuit **340***a* may request that the processor/controller **320** cause the switching circuitry **360** to switch the receive circuit **340***a* to antenna **370***b*. In some aspects, if the performance of the antenna **370***b* is determined to be below the acceptable performance limit after the switch, the processor/controller **320** may determine that the channel itself is bad. In such aspects, the receiver may or may not be switched back to the antenna **370***a*.

[0109] In some embodiments, if both the voice communications transmit circuit **330***a* and the data only communications transmit circuit **330***b* are actively transmitting while in the traffic or active state, a synchronized transmission blanking scheme may be provided in order for both the transmit circuit **330***a* and the transmit circuit **330***b* to switch antennas. The synchronized transmission blanking scheme allows coordination of the two transmit circuits **330***a* and **330***b* according to the different radio access technologies (e.g., voice and data only communications) to refrain from transmitting signals during the antenna switching.

[0110] In some embodiments, the transmit circuit **330***b* and/or the receive circuit **340***b* configured to communicate

according to a data only radio access technology may be in an idle state. Further, the transmit circuit **330***a* and/or the receive circuit **340***a* configured to communicate according to a voice communications radio access technology may be in an active state. The voice communications transmit circuit **330***a* and/or receive circuit **340***a* may use a primary antenna **340***a* and a secondary antenna **340***b* in order to implement the antenna switching algorithm. For each wakeup period, the data only communications receive circuit **340***b* may connect to the secondary antenna **340***b* and may detect whether an idle measurement of the secondary antenna **340***b* being used by the voice communications receive circuit **340***a* is too weak for receiving a page. If the idle measurement is too weak for page reception, the processor/controller **320** may determine that the secondary antenna **340***b* is blocked. The data only communications transmit circuit **330***b* and/or the receive circuit **340***b* may request a common manager to cause the switching circuitry **360** to switch the circuit **330***b* and/or **340***b* to another antenna that is not blocked. In some embodiments, the common manager is implemented using the processor/controller **320**. The common manager may inform the voice communications transmit circuit **330***a* and/or receive circuit **340***a* that the antenna switching algorithm may not be disabled and that the circuits **330***a* and/or **340***a* must continue to communicate using the primary and secondary antennas.

[0111] As described above, an access state includes the time when the access terminal **106** attempts access over an access channel to a network. When attempting access to the network, the access terminal **106** may transmit one or more access probes to an access point **104**. In some embodiments, the transmit circuit **330***a* and/or the receive circuit **340***a* configured to communicate according to a voice communications radio access technology may be in an access state, while the transmit circuit **330***b* and/or the receive circuit **340***b* configured to communicate according to a data only radio access technology may be in an idle state. In other embodiments, the data only communications transmit circuit **330***b* and/or the receive circuit **340***b* may be in an access state, while the voice communications transmit circuit **330***a* and/or the receive circuit **340***a* may be in an idle state. In either of these embodiments, before transmission of the one or more access probes begins, measurements may be obtained for a currently used antenna and for a subsequently switched-to antenna in order to choose the better antenna for access. For example, if the voice communications transmit circuit **330***a* and/or the receive circuit **340***a* are in an access state and the data only communications transmit circuit **330***b* and/or the receive circuit **340***b* are in an idle state, measurements may be taken from the antenna **370***a* currently being used by voice communications transmit circuit **330***a* and/or the receive circuit **340***a* prior to an access probe being sent. Further, prior to the access probe being sent by the transmit circuit **330***a*, the transmit circuit **330***a* and/or receive circuit **340***a* may switch to and take measurements of antenna **370***b*. In response, the transmit circuit **330***a* and/or receive circuit **340***a* may determine (e.g., under control of the processor/controller **320**) the antenna with the better performance based on the measurements. The measurements may include transmit or receive power measurements, transmit or receive automatic gain control (AGC) measurements, signal to interference plus noise ratio (SINR), signal to noise ratio (SNR), and the like.

[0112] In some embodiments, if a probe sequence fails, either of the transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b* may measure performance of a first antenna being used, and then may switch from the first antenna to a second antenna for performance measurements before the next probe sequence begins. In some embodiments, either of the transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b* may measure performance of a first antenna being used, and then may switch from the first antenna to a second antenna for performance measurements between transmission of each of a plurality of probes that are sent for access to the network. In some embodiments, the transmit and receive circuit that are in the access state may turn on the antenna switching algorithm, and may only switch antennas between each of the probes.

[0113] In some embodiments, if the voice communications transmit circuit **330***a* and receive circuit **340***a* are asleep while in the idle state, and the data only communications transmit circuit **330***b* and receive circuit **340***b* are in the traffic or active state, the data only communications transmit circuit **330***b* and receive circuit **340***b* may operate its own the antenna switching algorithm, and the voice communications transmit circuit **330***a* and receive circuit **340***a* may follow the switching decision data only communications circuitry.

[0114] As described above, transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b* may operate according to a priority scheme. For example, a first transmit circuit **330***a* may have priority over a second transmit circuit **330***b*. The priorities of each transmit circuit **330***a*, **330***b* and/or receive circuits **340***a*, **340***b* may change during operation, for example, depending on the type of data being transmitted and the type of radio access technology for that data. For example, if transmit circuit **330***a* is transmitting voice communications data during a time period in which another transmit circuit **330***b* is transmitting data only (e.g., LTE, EV-DO), the transmit circuit **330***a* may be assigned a higher priority that the other transmit circuit **330***b* during this time interval. During another time interval, the opposite could occur. The transmit circuit **330***a* with the highest priority may be able to transmit using an antenna that will provide the highest performance. The switching configuration or mapping between transmit circuits **330***a*, **330***b* and receive circuits **340***a*, **340***b* with the antennas **370***a* and **370***b* may therefore depend on which transmit circuit or receive circuit has priority.

[0115] It should be appreciated that the principles described above with reference to FIGS. **4-8** may be applied similarly where the number of transmit and receive circuits, as well as antennas, is greater than or less than the number described herein. Accordingly, the processor/controller **320** may be configured to switch multiple transmit circuits **330***a*, **330***b*, and **330***n* based on the performance characteristics of various antennas **370***a*, **370***b*, and **370***n*.

[0116] FIG. **9**A shows a flowchart of an implementation of an exemplary method **900** implemented by a wireless communication apparatus in accordance with some embodiments. The method **900** may be implemented at a wireless communication apparatus implemented as an access terminal **106**, for example. Although the method **900** is described below with respect to elements of the access terminal **106**, those having ordinary skill in the art will appreciate that other components may be used to implement one or more of the blocks described herein.

[0117] At block **902**, a first receive circuit is switched from receiving wireless communications via a first antenna to receiving wireless communications via a second antenna based on one or more performance characteristics of at least one of the first antenna and the second antenna, wherein at least the first receive circuit and a second receive circuit of the

wireless communication apparatus are each configured to simultaneously receive, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies. In one aspect, a processor/controller **320** may control switching circuitry **360** to perform the switching.

[0118] In some embodiments, the method further comprises receiving wireless communications using the first receive circuit according to a first radio access technology and receiving wireless communications using the second receive circuit according to a second radio access technology, and wherein first antenna and the second antenna are configured to be used by both the first receive circuit and the second receive circuit and wherein a third antenna is configured to be used only by the third receive circuit. In some embodiments, the first radio access technology includes data only communications and the second radio access technology includes voice only communications. In some embodiments, the method further comprises sensing proximity of an object relative to each of the first antenna and the second antenna, wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on the sensed proximity of the object. In some embodiments, the selectively switching from receiving wireless communications via a first antenna to receiving wireless communications via a second antenna is based on a proximity of the first antenna to the object as indicated by the sensed proximity.

[0119] In some embodiments, the method further comprises selectively switching from receiving wireless communications via a first antenna to receiving wireless communications via a second antenna based on an orientation of the wireless communication device.

[0120] In some embodiments, the method further comprises selectively switching from receiving wireless communications via a first antenna to receiving wireless communications via a second antenna based on preferences for each of the plurality of receive circuits, the preferences based on priority levels assigned to different radio access technologies associated with each of the first receive circuit and the second receive circuit. In some embodiments, the different radio access technologies associated with each of the first receive circuit and the second receive circuit include voice only communications and data only communications, and wherein voice only communications have a higher priority than data communications.

[0121] In some embodiments, the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on a receive power level of each of the first antenna and second antenna, and the method further comprises switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting a first receive power level of the first antenna is less than a first threshold power level. As described above, other performance characteristic may include automatic gain control (AGC) measurements, signal to interference plus noise ratio (SINR), signal to noise ratio (SNR), and the like. If interference is used as the performance characteristics, the comparison may switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting a first interference level of the first antenna is more than a first threshold interference level.

[0122] In some embodiments, the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on a receive power level of each of the first antenna and second antenna, and the method further comprises switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting: a first receive power level of the first antenna is less than a threshold power level; and a difference between the second receive power level and the first receive power level is greater than a threshold difference. Other performance characteristic may include automatic gain control (AGC) measurements, signal to interference plus noise ratio (SINR), signal to noise ratio (SNR), and the like. If interference is used as the performance characteristics, the comparison may switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting a first interference level of the first antenna is more than a first threshold interference level and the difference between a second interference level and the first interference level is greater than a threshold difference.

[0123] In some embodiments, the method further comprises selectively switching from receiving wireless communications via a first antenna to receiving wireless communications via a second antenna during an idle state of the first receive circuit.

[0124] In some embodiments, the second receive circuit is configured to receive wireless communications via the first antenna and the second antenna, and the method further comprises detecting performance characteristics of the first antenna and the second antenna based on the wireless communications received using the second receive circuit, and selectively switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on the detected performance characteristics. In some embodiments, the performance characteristics include a power differential between the first antenna and the second antenna. Other performance characteristic may include differentials in automatic gain control (AGC) measurements, signal to interference plus noise ratio (SINR), signal to noise ratio (SNR), and the like. In some embodiments, the method further comprises receiving wireless communications using the first receive circuit according to a first radio access technology, receiving wireless communications using the second receive circuit according to a second radio access technology, wherein the first receive circuit is in an idle state and the second receive circuit is in an active state. In some embodiments, the method further comprises receiving wireless communications using the first receive circuit according to a first radio access technology, receiving wireless communications using the second receive circuit according to a second radio access technology, wherein the first receive circuit is in an active state and the second receive circuit is in an active state.

[0125] In some embodiments, the second receive circuit is configured to receive wireless communications via the second antenna, and the method further comprises detecting performance characteristics of the second antenna based on the wireless communications transmitted and received using the second receive circuit, comparing the detected performance characteristics of the second antenna with performance characteristics of the first antenna, and selectively switching the first receive circuit from receiving wireless

communications via the first antenna to receive wireless communications via the second antenna based on the comparison.

[0126] In some embodiments, the one or more performance characteristics of the first antenna and the second antenna include one or more downlink performance metrics. In some embodiments, the one or more downlink performance metrics of the first antenna include at least one of a setpoint and frame erasures.

[0127] FIG. **9**B shows a flowchart of an implementation of an exemplary method **902** detailing block **902** illustrated in FIG. **9**A in brackets. The method **902** may be implemented at a wireless communication apparatus implemented as an access terminal **106**, for example. Although the method **902** is described below with respect to elements of the access terminal **106**, those having ordinary skill in the art will appreciate that other components may be used to implement one or more of the blocks described herein.

[0128] At block **904**, the method **902** begins by determining the performance characteristics of a first antenna. For example, the receive power level of the first antenna may be obtained by measuring the receive automatic gain control (AGC) of the first antenna using the receive circuit **340***a*, **340***b*, or **340***n* that is currently switched to the first antenna. Other performance characteristic that may be measured may include automatic gain control (AGC) measurements, signal to interference plus noise ratio (SINR), signal to noise ratio (SNR), and the like. The measurement circuitry **342***b* and **342***d* may be used to detect the performance characteristic level of the signal received using the first antenna. A person of skill in the art will recognize that the transmit power level, AGC, SINR, or SNR of the first antenna may also be measured using the transmit circuit **330***a*, **330***b*, or **330***n* that is currently switched to the first antenna in order to determine the performance characteristics of the first antenna. As described above, factors affecting the performance characteristics of the first antenna may include the arrangements of various antennas on an access terminal **106**, the proximity of external objects to the antenna, or inherent antenna characteristics. For example, the hand of a user may be wrapped around a portion of an access terminal **106** including the first antenna, effectively blocking the antenna. As another example, the access terminal **106** may be positioned such that the first antenna operates with less than ideal receive and/or transmit conditions.

[0129] At block **906**, the method continues by comparing the performance characteristics of the first antenna to a threshold. For example, the threshold may include a performance characteristic level sufficient to support the particular type of communications being transmitted and/or received, such as voice communications or data only communications. Based on the comparison, the method determines whether to switch to a second antenna at block **908**. For example, the performance characteristics of the first antenna are worse than the threshold (e.g., the receive power level of the antenna is less than a sufficient receive power level to support the communications, the interference level is above an acceptable interference level, etc.), the processor/controller **320** may cause the switching circuitry **360** to switch the receiver and/or transmitter currently operating using the first antenna to operate using a second antenna.

[0130] FIG. **9**C shows a flowchart of an implementation of another exemplary method **902** detailing block **902** illustrated in FIG. **9**A in brackets. The method **902** may be implemented at a wireless communication apparatus implemented as an access terminal **106**, for example. Although the method **902** is described below with respect to elements of the access terminal **106**, those having ordinary skill in the art will appreciate that other components may be used to implement one or more of the blocks described herein.

[0131] At block **910**, the method **902** begins by determining the performance characteristics of a first antenna. For example, the receive power level of the first antenna may be obtained by measuring the receive automatic gain control (AGC) of the antenna using the receive circuit **340***a*, **340***b* that is currently switched to the first antenna. Other performance characteristic that may be measured may include automatic gain control (AGC) measurements, signal to interference plus noise ratio (SINR), signal to noise ratio (SNR), and the like. The measurement circuitry **342***b* and **342***d* may be used to detect the performance characteristic level of the signal received using the first antenna. A person of skill in the art will recognize that the transmit AGC of the first antenna may also be measured using the transmit circuit **330***a*, **330***b* that is currently switched to the first antenna in order to determine the performance characteristics of the first antenna. At block **912**, the method **902** continues by determining the performance characteristics of the second antenna. For example, the receive circuit **340***a*, **340***b* connected to the first antenna may be switched to the second antenna to measure AGC of the second antenna (e.g., using the measurement circuitry **342***b* or **32***d*). A person of skill in the art will recognize that the transmit circuit **330***a*, **330***b* connected to the first antenna may be switched to the second antenna to measure the AGC of the second antenna. As described above, factors affecting the performance characteristics of the first antenna may include the arrangements of various antennas on an access terminal **106**, the proximity of external objects to the antenna, or inherent antenna characteristics.

[0132] At block **914**, the method continues by comparing the performance characteristics of the first antenna to the performance characteristics of the second antenna. For example, the processor/controller **320** of an access terminal **106** including the first and second antennas (e.g., antennas **370***a* and **370***b*) may determine whether the difference between the performance characteristics of the first and second antennas is greater than a threshold difference that may be provided to ensure switching is not done unnecessarily. For example, it may only be necessary to switch the transmit circuit **330***a*, **330***b* and/or receive circuit **340***a*, **340***b* currently connected to the first antenna from the first antenna to the second antenna if the difference between two power levels or interference levels is large enough. A person of skill in the art will recognize that any other threshold difference may be used to determine whether to switch antennas.

[0133] Based on the comparison, the method continues at block **916** by determining whether to switch to the second antenna. For example, if the difference between the performance characteristics of the first antenna and the second antenna are above the threshold difference (e.g., indicating a large difference in performance characteristics between the two antennas), the processor/controller **320** may cause the switching circuitry **360** to switch the receiver and/or transmitter currently operating using the first antenna to operate using a second antenna.

[0134] FIG. **10** is a functional block diagram of an exemplary wireless communication apparatus **1000** that may be employed within the wireless communication system **100** in accordance with some embodiments. Those skilled in the art

will appreciate that a wireless communication device **1000** may have more components, such as any one or more of the components shown in FIGS. **3** and/or **4**. The wireless communication device **1000** shown includes only those components useful for describing some prominent features of certain embodiments. The device **1000** includes a receiving module **1002** and a transmitting module **1004**. In some cases, a means for receiving may include the receiving module **1002**. In some embodiments, the receiving module **1002** may include a plurality of receive circuits including a first receive circuit, at least two of the plurality of receive circuits each configured to simultaneously receive, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies. For example, the plurality of receive circuits may include transmit circuits **340***a*, **340***b*. In some cases, a means for transmitting may include a transmitting module **1004**. In some embodiments, the transmitting module **1004** may include a plurality of transmit circuits, such as transmit circuits **330***a*, **330***b*. The device **1000** further includes a first antenna **1006**, second antenna **1008**, and a third antenna **1012**. The device **1000** further includes a switching module **1010**. The switching module **1010** may be configured to perform one or more of the functions described above with respect to block **902** of FIG. **9**A. For example, the switching module **1010** may be configured to selectively switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on one or more performance characteristics of at least one of the first antenna and the second antenna. In some cases, a means for switching and/or a means for selectively switching may include the switching module **1010**. The switching module **1010** and/or the means for switching may include the processor/controller **320** and/or the switching circuitry **360**.

[0135] Furthermore, the receiving module, the transmitting module, the means for receiving, and/or the means for transmitting may be configured to perform one or more of the functions described above with respect to blocks **904**-**908** of FIG. **9**B and/or blocks **910**-**916** of FIG. **9**C. In some embodiments, the switching module **1010** and/or the means for switching may be configured to perform one or more of the functions described above with respect to block **908** of FIG. **9**B and/or block **916** of FIG. **9**C.

[0136] If implemented in software, the functions, steps, and/or blocks described above may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. The steps of a method or algorithm disclosed herein may be implemented in a processor-executable software module which may reside on a computer-readable medium. Computer-readable media includes both physical computer storage media and communication media, the communication media including any medium that can be enabled to transfer a computer program from one place to another. A storage media may be any available media that may be accessed by a computer. By way of example, and not limitation, such computer-readable media may include RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that may be used to store desired program code in the form of instructions or data structures and that may be accessed by a computer. Also, any connection can be properly termed a computer-readable medium. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk, and blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media. Additionally, the operations of a method or algorithm may reside as one or any combination or set of codes and instructions on a machine readable medium and computer-readable medium, which may be incorporated into a computer program product.

[0137] Furthermore, as indicated by the systems and methods described above, the teachings herein may be incorporated into a device employing various components for communicating with at least one other device. FIG. **12** depicts several sample components that may be employed to facilitate communication between devices in accordance with some embodiments. Specifically, FIG. **12** is a simplified block diagram of a first wireless device **1510** (e.g., an access point) and a second wireless device **1550** (e.g., an access terminal) of a multiple-in-multiple-out (MIMO) system **1500**. At the first device **1510**, traffic data for a number of data streams is provided from a data source **1512** to a transmit (TX) data processor **1514**.

[0138] In some aspects, each data stream is transmitted over a respective transmit antenna. The TX data processor **1514** formats, codes, and interleaves the traffic data for each data stream based on a particular coding scheme selected for that data stream to provide coded data.

[0139] The coded data for each data stream may be multiplexed with pilot data using OFDM techniques. The pilot data is typically a known data pattern that is processed in a known manner and may be used at the receiver system to estimate the channel response. The multiplexed pilot and coded data for each data stream is then modulated (i.e., symbol mapped) based on a particular modulation scheme (e.g., BPSK, QSPK, M-PSK, or M-QAM) selected for that data stream to provide modulation symbols. The data rate, coding, and modulation for each data stream may be determined by instructions performed by a processor **1530**. A data memory **1532** may store program code, data, and other information used by the processor **1530** or other components of the device **1510**.

[0140] The modulation symbols for all data streams are then provided to a TX MIMO processor **1520**, which may further process the modulation symbols (e.g., for OFDM). The TX MIMO processor **1520** then provides N_T modulation symbol streams to N_T transceivers (XCVR) **1522**A through **1522**T. In some aspects, the TX MIMO processor **1520** applies beam-forming weights to the symbols of the data streams and to the antenna from which the symbol is being transmitted.

[0141] Each transceiver **1522** receives and processes a respective symbol stream to provide one or more analog signals, and further conditions (e.g., amplifies, filters, and up converts) the analog signals to provide a modulated signal suitable for transmission over the MIMO channel. N_T modulated signals from transceivers **1522**A through **1522**T are then transmitted from N_T antennas **1524**A through **1524**T, respectively.

[0142] At the second device **1550**, the transmitted modulated signals are received by N_R antennas **1552**A through **1552**R and the received signal from each antenna **1552** is provided to a respective transceiver (XCVR) **1554**A through **1554**R. Each transceiver **1554** conditions (e.g., filters, amplifies, and down converts) a respective received signal, digitizes

the conditioned signal to provide samples, and further processes the samples to provide a corresponding "received" symbol stream.

[0143] A receive (RX) data processor **1560** then receives and processes the N_R received symbol streams from N_R transceivers **1554** based on a particular receiver processing technique to provide N_T "detected" symbol streams. The RX data processor **1560** then demodulates, deinterleaves, and decodes each detected symbol stream to recover the traffic data for the data stream. The processing by the RX data processor **1560** is complementary to that performed by the TX MIMO processor **1520** and the TX data processor **1514** at the device **1510**.

[0144] A processor **1570** periodically determines which pre-coding matrix to use (discussed below). The processor **1570** formulates a reverse link message comprising a matrix index portion and a rank value portion. A data memory **1572** may store program code, data, and other information used by the processor **1570** or other components of the second device **1550**.

[0145] The reverse link message may comprise various types of information regarding the communication link and/or the received data stream. The reverse link message is then processed by a TX data processor **1538**, which also receives traffic data for a number of data streams from a data source **1536**, modulated by a modulator **1580**, conditioned by the transceivers **1554**A through **1554**R, and transmitted back to the device **1510**.

[0146] At the device **1510**, the modulated signals from the second device **1550** are received by the antennas **1524**, conditioned by the transceivers **1522**, demodulated by a demodulator (DEMOD) **1540**, and processed by a RX data processor **1542** to extract the reverse link message transmitted by the second device **1550**. The processor **1530** then determines which pre-coding matrix to use for determining the beamforming weights then processes the extracted message.

[0147] FIG. **12** also illustrates that the communication components may include one or more components that perform access control operations as taught herein. For example, an access control component **1590** may cooperate with the processor **1530** and/or other components of the device **1510** to send/receive signals to/from another device (e.g., device **1550**) as taught herein. Similarly, an access control component **1592** may cooperate with the processor **1570** and/or other components of the device **1550** to send/receive signals to/from another device (e.g., device **1510**). It should be appreciated that for each device **1510** and **1550** the functionality of two or more of the described components may be provided by a single component. For example, a single processing component may provide the functionality of the access control component **1590** and the processor **1530** and a single processing component may provide the functionality of the access control component **1592** and the processor **1570**. Furthermore, the components of the apparatus **1500** described with reference to FIG. **3** may be incorporated with/into the components of FIG. **12**.

[0148] It should be understood that any reference to an element herein using a designation such as "first," "second," and so forth does not generally limit the quantity or order of those elements. Rather, these designations may be used herein as a convenient method of distinguishing between two or more elements or instances of an element. Thus, a reference to first and second elements does not mean that only two elements may be employed there or that the first element must precede the second element in some manner. Also, unless stated otherwise a set of elements may include one or more elements.

[0149] A person/one having ordinary skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0150] A person/one having ordinary skill in the art would further appreciate that any of the various illustrative logical blocks, modules, processors, means, circuits, and algorithm steps described in connection with the aspects disclosed herein may be implemented as electronic hardware (e.g., a digital implementation, an analog implementation, or a combination of the two, which may be designed using source coding or some other technique), various forms of program or design code incorporating instructions (which may be referred to herein, for convenience, as "software" or a "software module), or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

[0151] The various illustrative logical blocks, modules, and circuits described in connection with the aspects disclosed herein and in connection with FIGS. **1-15** may be implemented within or performed by an integrated circuit (IC), an access terminal, or an access point. The IC may include a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, electrical components, optical components, mechanical components, or any combination thereof designed to perform the functions described herein, and may execute codes or instructions that reside within the IC, outside of the IC, or both. The logical blocks, modules, and circuits may include antennas and/or transceivers to communicate with various components within the network or within the device. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration. The functionality of the modules may be implemented in some other manner as taught herein. The functionality described herein (e.g., with regard to one or more of the accompanying figures) may correspond in some aspects to similarly designated "means for" functionality in the appended claims.

[0152] It is understood that any specific order or hierarchy of steps in any disclosed process is an example of a sample approach. Based upon design preferences, it is understood

that the specific order or hierarchy of steps in the processes may be rearranged while remaining within the scope of the present disclosure. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[0153] Various modifications to the embodiments described in this disclosure may be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of this disclosure. Thus, the disclosure is not intended to be limited to the embodiments shown herein, but is to be accorded the widest scope consistent with the claims, the principles and the novel features disclosed herein. The word "exemplary" is used exclusively herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments.

[0154] Certain features that are described in this specification in the context of separate embodiments also can be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment also can be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[0155] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the embodiments described above should not be understood as requiring such separation in all embodiments, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products. Additionally, other embodiments are within the scope of the following claims. In some cases, the actions recited in the claims can be performed in a different order and still achieve desirable results.

What is claimed is:

1. A wireless communication apparatus, comprising:

a plurality of antennas including at least a first antenna, a second antenna, and a third antenna;

a plurality of receive circuits including a first receive circuit, at least two of the plurality of receive circuits each configured to simultaneously receive, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies; and

a controller configured to selectively switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on one or more performance characteristics of at least one of the first antenna and the second antenna.

2. The wireless communication apparatus of claim **1**, wherein:

the first receive circuit is configured to receive wireless communications according to a first radio access technology and a second receive circuit is configured to receive wireless communications according to a second radio access technology;

the first antenna and the second antenna are configured to be used by both the first receive circuit and the second receive circuit; and

the third antenna is configured to be used by a third receive circuit.

3. The wireless communication apparatus of claim **2**, wherein the first receive circuit and the second receive circuit share with each other information relating to the one or more performance characteristic of the first antenna and the second antenna.

4. The wireless communication apparatus of claim **2**, wherein the first radio access technology includes data only communications and the second radio access technology includes voice only communications.

5. The wireless communication apparatus of claim **1**, further comprising a plurality of proximity sensors configured to sense proximity of an object relative to each of the plurality of antennas, and wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on state information of the plurality of proximity sensors.

6. The wireless communication apparatus of claim **5**, wherein the controller is configured to selectively switch based on a proximity of the first antenna to the object as indicated by the state information of the plurality of proximity sensors.

7. The wireless communication apparatus of claim **1**, wherein the controller is configured to selectively switch based on an orientation of the wireless communication device.

8. The wireless communication apparatus of claim **2**, wherein the controller is configured to selectively switch based on preferences for each of the plurality of receive circuits, the preferences based on priority levels assigned to different radio access technologies associated with each of the plurality of receive circuits.

9. The wireless communication apparatus of claim **8**, wherein the different radio access technologies associated with each of the plurality of receive circuits include voice only communications and data only communications, and wherein voice only communications have a higher priority than data communications.

10. The wireless communication apparatus of claim **8**, wherein the controller is configured to assign the preferences to each of the plurality of receive circuits based on a state of each of the plurality of receive circuits.

11. The wireless communication apparatus of claim **8**, wherein the first receive circuit has a higher preference level than the second receive circuit, and wherein the controller is configured to switch the first receive circuit to receive wireless communications via the second antenna based on the higher preference level.

12. The wireless communication apparatus of claim **8**, wherein the second receive circuit has a lower preference level than the first receive circuit, and the second receive circuit is denied a request to switch to the second antenna based on the lower preference level.

13. The wireless communication apparatus of claim 8, wherein the receive circuit according to the highest preference level has control of switching circuitry.

14. The wireless communication apparatus of claim 1, further comprising:

wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on a receive power level of each of the first antenna and second antenna; and

wherein the controller is configured to switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting a first receive power level of the first antenna is less than a first threshold power level.

15. The wireless communication apparatus of claim 1, further comprising:

wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on a receive power level of each of the first antenna and second antenna; and

wherein the controller is configured to switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting:

a first receive power level of the first antenna is less than a threshold power level; and

a difference between the second receive power level and the first receive power level is greater than a threshold difference.

16. The wireless communication apparatus of claim 1, wherein the controller is configured to selectively switch during an idle state of the first receive circuit.

17. The wireless communication apparatus of claim 1, further comprising:

a second receive circuit configured to receive wireless communications via the first antenna and the second antenna; and

wherein the controller is configured to:

detect performance characteristics of the first antenna and the second antenna based on the wireless communications received using the second receive circuit; and

selectively switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on the detected performance characteristics.

18. The wireless communication apparatus of claim 17, wherein the performance characteristics include a power differential between the first antenna and the second antenna.

19. The wireless communication apparatus of claim 17, further comprising:

wherein the first receive circuit is configured to receive wireless communications according to a first radio access technology and the second receive circuit is configured to receive wireless communications according to a second radio access technology; and

wherein the first receive circuit is in an idle state and the second receive circuit is in an active state.

20. The wireless communication apparatus of claim 17, further comprising:

wherein the first receive circuit is configured to receive wireless communications according to a first radio access technology and the second receive circuit is configured to receive wireless communications according to a second radio access technology; and

wherein the first receive circuit is in an active state and the second receive circuit is in an active state.

21. The wireless communication apparatus of claim 1, further comprising:

a second receive circuit configured to receive wireless communications via the second antenna; and

wherein the controller is configured to:

detect performance characteristics of the second antenna based on the wireless communications transmitted and received using the second receive circuit;

compare the detected performance characteristics of the second antenna with performance characteristics of the first antenna; and

selectively switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on the comparison.

22. The wireless communication apparatus of claim 1, wherein the one or more performance characteristics of the first antenna and the second antenna include one or more downlink performance metrics.

23. The wireless communication apparatus of claim 22, wherein the one or more downlink performance metrics of the first antenna include at least one of a setpoint and frame erasures.

24. The wireless communication apparatus of claim 1, further comprising a common manager configured to coordinate the selective switching by the controller.

25. The wireless communication apparatus of claim 2, wherein the controller is configured to switch the first receive circuit back to receiving wireless communications via the first antenna if a performance of the first receive circuit is lower after the switch.

26. The wireless communication apparatus of claim 2, wherein the controller is configured to schedule the switch of the first receive circuit to receive wireless communications via the second antenna.

27. The wireless communication apparatus of claim 2, wherein the first antenna is a default antenna for the first receive circuit, and wherein the controller is configured to switch the first receive circuit to receive wireless communications via the first antenna if the second receive circuit is in an active state and is receiving wireless communications via the second antenna.

28. A method implemented in a wireless communication apparatus, the method comprising:

selectively switching a first receive circuit from receiving wireless communications via a first antenna to receive wireless communications via a second antenna based on one or more performance characteristics of at least one of the first antenna and the second antenna, wherein at least the first receive circuit and a second receive circuit of the wireless communication apparatus are each configured to simultaneously receive, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies.

29. The method of claim 28, further comprising:

receiving wireless communications using the first receive circuit according to a first radio access technology;

receiving wireless communications using the second receive circuit according to a second radio access technology; and

wherein first antenna and the second antenna are configured to be used by both the first receive circuit and the second receive circuit and wherein a third antenna is configured to be used by a third receive circuit.

30. The method of claim **29**, further comprising sharing information relating to the one or more performance characteristic of the first antenna and the second antenna between the first receive circuit and the second receive circuit.

31. The method of claim **29**, wherein the first radio access technology includes data only communications and the second radio access technology includes voice only communications.

32. The method of claim **28**, further comprising sensing proximity of an object relative to each of the first antenna and the second antenna, wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on the sensed proximity of the object.

33. The method of claim **28**, further comprising selectively switching based on a proximity of the first antenna to the object as indicated by the sensed proximity.

34. The method of claim **28**, further comprising selectively switching based on an orientation of the wireless communication device.

35. The method of claim **28**, further comprising selectively switching based on preferences for each of the plurality of receive circuits, the preferences based on priority levels assigned to different radio access technologies associated with each of the first receive circuit and the second receive circuit.

36. The method of claim **35**, wherein the different radio access technologies associated with each of the first receive circuit and the second receive circuit include voice only communications and data only communications, and wherein voice only communications have a higher priority than data communications.

37. The method of claim **35**, further comprising assigning the preferences to each of the plurality of receive circuits based on a state of each of the plurality of receive circuits.

38. The method of claim **35**, wherein the first receive circuit has a higher preference level than the second receive circuit, and further comprising switching the first receive circuit to receive wireless communications via the second antenna based on the higher preference level.

39. The method of claim **35**, wherein the second receive circuit has a lower preference level than the first receive circuit, and further comprising denying the second receive circuit a request to switch to the second antenna based on the lower preference level.

40. The method of claim **35**, providing the receive circuit according to the highest preference level with control of switching circuitry.

41. The method of claim **28**, further comprising:

wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on a receive power level of each of the first antenna and second antenna; and

switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting a first receive power level of the first antenna is less than a first threshold power level.

42. The method of claim **28**, further comprising:

wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on a receive power level of each of the first antenna and second antenna; and

switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting:

a first receive power level of the first antenna is less than a threshold power level; and

a difference between the second receive power level and the first receive power level is greater than a threshold difference.

43. The method of claim **28**, further comprising selectively switching during an idle state of the first receive circuit.

44. The method of claim **28**, further comprising:

wherein the second receive circuit is configured to receive wireless communications via the first antenna and the second antenna;

detecting performance characteristics of the first antenna and the second antenna based on the wireless communications received using the second receive circuit; and

selectively switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on the detected performance characteristics.

45. The method of claim **44**, wherein the performance characteristics include a power differential between the first antenna and the second antenna.

46. The method of claim **44**, further comprising:

receiving wireless communications using the first receive circuit according to a first radio access technology;

receiving wireless communications using the second receive circuit according to a second radio access technology; and

wherein the first receive circuit is in an idle state and the second receive circuit is in an active state.

47. The method of claim **44**, further comprising:

receiving wireless communications using the first receive circuit according to a first radio access technology;

receiving wireless communications using the second receive circuit according to a second radio access technology; and

wherein the first receive circuit is in an active state and the second receive circuit is in an active state.

48. The method of claim **28**, further comprising:

wherein the second receive circuit is configured to receive wireless communications via the second antenna;

detecting performance characteristics of the second antenna based on the wireless communications transmitted and received using the second receive circuit;

comparing the detected performance characteristics of the second antenna with performance characteristics of the first antenna; and

selectively switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on the comparison.

49. The method of claim 28, wherein the one or more performance characteristics of the first antenna and the second antenna include one or more downlink performance metrics.

50. The method of claim 49, wherein the one or more downlink performance metrics of the first antenna include at least one of a setpoint and frame erasures.

51. The method of claim 28, further comprising coordinating the selective switching by the controller using a common manager.

52. The method of claim 28, further comprising switching the first receive circuit back to receiving wireless communications via the first antenna if a performance of the first receive circuit is lower after the switch.

53. The method of claim 28, further comprising scheduling the switch of the first receive circuit to receive wireless communications via the second antenna.

54. The method of claim 28, wherein the first antenna is a default antenna for the first receive circuit, and further comprising switching the first receive circuit to receive wireless communications via the first antenna if the second receive circuit is in an active state and is receiving wireless communications via the second antenna.

55. A wireless communication apparatus, comprising:

a plurality of antennas including a first antenna, a second antenna, and a third antenna;

a plurality of receive circuits including a first receive circuit, at least two of the plurality of receive circuits each configured to simultaneously receive, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies; and

means for selectively switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on one or more performance characteristics of at least one of the first antenna and the second antenna.

56. The wireless communication apparatus of claim 55, wherein:

the first receive circuit is configured to receive wireless communications according to a first radio access technology and a second receive circuit is configured to receive wireless communications according to a second radio access technology;

the first antenna and the second antenna are configured to be used by both the first receive circuit and the second receive circuit; and

the third antenna is configured to be used by a third receive circuit.

57. The wireless communication apparatus of claim 56, wherein the first receive circuit and the second receive circuit share with each other information relating to the one or more performance characteristic of the first antenna and the second antenna.

58. The wireless communication apparatus of claim 56, wherein the first radio access technology includes data only communications and the second radio access technology includes voice only communications.

59. The wireless communication apparatus of claim 55, further comprising a plurality of proximity sensors configured to sense proximity of an object relative to each of the plurality of antennas, and wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on state information of the plurality of proximity sensors.

60. The wireless communication apparatus of claim 59, further comprising means for selectively switching based on a proximity of the first antenna to the object as indicated by the state information of the plurality of proximity sensors.

61. The wireless communication apparatus of claim 55, further comprising means for selectively switching based on an orientation of the wireless communication device.

62. The wireless communication apparatus of claim 55, further comprising means for selectively switching based on preferences for each of the plurality of receive circuits, the preferences based on priority levels assigned to different radio access technologies associated with each of the plurality of receive circuits.

63. The wireless communication apparatus of claim 62, wherein the different radio access technologies associated with each of the plurality of receive circuits include voice only communications and data only communications, and wherein voice only communications have a higher priority than data communications.

64. The wireless communication apparatus of claim 62, means for assigning the preferences to each of the plurality of receive circuits based on a state of each of the plurality of receive circuits.

65. The wireless communication apparatus of claim 62, wherein the first receive circuit has a higher preference level than the second receive circuit, and further comprising means for switching the first receive circuit to receive wireless communications via the second antenna based on the higher preference level.

66. The wireless communication apparatus of claim 62, wherein the second receive circuit has a lower preference level than the first receive circuit, and the second receive circuit is denied a request to switch to the second antenna based on the lower preference level.

67. The wireless communication apparatus of claim 62, wherein the receive circuit according to the highest preference level has control of switching circuitry.

68. The wireless communication apparatus of claim 55, further comprising:

wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on a receive power level of each of the first antenna and second antenna; and

means for switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting a first receive power level of the first antenna is less than a first threshold power level.

69. The wireless communication apparatus of claim 55, further comprising:

wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on a receive power level of each of the first antenna and second antenna; and

means for switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting:

a first receive power level of the first antenna is less than a threshold power level; and

a difference between the second receive power level and the first receive power level is greater than a threshold difference.

70. The wireless communication apparatus of claim **55**, further comprising means for selectively switching during an idle state of the first receive circuit.

71. The wireless communication apparatus of claim **55**, further comprising:

a second receive circuit configured to receive wireless communications via the first antenna and the second antenna;

means for detecting performance characteristics of the first antenna and the second antenna based on the wireless communications received using the second receive circuit; and

means for selectively switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on the detected performance characteristics.

72. The wireless communication apparatus of claim **71**, wherein the performance characteristics include a power differential between the first antenna and the second antenna.

73. The wireless communication apparatus of claim **71**, further comprising:

wherein the first receive circuit is configured to receive wireless communications according to a first radio access technology and the second receive circuit is configured to receive wireless communications according to a second radio access technology; and

wherein the first receive circuit is in an idle state and the second receive circuit is in an active state.

74. The wireless communication apparatus of claim **71**, further comprising:

wherein the first receive circuit is configured to receive wireless communications according to a first radio access technology and the second receive circuit is configured to receive wireless communications according to a second radio access technology; and

wherein the first receive circuit is in an active state and the second receive circuit is in an active state.

75. The wireless communication apparatus of claim **55**, further comprising:

a second receive circuit configured to receive wireless communications via the second antenna;

means for detecting performance characteristics of the second antenna based on the wireless communications transmitted and received using the second receive circuit;

means for comparing the detected performance characteristics of the second antenna with performance characteristics of the first antenna; and

means for selectively switching the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on the comparison.

76. The wireless communication apparatus of claim **55**, wherein the one or more performance characteristics of the first antenna and the second antenna include one or more downlink performance metrics.

77. The wireless communication apparatus of claim **76**, wherein the one or more downlink performance metrics of the first antenna include at least one of a setpoint and frame erasures.

78. The wireless communication apparatus of claim **55**, further comprising a common manager configured to coordinate the selective switching by the controller.

79. The wireless communication apparatus of claim **55**, further comprising means for switching the first receive circuit back to receiving wireless communications via the first antenna if a performance of the first receive circuit is lower after the switch.

80. The wireless communication apparatus of claim **55**, further comprising means for scheduling the switch of the first receive circuit to receive wireless communications via the second antenna.

81. The wireless communication apparatus of claim **55**, wherein the first antenna is a default antenna for the first receive circuit, and further comprising means for switching the first receive circuit to receive wireless communications via the first antenna if the second receive circuit is in an active state and is receiving wireless communications via the second antenna.

82. A computer program product, comprising:

a computer-readable medium comprising:

code, when executed by a computer, causes the computer to selectively switch a first receive circuit from receiving wireless communications via a first antenna to receive wireless communications via a second antenna based on one or more performance characteristics of at least one of the first antenna and the second antenna, wherein at least the first receive circuit and a second receive circuit of the wireless communication apparatus are each configured to simultaneously receive, with respect to the other, wireless communications from a different one of at least two networks relating to different radio access technologies.

83. The computer program product of claim **82**, wherein the computer-readable medium further comprises:

code, when executed by the computer, causes the computer to receive wireless communications using the first receive circuit according to a first radio access technology;

code, when executed by the computer, causes the computer to receive wireless communications using the second receive circuit according to a second radio access technology;

wherein first antenna and the second antenna are configured to be used by both the first receive circuit and the second receive circuit and wherein a third antenna is configured to be used only by a first receive circuit.

84. The computer program product of claim **83**, wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to share information relating to the one or more performance characteristic of the first antenna and the second antenna between the first receive circuit and the second receive circuit.

85. The computer program product of claim **83**, wherein the first radio access technology includes data only communications and the second radio access technology includes voice only communications.

86. The computer program product of claim **82**, wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to sense proximity of an object relative to each of the first antenna and the second antenna, wherein the one or more performance char-

acteristics of the first antenna and the second antenna is determined based at least in part on the sensed proximity of the object.

87. The computer program product of claim **86**, wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to selectively switch based on a proximity of the first antenna to the object as indicated by the sensed proximity.

88. The computer program product of claim **82**, wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to selectively switch based on an orientation of the wireless communication device.

89. The computer program product of claim **82**, wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to selectively switch based on preferences for each of the plurality of receive circuits, the preferences based on priority levels assigned to different radio access technologies associated with each of the first receive circuit and the second receive circuit.

90. The computer program product of claim **89**, wherein the different radio access technologies associated with each of the first receive circuit and the second receive circuit include voice only communications and data only communications, and wherein voice only communications have a higher priority than data communications.

91. The computer program product of claim **89**, wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to assign the preferences to each of the plurality of receive circuits based on a state of each of the plurality of receive circuits.

92. The computer program product of claim **89**, wherein the first receive circuit has a higher preference level than the second receive circuit, and wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to switch the first receive circuit to receive wireless communications via the second antenna based on the higher preference level.

93. The computer program product of claim **89**, wherein the second receive circuit has a lower preference level than the first receive circuit, and wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to deny the second receive circuit a request to switch to the second antenna based on the lower preference level.

94. The computer program product of claim **89**, wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to provide the receive circuit according to the highest preference level with control of switching circuitry.

95. The computer program product of claim **82**, further comprising:

wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on a receive power level of each of the first antenna and second antenna; and

wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting a first receive power level of the first antenna is less than a first threshold power level.

96. The computer program product of claim **82**, further comprising:

wherein the one or more performance characteristics of the first antenna and the second antenna is determined based at least in part on a receive power level of each of the first antenna and second antenna; and

wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna in response to detecting:

a first receive power level of the first antenna is less than a threshold power level; and

a difference between the second receive power level and the first receive power level is greater than a threshold difference.

97. The computer program product of claim **82**, wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to selectively switch during an idle state of the first receive circuit.

98. The computer program product of claim **82**, further comprising:

wherein the second receive circuit is configured to receive wireless communications via the first antenna and the second antenna; and

wherein the computer-readable medium further comprises:

code, when executed by the computer, causes the computer to detect performance characteristics of the first antenna and the second antenna based on the wireless communications received using the second receive circuit; and

code, when executed by the computer, causes the computer to switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on the detected performance characteristics.

99. The computer program product of claim **98**, wherein the performance characteristics include a power differential between the first antenna and the second antenna.

100. The computer program product of claim **98**, further comprising:

wherein the computer-readable medium further comprises:

code, when executed by the computer, causes the computer to receive wireless communications using the first receive circuit according to a first radio access technology;

code, when executed by the computer, causes the computer to receive wireless communications using the second receive circuit according to a second radio access technology; and

wherein the first receive circuit is in an idle state and the second receive circuit is in an active state.

101. The computer program product of claim **98**, further comprising:

wherein the computer-readable medium further comprises:

code, when executed by the computer, causes the computer to receive wireless communications using the first receive circuit according to a first radio access technology;

code, when executed by the computer, causes the computer to receive wireless communications using the second receive circuit according to a second radio access technology; and

wherein the first receive circuit is in an active state and the second receive circuit is in an active state.

102. The computer program product of claim **82**, further comprising:

wherein the second receive circuit is configured to receive wireless communications via the second antenna; and

wherein the computer-readable medium further comprises:

code, when executed by the computer, causes the computer to detect performance characteristics of the second antenna based on the wireless communications transmitted and received using the second receive circuit;

code, when executed by the computer, causes the computer to compare the detected performance characteristics of the second antenna with performance characteristics of the first antenna; and

code, when executed by the computer, causes the computer to selectively switch the first receive circuit from receiving wireless communications via the first antenna to receive wireless communications via the second antenna based on the comparison.

103. The computer program product of claim **82**, wherein the one or more performance characteristics of the first antenna and the second antenna include one or more downlink performance metrics.

104. The computer program product of claim **103**, wherein the one or more downlink performance metrics of the first antenna include at least one of a setpoint and frame erasures.

105. The computer program product of claim **82**, wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to coordinate the selective switching by the controller using a common manager.

106. The computer program product of claim **82**, wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to switch the first receive circuit back to receiving wireless communications via the first antenna if a performance of the first receive circuit is lower after the switch.

107. The computer program product of claim **82**, wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to schedule the switch of the first receive circuit to receive wireless communications via the second antenna.

108. The computer program product of claim **82**, wherein the first antenna is a default antenna for the first receive circuit, and wherein the computer-readable medium further comprises code, when executed by the computer, causes the computer to switch the first receive circuit to receive wireless communications via the first antenna if the second receive circuit is in an active state and is receiving wireless communications via the second antenna.

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First Named Inventor	Xiaobo ZHANG
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Examiner Name	DEEPA BELUR
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	First Named Inventor	Xiaobo ZHANG
	Art Unit	2472
	Examiner Name	DEEPA BELUR
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	1	R1-1609080, Samsung, dated October 10-14, 2016 (Meeting dates) September 30, 2016 (Publication)	☒
	2	R1-1609414, Huawei, HiSilicon, dated October 10-14, 2016 (Meeting dates) October 1, 2016 (Publication)	☒
	3	R1-1609525, Intel Corporation, dated October 10-14, 2016 (Meeting date) October 1, 2016 (Publication)	☒
	4	R1-1609662, Nokia, Alcatel-Lucent Shanghai Bell, dated October 10-14, 2016 (Meeting date) September 30, 2016 (Publication)	☒
	5	R1-1609739, Nokia, Alcatel-Lucent Shanghai Bell, dated October 10-14, 2016 (Meeting dates) October 1, 2016 (Publication)	☒
	6	R1-1610145, Qualcomm, dated October 10-14, 2016 (Meeting date) October 1, 2016 (Publication)	☒
	7	R1-1610239, Nokia, Alcatel-Lucent Shanghai Bell, dated October 10-14, 2016 (Meeting date) September 30, 2016 (Publication)	☒
	8	R1-1611385, CATT, dated November 14-18, 2016 (Meeting date) November 5, 2016 (Publication)	☒
	9	R1-1611387, CATT, dated November 14-18, 2016 (Meeting dates) November 5, 2016 (Publication)	☒
	10	R1-1611415, ZTE, ZTE Microelectronics, dated November 14-18, 2016 (Meeting date) November 5, 2016 (Publication)	☒
	11	R1-1611417, ZTE, ZTE Microelectronics, dated November 14-18, 2016 (Meeting date) November 5, 2016 (Publication)	☒

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	First Named Inventor	Xiaobo ZHANG
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	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	12	R1-1611421, ZTE, ZTE Microelectronics, dated November 14-18, 2016 (Meeting date) November 5, 2016 (Publication)	☒
	13	R1-1612015, Qualcomm, dated November 14-18, 2016 (Meeting dates) November 6, 2016 (Publication)	☒
	14	R1-1612056, Qualcomm, dated November 14-18, 2016 (Meeting dates) November 6, 2016 (Publication)	☒
	15	R1-1612190, CMCC, dated November 14-18, 2016 (Meeting dates) November 6, 2016 (Publication)	☒
	16	R1-1612493, Samsung, dated November 14-18, 2016 (Meeting date) November 4, 2016 (Publication)	☒
	17	R1-1612717, NTT DOCOMO, dated November 14-18, 2016 (Meeting dates) November 5, 2016 (Publication)	☒
	18	R1-1612862, Nokia, Alcatel-Lucent Shanghai Bell, dated November 14-18, 2016 (Meeting date) November 4, 2016 (Publication)	☒
	19	R1-1613589, Samsung, Ericsson, NTT DOCOMO, Intel, Verizon, KT, dated 14-18, 2016 (Meeting dates) November 19, 2016 (Publication)	☒
	20	R1-1613716, ZTE, ZTE Microelectronics, dated November 14-18, 2016 (Meeting date) November 19, 2016 (Publication)	☒
	21	R1-164147, Intel Corporation, dated May 23-27, 2016 (Meeting dates) May 14, 2016 (Publication)	☒
	22	R1-166881, LG Electronics, dated August 22- 26, 2016 (Meeting dates) August 13, 2016 (Publication)	☒

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	18089999
	Filing Date	2022-12-28
	First Named Inventor	Xiaobo ZHANG
	Art Unit	2472
	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

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

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	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

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

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	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

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

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	Examiner Name	DEEPA BELUR
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

CERTIFICATION STATEMENT

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

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

OR

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

☐ See attached certification statement.

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

☐ A certification statement is not submitted herewith.

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

Signature	/JIALIN ZHONG/	Date (YYYY-MM-DD)	2024-09-25
Name/Print	JIALIN ZHONG	Registration Number	62937

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

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

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

US 20110038330A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2011/0038330 A1**

(43) **Pub. Date: Feb. 17, 2011**

Luo et al.

(54) **ROBUST DECODING OF COMP TRANSMISSIONS**

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(73) Assignee: **QUALCOMM INCORPORATED**, San Diego, CA (US)

(21) Appl. No.: **12/846,640**

(22) Filed: **Jul. 29, 2010**

Related U.S. Application Data

(60) Provisional application No. 61/230,068, filed on Jul. 30, 2009.

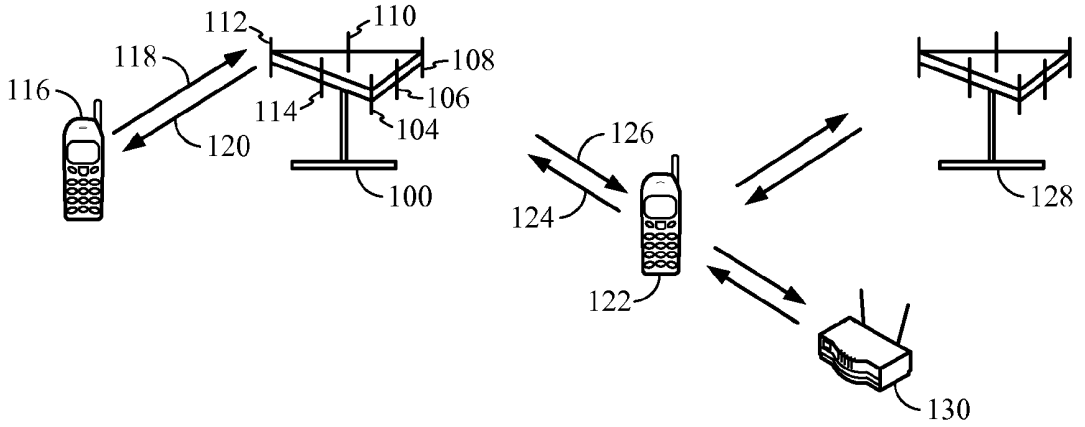
Publication Classification

(51) **Int. Cl.**
H04W 72/04 (2009.01)
H04W 4/00 (2009.01)

(52) **U.S. Cl.** **370/329**; 370/328

(57) **ABSTRACT**

Techniques for transmitting data and resource signals (RS) are provided. According to certain aspects, an access point may determine RS resource locations related to one or more access points in a CoMP set transmitting a common reference signal (CRS), map data transmissions initially over resources other than those related to the RS resource locations, and map remaining data transmissions over resources related to the RS resource locations. According to certain aspects, a wireless device may receive a signal from access points in a coordinated multiple point (CoMP) communication set comprising a common reference signal (CRS) superimposed over data, determine CRS locations in the signal that correspond to the CRS, and decode data from the signal based at least in part on the determined CRS locations.



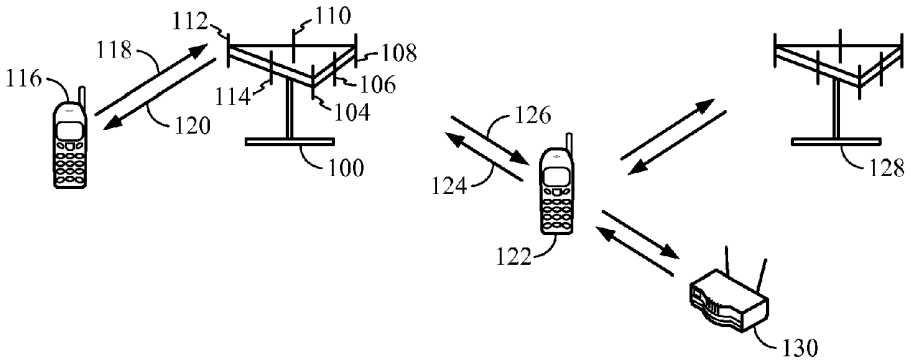

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122
130

FIG. 1

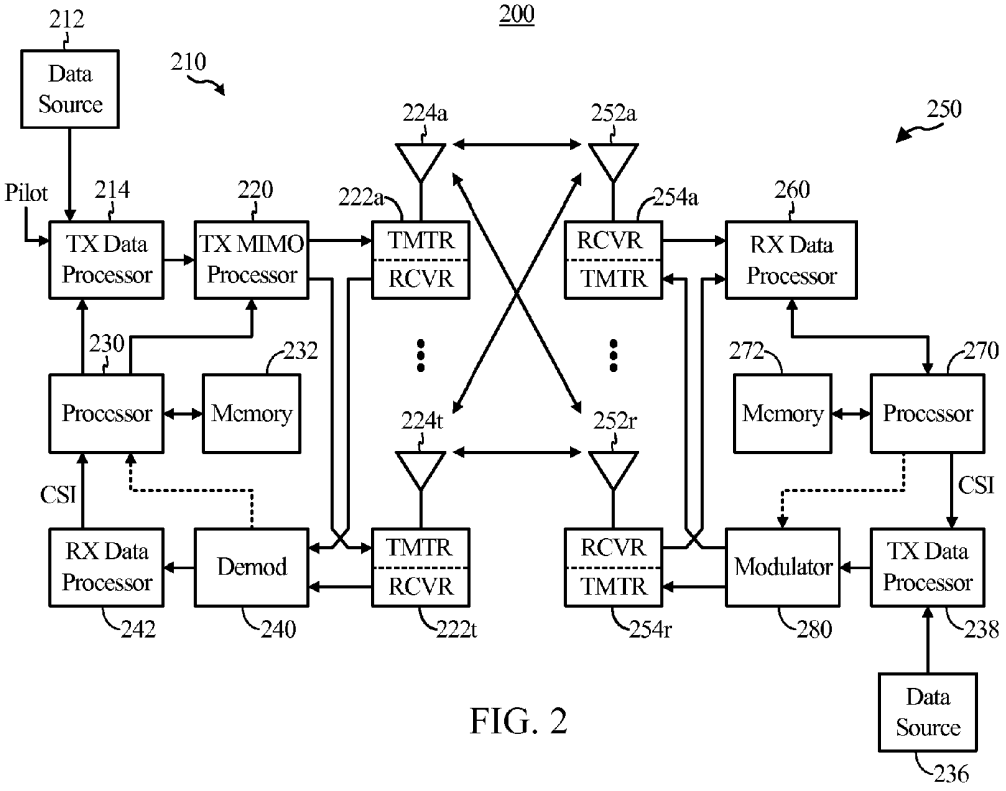

200
212
210
Data Source
224a
252a
250
Pilot
214
220
222a
254a
260
TX Data Processor
TX MIMO Processor
TMTR
RCVR
RCVR
TMTR
RX Data Processor
230
232
272
270
Processor
Memory
224t
252r
Memory
Processor
CSI
CSI
RX Data Processor
Demod
TMTR
RCVR
RCVR
TMTR
Modulator
TX Data Processor
242
240
222t
254r
280
238
Data Source
236

FIG. 2

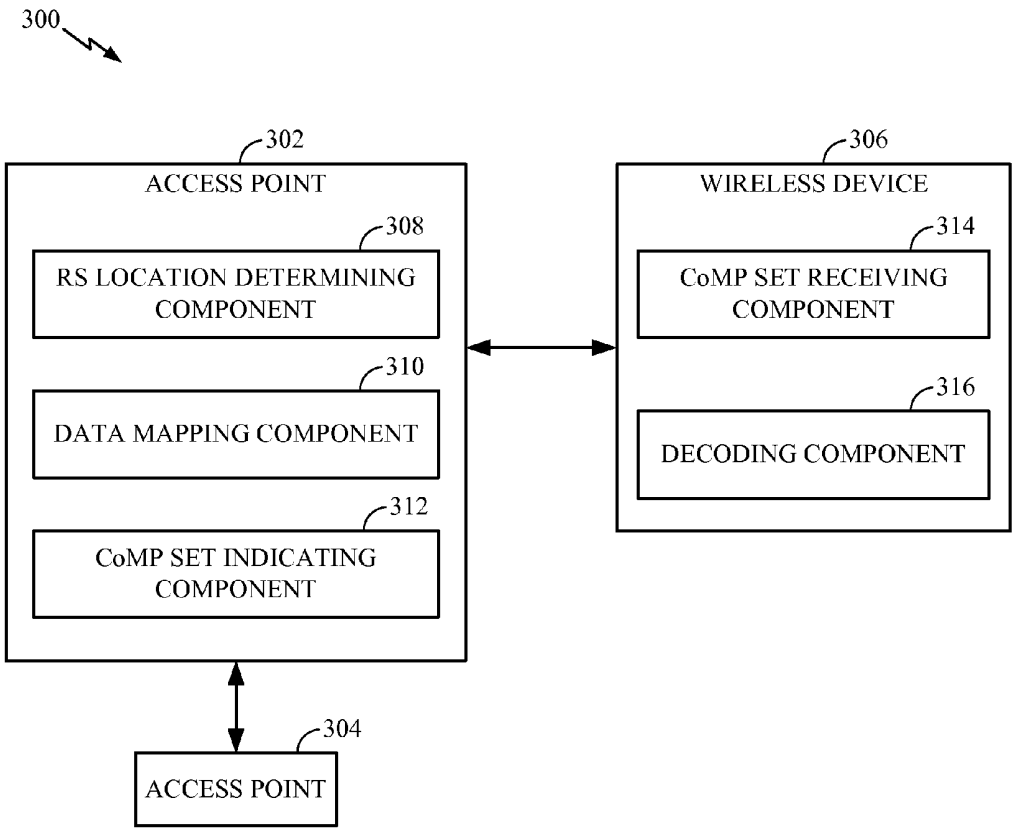

300
302
ACCESS POINT
308
RS LOCATION DETERMINING COMPONENT
310
DATA MAPPING COMPONENT
312
CoMP SET INDICATING COMPONENT
306
WIRELESS DEVICE
314
CoMP SET RECEIVING COMPONENT
316
DECODING COMPONENT
304
ACCESS POINT

FIG. 3

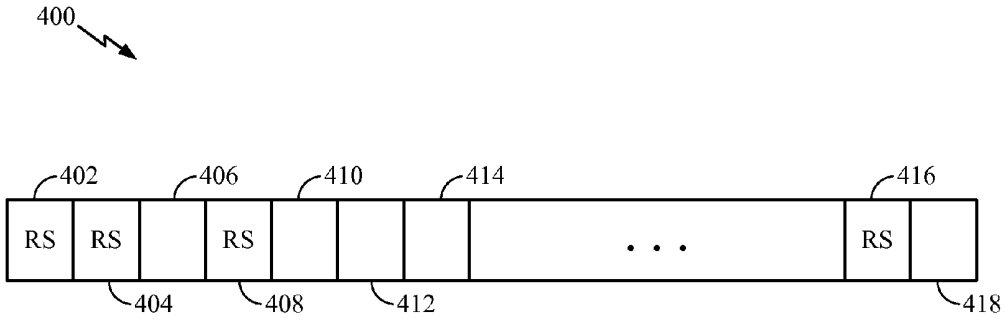

400
402
406
410
414
416
RS
RS
RS
RS
404
408
412
418

FIG. 4

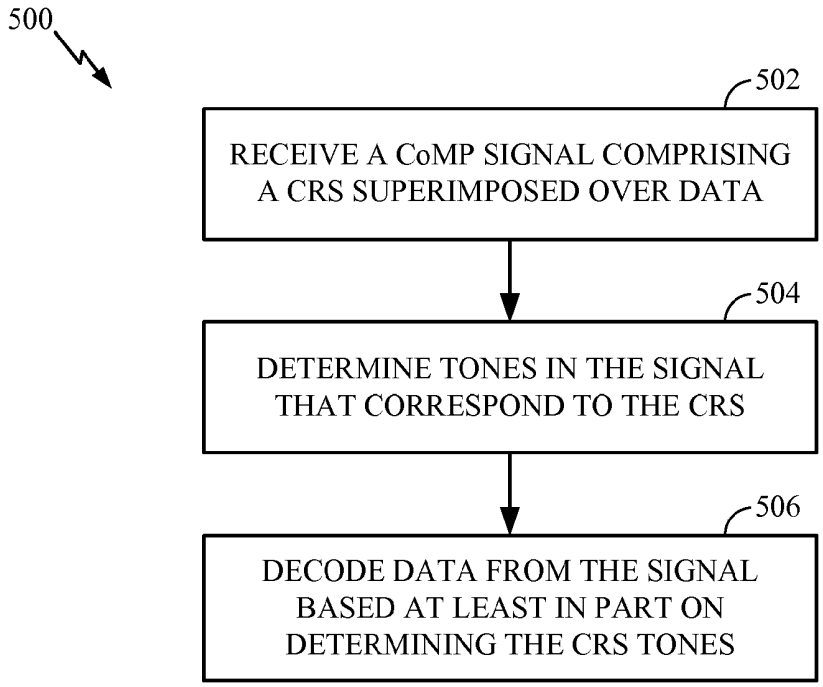

500
502
RECEIVE A CoMP SIGNAL COMPRISING A CRS SUPERIMPOSED OVER DATA
504
DETERMINE TONES IN THE SIGNAL THAT CORRESPOND TO THE CRS
506
DECODE DATA FROM THE SIGNAL BASED AT LEAST IN PART ON DETERMINING THE CRS TONES

FIG. 5

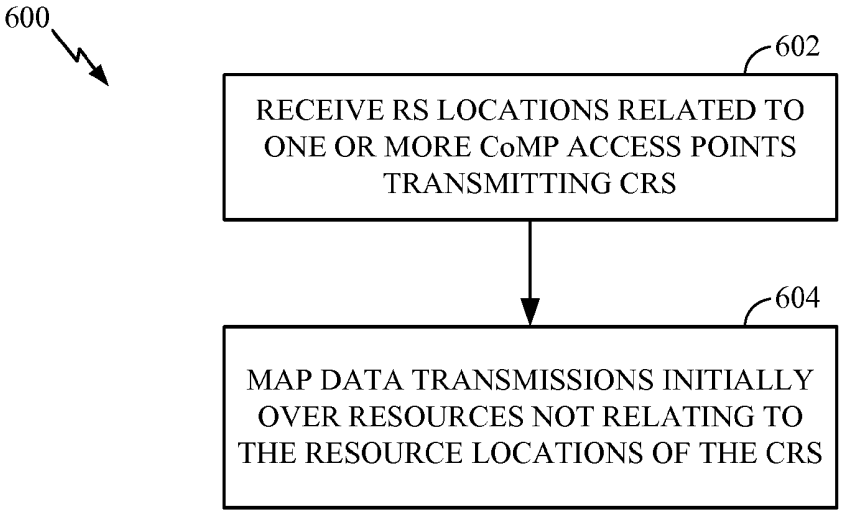

600
602
RECEIVE RS LOCATIONS RELATED TO ONE OR MORE CoMP ACCESS POINTS TRANSMITTING CRS
604
MAP DATA TRANSMISSIONS INITIALLY OVER RESOURCES NOT RELATING TO THE RESOURCE LOCATIONS OF THE CRS

FIG. 6

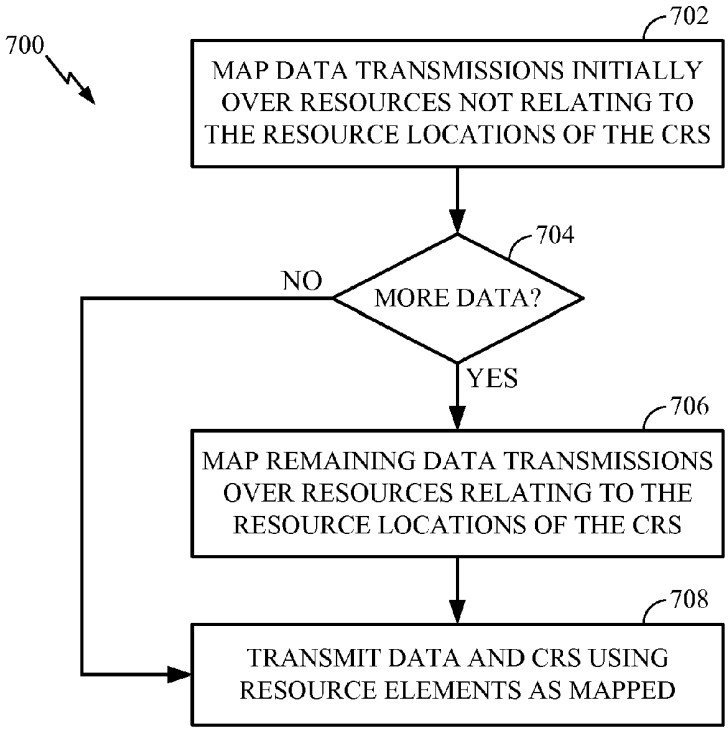


FIG. 7

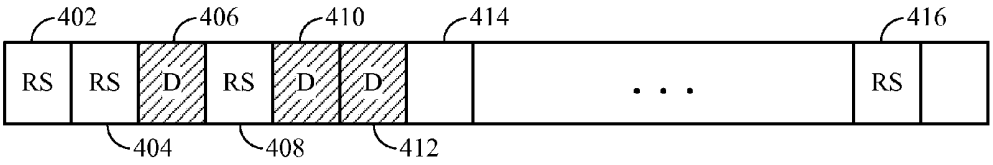


FIG. 8

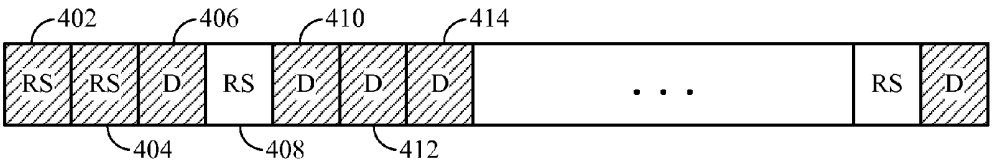


FIG. 9

ROBUST DECODING OF COMP TRANSMISSIONS

CLAIM OF PRIORITY UNDER 35 U.S.C. §119

[0001] The present application for patent claims benefit of U.S. Provisional Patent Application No. 61/230,068, entitled, "Robust Decoding of CoMP Transmissions," filed Jul. 30, 2009, and assigned to the assignee hereof and hereby expressly incorporated by reference herein.

BACKGROUND

Field

[0002] Wireless communication systems are widely deployed to provide various types of communication content such as voice, data, and so on. These systems may be multiple-access systems capable of supporting communication with multiple users by sharing the available system resources (e.g., bandwidth and transmit power). Examples of such multiple-access systems include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, 3GPP Long Term Evolution (LTE) systems, and orthogonal frequency division multiple access (OFDMA) systems.

[0003] Generally, a wireless multiple-access communication system can simultaneously support communication for multiple wireless terminals. Each terminal communicates with one or more base stations via transmissions on the forward and reverse links. The forward link (or downlink) refers to the communication link from the base stations to the terminals, and the reverse link (or uplink) refers to the communication link from the terminals to the base stations. This communication link may be established via a single-in-single-out, multiple-in-signal-out or a multiple-in-multiple-out (MIMO) system.

[0004] A MIMO system employs multiple (N_T) transmit antennas and multiple (N_R) receive antennas for data transmission. A MIMO channel formed by the N_T transmit and N_R receive antennas may be decomposed into N_S independent channels, which are also referred to as spatial channels, where $N_S \leq \min\{N_T, N_R\}$. Each of the N_S independent channels corresponds to a dimension. The MIMO system can provide improved performance (e.g., higher throughput and/or greater reliability) if the additional dimensionalities created by the multiple transmit and receive antennas are utilized.

[0005] In addition, in coordinated multiple point (CoMP) configurations, multiple base stations can transmit to and/or receive from a given mobile terminal, facilitating increased throughput and/or signal quality in communicating with the mobile terminal. In one example, base stations cooperating using CoMP can transmit substantially the same data, during substantially the same time periods, to a given mobile terminal.

SUMMARY

[0006] Certain aspects of the present disclosure provide a method for wireless communications. The method generally includes receiving a signal from access points in a coordinated multiple point (CoMP) communication set, the signal comprising a common reference signal (CRS) superimposed over data, determining CRS locations in the signal that correspond to the CRS, and decoding data from the signal based at least in part on the determined CRS locations.

[0007] Certain aspects of the present disclosure provide a method for wireless communications. The method generally includes determining reference signal (RS) resource locations related to one or more access points in a coordinated multiple point (CoMP) set transmitting a common reference signal (CRS), mapping data transmissions initially over a first set of resources that do not correspond to determined RS resource locations, and mapping remaining data transmissions over a second set of resources that correspond to determined RS resource locations.

[0008] Certain aspects of the present disclosure provide an apparatus for wireless communications. The apparatus generally includes at least one processor configured to receive a signal from access points in a coordinated multiple point (CoMP) communication set, the signal comprising a common reference signal (CRS) superimposed over data, determine CRS locations in the signal that correspond to the CRS, and decode data from the signal based at least in part on the determined CRS locations, and a memory coupled to the at least one processor.

[0009] Certain aspects of the present disclosure provide an apparatus for wireless communications. The apparatus generally includes at least one processor configured to determine reference signal (RS) resource locations related to one or more access points in a coordinated multiple point (CoMP) set transmitting a common reference signal (CRS), map data transmissions initially over a first set of resources that do not correspond to determined RS resource locations, and map remaining data transmissions over a second set of resources that correspond to determined RS resource locations, and a memory coupled to the at least one processor.

[0010] Certain aspects of the present disclosure provide an apparatus for wireless communications. The apparatus generally includes means for receiving a signal from access points in a coordinated multiple point (CoMP) communication set, the signal comprising a common reference signal (CRS) superimposed over data, means for determining CRS locations in the signal that correspond to the CRS, and means for decoding data from the signal based at least in part on the determined CRS locations.

[0011] Certain aspects of the present disclosure provide an apparatus for wireless communications. The apparatus generally includes means for determining reference signal (RS) resource locations related to one or more access points in a coordinated multiple point (CoMP) set transmitting a common reference signal (CRS), means for mapping data transmissions initially over a first set of resources that do not correspond to determined RS resource locations, and means for mapping remaining data transmissions over a second set of resources that correspond to determined RS resource locations.

[0012] Certain aspects provide a computer-program product for wireless communications, comprising a computer readable medium having instructions stored thereon, the instructions being executable by one or more processors. The instructions generally include instructions for receiving a signal from access points in a coordinated multiple point (CoMP) communication set, the signal comprising a common reference signal (CRS) superimposed over data, instructions for determining CRS locations in the signal that correspond to the CRS, and instructions for decoding data from the signal based at least in part on the determined CRS locations.

[0013] Certain aspects provide a computer-program product for wireless communications, comprising a computer readable medium having instructions stored thereon, the instructions being executable by one or more processors. The instructions generally include instructions for determining reference signal (RS) resource locations related to one or more access points in a coordinated multiple point (CoMP) set transmitting a common reference signal (CRS), instructions for mapping data transmissions initially over a first set of resources that do not correspond to determined RS resource locations, and instructions for mapping remaining data transmissions over a second set of resources that correspond to determined RS resource locations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The features, nature, and advantages of the present disclosure will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

[0015] FIG. **1** illustrates a multiple access wireless communication system according to one embodiment.

[0016] FIG. **2** illustrates a block diagram of a communication system.

[0017] FIG. **3** illustrates an example system that facilitates mapping and decoding data in light of common reference signal (CRS) transmissions.

[0018] FIG. **4** illustrates an example portion of resource blocks that are allocated for data and CRS transmissions.

[0019] FIG. **5** illustrates an example methodology that facilitates decodes data over resources additionally used for CRS transmissions.

[0020] FIG. **6** illustrates an example methodology that facilitates initially mapping data over resources not utilized for CRS transmissions.

[0021] FIG. **7** illustrates an example methodology that facilitates initially mapping data over resources not utilized for CRS transmissions.

[0022] FIG. **8** illustrates an example portion of resource blocks that are allocated for data transmission, initially avoiding resource blocks used for CRS transmissions

[0023] FIG. **9** illustrates an example portion of resource blocks that are allocated for data transmission, utilizing resource blocks used for CRS transmissions.

DESCRIPTION

[0024] The techniques described herein may be used for various wireless communication networks such as Code Division Multiple Access (CDMA) networks, Time Division Multiple Access (TDMA) networks, Frequency Division Multiple Access (FDMA) networks, Orthogonal FDMA (OFDMA) networks, Single-Carrier FDMA (SC-FDMA) networks, etc. The terms "networks" and "systems" are often used interchangeably. A CDMA network may implement a radio technology such as Universal Terrestrial Radio Access (UTRA), cdma2000, etc. UTRA includes Wideband-CDMA (W-CDMA) and Low Chip Rate (LCR). cdma2000 covers IS-2000, IS-95 and IS-856 standards. A TDMA network may implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA network may implement a radio technology such as Evolved UTRA (E-UTRA), IEEE 802.11, IEEE 802.16, IEEE 802.20, Flash-OFDM®, etc. UTRA, E-UTRA and GSM are part of Universal Mobile Telecommunication System (UMTS). Long Term Evolution (LTE) is an upcoming release of UMTS that uses E-UTRA. UTRA, E-UTRA, GSM, UMTS and LTE are described in documents from an organization named "3rd Generation Partnership Project" (3GPP). cdma2000 is described in documents from an organization named "3rd Generation Partnership Project 2" (3GPP2). These various radio technologies and standards are known in the art. For clarity, certain aspects of the techniques are described below for LTE, and LTE terminology is used in much of the description below.

[0025] Single carrier frequency division multiple access (SC-FDMA), which utilizes single carrier modulation and frequency domain equalization is a technique. SC-FDMA has similar performance and essentially the same overall complexity as those of OFDMA system. SC-FDMA signal has lower peak-to-average power ratio (PAPR) because of its inherent single carrier structure. SC-FDMA has drawn great attention, especially in the uplink communications where lower PAPR greatly benefits the mobile terminal in terms of transmit power efficiency. It is currently a working assumption for uplink multiple access scheme in 3GPP Long Term Evolution (LTE), or Evolved UTRA.

[0026] Referring to FIG. **1**, a multiple access wireless communication system according to one embodiment is illustrated. An access point **100** (AP) includes multiple antenna groups, one including 104 and 106, another including 108 and 110, and an additional including 112 and 114. In FIG. **1**, only two antennas are shown for each antenna group, however, more or fewer antennas may be utilized for each antenna group. Access terminal **116** (AT) is in communication with antennas **112** and **114**, where antennas **112** and **114** transmit information to access terminal **116** over forward link **120** and receive information from access terminal **116** over reverse link **118**. Access terminal **122** is in communication with antennas **106** and **108**, where antennas **106** and **108** transmit information to access terminal **122** over forward link **126** and receive information from access terminal **122** over reverse link **124**. In a FDD system, communication links **118**, **120**, **124** and **126** may use different frequency for communication. For example, forward link **120** may use a different frequency then that used by reverse link **118**.

[0027] Each group of antennas and/or the area in which they are designed to communicate is often referred to as a sector of the access point. In the embodiment, antenna groups each are designed to communicate to access terminals in a sector of the areas covered by access point **100**.

[0028] In communication over forward links **120** and **126**, the transmitting antennas of access point **100** utilize beamforming in order to improve the signal-to-noise ratio of forward links for the different access terminals **116** and **124**. Also, an access point using beamforming to transmit to access terminals scattered randomly through its coverage causes less interference to access terminals in neighboring cells than an access point transmitting through a single antenna to all its access terminals.

[0029] An access point may be a fixed station used for communicating with the terminals and may also be referred to as an access point, a Node B, or some other terminology. An access terminal may also be called an access terminal, user equipment (UE), a wireless communication device, terminal, access terminal or some other terminology. Moreover, an access point may be a macrocell access point, femtocell access point, picocell access point, and/or the like.

[0030] In one example, as depicted, access terminal **122** can similarly communicate with access points **128** and/or **130**. In one example, access point **128** can be a macrocell access point and access point **130** can be a smaller scale access point, such as a femtocell access point; however, it is to be appreciated that these access points **128** and **130** can, as well, be substantially any sort of access point. Access points **100**, **128** and/or **130** can communicate with access terminal **122** in a coordinated multiple point (CoMP) mode such that access points **100**, **128**, and/or **130** transmit substantially the same data at substantially the same time to the access terminal **122**. Similarly, the access points **100**, **128** and/or **130** can receive transmissions from the access terminal **122**. It is to be appreciated that access points **100**, **128**, and/or **130** can also communicate with one another, over a backhaul link (e.g., through a core wireless network or otherwise), over the air, and/or the like to facilitate CoMP communications.

[0031] In addition, access points **100**, **128** and **130** can transmit a dedicated reference signal (DRS) to access terminal **122**, which can be substantially the same DRS in CoMP communications. Access points **100**, **128**, and **130** can also transmit a common reference signal (CRS), which can be mapped over resources selected based on an identifier of a cell provided by the given access point. Access points **100**, **128**, and **130**, and/or access terminal **122** can mitigate possible interference caused by CRS transmissions. In one example, access points **100**, **128** and **130** can first map data transmissions over resource elements not used for transmitting CRS. In another example, access points **100**, **128**, and/or **130** can indicate the CoMP set of cells to the access terminal **122**, and the access terminal **122** can determine when CRSs are transmitted based on identifiers of the cells and use this information in decoding. In yet another example, access points **100**, **128** and **130** can transmit CRSs superimposed on data transmissions from other cells, and the access terminal **122** can utilize joint detection, interference cancellation, and/or the like to decode data transmissions.

[0032] FIG. **2** is a block diagram of an embodiment of a transmitter system **210** (also known as the access point) and a receiver system **250** (also known as access terminal) in a MIMO system **200**. At the transmitter system **210**, traffic data for a number of data streams is provided from a data source **212** to a transmit (TX) data processor **214**.

[0033] In an embodiment, each data stream is transmitted over a respective transmit antenna. TX data processor **214** formats, codes, and interleaves the traffic data for each data stream based on a particular coding scheme selected for that data stream to provide coded data.

[0034] The coded data for each data stream may be multiplexed with pilot data using OFDM techniques. The pilot data is typically a known data pattern that is processed in a known manner and may be used at the receiver system to estimate the channel response. The multiplexed pilot and coded data for each data stream is then modulated (i.e., symbol mapped) based on a particular modulation scheme (e.g., BPSK, QPSK, M-PSK, or M-QAM) selected for that data stream to provide modulation symbols. The data rate, coding and modulation for each data stream may be determined by instructions performed by processor **230**.

[0035] The modulation symbols for all data streams are then provided to a TX MIMO processor **220**, which may further process the modulation symbols (e.g., for OFDM). TX MIMO processor **220** then provides N_T modulation symbol streams to N_T transmitters (TMTR) **222***a* through **222***t*. In certain embodiments, TX MIMO processor **220** applies beamforming weights to the symbols of the data streams and to the antenna from which the symbol is being transmitted.

[0036] Each transmitter **222** receives and processes a respective symbol stream to provide one or more analog signals, and further conditions (e.g., amplifies, filters, and upconverts) the analog signals to provide a modulated signal suitable for transmission over the MIMO channel. N_T modulated signals from transmitters **222***a* through **222***t* are then transmitted from N_T antennas **224***a* through **224***t*, respectively.

[0037] At receiver system **250**, the transmitted modulated signals are received by N_R antennas **252***a* through **252***r* and the received signal from each antenna **252** is provided to a respective receiver (RCVR) **254***a* through **254***r*. Each receiver **254** conditions (e.g., filters, amplifies, and downconverts) a respective received signal, digitizes the conditioned signal to provide samples, and further processes the samples to provide a corresponding "received" symbol stream.

[0038] An RX data processor **260** then receives and processes the N_R received symbol streams from N_R receivers **254** based on a particular receiver processing technique to provide N_T "detected" symbol streams. The RX data processor **260** then demodulates, deinterleaves and decodes each detected symbol stream to recover the traffic data for the data stream. The processing by RX data processor **260** is complementary to that performed by TX MIMO processor **220** and TX data processor **214** at transmitter system **210**.

[0039] A processor **270** periodically determines which pre-coding matrix to use (discussed below). Processor **270** formulates a reverse link message comprising a matrix index portion and a rank value portion.

[0040] The reverse link message may comprise various types of information regarding the communication link and/or the received data stream. The reverse link message is then processed by a TX data processor **238**, which also receives traffic data for a number of data streams from a data source **236**, modulated by a modulator **280**, conditioned by transmitters **254***a* through **254***r*, and transmitted back to transmitter system **210**.

[0041] At transmitter system **210**, the modulated signals from receiver system **250** are received by antennas **224**, conditioned by receivers **222**, demodulated by a demodulator **240** and processed by a RX data processor **242** to extract the reserve link message transmitted by the receiver system **250**. Processor **230** then determines which pre-coding matrix to use for determining the beamforming weights then processes the extracted message.

[0042] In an aspect, logical channels are classified into Control Channels and Traffic Channels. Logical Control Channels comprise Broadcast Control Channel (BCCH) which is DL channel for broadcasting system control information. Paging Control Channel (PCCH) which is DL channel that transfers paging information. Multicast Control Channel (MCCH) which is Point-to-multipoint DL channel used for transmitting Multimedia Broadcast and Multicast Service (MBMS) scheduling and control information for one or several MTCHs. Generally, after establishing RRC connection this channel is only used by UEs that receive MBMS (Note: old MCCH+MSCH). Dedicated Control Channel (DCCH) is Point-to-point bi-directional channel that transmits dedicated control information and used by UEs having an RRC connection. In aspect, Logical Traffic Channels comprises a Dedicated Traffic Channel (DTCH) which is Point-

to-point bi-directional channel, dedicated to one UE, for the transfer of user information. Also, a Multicast Traffic Channel (MTCH) for Point-to-multipoint DL channel for transmitting traffic data.

[0043] In an aspect, Transport Channels are classified into DL and UL. DL Transport Channels comprise a Broadcast Channel (BCH), Downlink Shared Data Channel (DL-SDCH) and a Paging Channel (PCH), the PCH for support of UE power saving (DRX cycle is indicated by the network to the UE), broadcasted over entire cell and mapped to PHY resources which can be used for other control/traffic channels. The UL Transport Channels comprises a Random Access Channel (RACH), a Request Channel (REQCH), an Uplink Shared Data Channel (UL-SDCH) and plurality of PHY channels. The PHY channels comprise a set of DL channels and UL channels.

[0044] The DL PHY channels comprise:

[0045] Common Pilot Channel (CPICH)

[0046] Synchronization Channel (SCH)

[0047] Common Control Channel (CCCH)

[0048] Shared DL Control Channel (SDCCH)

[0049] Multicast Control Channel (MCCH)

[0050] Shared UL Assignment Channel (SUACH)

[0051] Acknowledgement Channel (ACKCH)

[0052] DL Physical Shared Data Channel (DL-PSDCH)

[0053] UL Power Control Channel (UPCCH)

[0054] Paging Indicator Channel (PICH)

[0055] Load Indicator Channel (LICH)

[0056] The UL PHY Channels comprise:

[0057] Physical Random Access Channel (PRACH)

[0058] Channel Quality Indicator Channel (CQICH)

[0059] Acknowledgement Channel (ACKCH)

[0060] Antenna Subset Indicator Channel (ASICH)

[0061] Shared Request Channel (SREQCH)

[0062] UL Physical Shared Data Channel (UL-PSDCH)

[0063] Broadband Pilot Channel (BPICH)

[0064] In an aspect, a channel structure is provided that preserves low PAR (at any given time, the channel is contiguous or uniformly spaced in frequency) properties of a single carrier waveform.

[0065] For the purposes of the present document, the following abbreviations apply:

[0066] AM Acknowledged Mode

[0067] AMD Acknowledged Mode Data

[0068] ARQ Automatic Repeat Request

[0069] BCCH Broadcast Control CHannel

[0070] BCH Broadcast CHannel

[0071] C- Control-

[0072] CCE Control Channel Element

[0073] CCCH Common Control CHannel

[0074] CCH Control CHannel

[0075] CCTrCH Coded Composite Transport Channel

[0076] CP Cyclic Prefix

[0077] CQI Channel Quality Indicator

[0078] CRC Cyclic Redundancy Check

[0079] CRS Common Reference Signal

[0080] CTCH Common Traffic CHannel

[0081] DCCH Dedicated Control CHannel

[0082] DCH Dedicated CHannel

[0083] DCI Downlink Control Information

[0084] DL DownLink

[0085] DRS Dedicated Reference Signal

[0086] DSCH Downlink Shared CHannel

[0087] DTCH Dedicated Traffic CHannel

[0088] E-CID Enhanced Cell IDentification

[0089] FACH Forward link Access CHannel

[0090] FDD Frequency Division Duplex

[0091] FSTD Frequency Switched Transmit Diversity

[0092] L1 Layer 1 (physical layer)

[0093] L2 Layer 2 (data link layer)

[0094] L3 Layer 3 (network layer)

[0095] LI Length Indicator

[0096] LLR Log-Likelihood Ratio

[0097] LSB Least Significant Bit

[0098] MAC Medium Access Control

[0099] MBMS Multimedia Broadcast Multicast Service

[0100] MCCH MBMS point-to-multipoint Control CHannel

[0101] MRW Move Receiving Window

[0102] MSB Most Significant Bit

[0103] MSCH MBMS point-to-multipoint Scheduling CHannel

[0104] MTCH MBMS point-to-multipoint Traffic CHannel

[0105] PCCH Paging Control CHannel

[0106] PCH Paging CHannel

[0107] PDU Protocol Data Unit

[0108] PHY PHYsical layer

[0109] PhyCH Physical CHannels

[0110] PMI Precoding Matrix Indicator

[0111] PRACH Physical Random Access CHannel

[0112] RACH Random Access CHannel

[0113] RLC Radio Link Control

[0114] RRC Radio Resource Control

[0115] RE Resource Element

[0116] RS Reference Signal

[0117] RTT Round Trip Time

[0118] Rx Receive

[0119] SAP Service Access Point

[0120] SDU Service Data Unit

[0121] SFBC Space Frequency Block Code

[0122] SHCCH SHared channel Control CHannel

[0123] SN Sequence Number

[0124] SUFI SUper FIeld

[0125] TA Timing Advance

[0126] TCH Traffic CHannel

[0127] TDD Time Division Duplex

[0128] TFI Transport Format Indicator

[0129] TM Transparent Mode

[0130] TMD Transparent Mode Data

[0131] TTI Transmission Time Interval

[0132] Tx Transmit

[0133] U- User-

[0134] UE User Equipment

[0135] UL UpLink

[0136] UM Unacknowledged Mode

[0137] UMD Unacknowledged Mode Data

[0138] UMTS Universal Mobile Telecommunications System

[0139] UTRA UMTS Terrestrial Radio Access

[0140] UTRAN UMTS Terrestrial Radio Access Network

[0141] MBSFN multicast broadcast single frequency network

[0142] MCE MBMS coordinating entity

[0143] MCH multicast channel

[0144] DL-SCH downlink shared channel

[0145] MSCH MBMS control channel

[0146] PDCCH physical downlink control channel

[0147] PDSCH physical downlink shared channel

[0148] FIG. **3** illustrates a system **300** that may transmit data and CRSs together, in accordance with certain aspects of the present disclosure. As will be described in greater detail below, the data may be initially mapped to resource elements (REs) that do not contain CRS for any base stations in a CoMP set. After this initial mapping (e.g., after exhausting the REs that are not used for CRS), data may be mapped to REs that are used for CRS. Such mapping may facilitate effectively communicating data in a CoMP configuration despite transmission of CRSs.

[0149] As illustrated, system **300** may includes access points **302** and **304** that can each be a base station, femtocell access point, picocell access point, relay node, mobile base station, mobile device operating in a peer-to-peer communications modes, and/or the like, for example, that provide access to a wireless network.

[0150] Access points **302** and **304** may provide CoMP network access to wireless device **306**. In one example, access points **302** and **304** can be in a CoMP set, which refers to a collection of access points that transmit to a given wireless device using CoMP. Wireless device **306** can be a mobile device, portion thereof, or substantially any device that can receive access to a wireless network. In addition, access points **302** and **304** can communicate with one another to provide the CoMP access (e.g., over a backhaul through a wireless network, over the air, etc.). It is to be appreciated, in an example, that access point **304** can comprise the components described in connection with access point **302** to provide similar functionality.

[0151] Access point **302** can include an RS location determining component **308** that receives (e.g., via a backhaul connection with other access points) or otherwise determines resource locations of RSs for access points in a CoMP set. The access point **302** may also include a data mapping component **310** that may be configured to select resource elements (REs) over which to map data transmissions. The AP **302** may also include a CoMP set indicating component **312** that may be configured to provide information regarding access points in a CoMP set to one or more wireless devices, including wireless device **306**.

[0152] Wireless device **306** may include components configured to perform complementary operations to those components of the AP **302**. As an example, the wireless device **306** may include a CoMP set receiving component **314** configured to receive information regarding a CoMP set of access points. The wireless device **306** may also include a decoding component **316** configured to decode data transmitted by the CoMP access points over a set of resources.

[0153] According to an example, the RS location determining component **308** may receive information regarding RS locations for other access points or related cells in a CoMP set, such as access point **304**. The RS location determining component **308**, for example, may receive this information from the access points, from a core wireless network, from wireless devices previously communicating with the access point **304**, and/or the like. In another example, RS location determining component **308** may compute RS locations for the access points based on an identifier thereof and/or of a related cell.

[0154] In any case, the data mapping component **310** may initially map data to selected REs that do not correspond to RS locations (of any access point in the CoMP set). If, after this initial mapping, there is still data to transmit, this remaining data may be mapped to REs that do correspond to RS locations. In this regard, much of the data can be transmitted without interference from RSs transmitted by access point in the CoMP set.

[0155] According to certain aspects, the CoMP set indicating component **312** can provide information regarding access points of the CoMP set to wireless device **306** (such as identifiers of the access points and/or related cells).

[0156] CoMP set receiving component **314** can obtain the CoMP set information and determine one or more RS locations related to the access points in the CoMP set. For example, CoMP set receiving component **314** can determine RS locations based at least in part on access point or related cell identifiers (e.g., by applying the same algorithm used by the access point to determine when to transmit the RS, by providing the identifier to a core network component that assigns resources for transmitting RSs, etc.).

[0157] The decoding component **316** can decode data based at least in part on knowing the RS resource locations, such that it can decode the RS and data over the RS resource locations, for example. According to certain aspects, the decoding component **316** may derive rate matching schemes for tones located in the symbols comprising CRS tones and decode data based on determining the CRS tones.

[0158] According to yet another example, access points **302** and **304** may transmit data regardless of the CRS transmissions such that when CRSs are transmitted, data resources are superimposed with the CRS. With knowledge of the CRS locations (e.g., determined based on the participating access points), the wireless device **306** may, thus, apply joint detection or interference cancellation (or other techniques) to decode those data tones overlapping with CRS tones from other cells participating in CoMP data transmissions.

[0159] FIG. **4** illustrates an example portion of resource blocks **400** in a communication frame. Access points in a CoMP set, as described, can transmit CRSs over resources selected as a function of cell identifier. In this example, access points in the CoMP set can transmit RSs over resource blocks **402**, **404**, **408** and **416**. As described in one example, an access point can receive information regarding RS locations for access points in the CoMP set.

[0160] As will be described in greater detail below, the access point may initially map data transmissions over resource blocks **406**, **410**, **412**, **414** and **418** to avoid mapping during CRS transmissions, as described. In this example, devices receive data transmissions over the resource elements that are free from CRS interference in resource blocks **406**, **410**, **412**, **414** and **418**. It is to be appreciated that where additional resource blocks are needed, the access point can then map over the resource blocks corresponding to RS locations.

[0161] FIG. **5** illustrates a methodology **500** that decodes data from signals received from CoMP access points. The operations may be performed, for example, by the receiving and decoding components **314** and **316** of the wireless device **306**.

[0162] At **502**, a CoMP signal comprising a CRS superimposed over data can be received. The CoMP signal can be received from various CoMP access points, as described. At **504**, tones in the signal that correspond to the CRS can be determined.

[0163] As described above, the tones may be determined using joint detection, interference cancellation, and/or the like. In another example, the tones can be determined based at least in part on computing resource locations of the CRS based on received access point or related cell identifiers, as described. Moreover, for example, rate matching schemes related to the CRS tones can be derived or decoded based on

the determined CRS resource locations. At **506**, data can be decoded from the signal based at least in part on determining the CRS tones.

[0164] FIG. **6** illustrates a methodology **600** that facilitates mapping data for transmission over resources other than those used for transmitting CRS. The operations may be performed, for example, by the RS location determining and data mapping components **310** and **312** of the access point **302**.

[0165] At **602**, RS locations related to one or more CoMP access points transmitting CRS can be received. As described, the RS locations can be received from the CoMP access points, a wireless network, etc., and/or computed based on identifiers of access point in the CoMP set. At **604**, data transmissions can be initially mapped over resources not relating to the resource locations of the CRS. Thus, for example, data can be mapped to initially avoid such resources to mitigate interference from the CRS of access points in the CoMP set.

[0166] FIG. **7** illustrates example operations **700** that may be performed, for example, by the access point **302**, to transmit data superimposed with CRS. The operations may be described with reference to FIGS. **8** and **9**.

[0167] The operations begin, at **702**, by mapping data transmissions initially over resources not relating to the resource locations of the CRS. For example, as illustrated in FIG. **8**, data (illustrated with a label "D" and cross-hatching) may be first mapped to REs **406** and **410** that do not relate to REs for CRS.

[0168] If there is not more data to map, as determined at block **704**, the data may be transmitted (at **708**) without using resources related to REs for CRS. On the other hand, if there is more data, at **706**, the remaining data transmissions may be mapped over resources relating to the resource locations of the CRS.

[0169] For example, as illustrated in FIG. **9**, the additional data may be mapped to REs **402** and **404** that do relate to REs for CRS. According to certain aspects, in order to mitigate interference, a serving access point may first map data to RE locations related to CRS for other access points in a CoMP set.

[0170] It is understood that the specific order or hierarchy of steps in the processes disclosed is an example of exemplary approaches. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the processes may be rearranged while remaining within the scope of the present disclosure. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[0171] Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0172] Those of skill would further appreciate that the various illustrative logical blocks, modules, circuits and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

[0173] The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0174] The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

[0175] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present disclosure. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the disclosure. Thus, the present disclosure is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

What is claimed is:

1. A method for wireless communications, comprising:

receiving a signal from access points in a coordinated multiple point (CoMP) communication set, the signal comprising a common reference signal (CRS) superimposed over data;

determining CRS locations in the signal that correspond to the CRS; and

decoding data from the signal based at least in part on the determined CRS locations.

2. The method of claim **1**, wherein the decoding comprises:

utilizing joint detection, based on knowledge of the determined CRS locations, over the signal to extract tones related to the CRS.

3. The method of claim **2**, further comprising:

receiving an indication of access points participating in CoMP; and

determining the CRS locations based on the indication.

4. The method of claim 3, further comprising:
deriving rate matching schemes for CRS tone locations of non-serving access points in the CoMP set, based on a serving cell CRS transmission; and
decoding data superimposed on CRS tone locations of the non-serving access points.

5. The method of claim 1, wherein the decoding comprises utilizing interference cancelation over the signal to cancel tones related to the CRS.

6. A method for wireless communications, comprising:
determining reference signal (RS) resource locations related to one or more access points in a coordinated multiple point (CoMP) set transmitting a common reference signal (CRS);
mapping data transmissions initially over a first set of resources that do not correspond to determined RS resource locations; and
mapping remaining data transmissions over a second set of resources that correspond to determined RS resource locations.

7. The method of claim 6, wherein mapping remaining data transmissions comprises mapping remaining data transmissions over resources that correspond to determined RS resource locations only after exhausting resource locations that do not correspond to determined RS resource locations.

8. The method of claim 6, wherein mapping remaining data transmissions comprises mapping remaining data transmissions initially to resource elements that correspond to determined RS resource locations used by access points in the CoMP set other than a serving access point.

9. The method of claim 6, wherein the determining the RS resource locations comprises computing the RS resource locations based at least in part on identifiers of the one or more access points or related cells.

10. The method of claim 6, further comprising providing an indication to one or more access points of access points participating in coordinated multiple point (CoMP) communication.

11. The method of claim 10, wherein the indication is provided via a physical downlink control channel (PDCCH).

12. An apparatus for wireless communications, comprising:
at least one processor configured to:
receive a signal from access points in a coordinated multiple point (CoMP) communication set, the signal comprising a common reference signal (CRS) superimposed over data,
determine CRS locations in the signal that correspond to the CRS, and
decode data from the signal based at least in part on the determined CRS locations; and
a memory coupled to the at least one processor.

13. The apparatus of claim 12, wherein the at least one processor configured to decode is further configured to:
utilize joint detection, based on knowledge of the determined CRS locations, over the signal to extract tones related to the CRS.

14. The apparatus of claim 13, wherein the at least one processor is further configured to:
receive an indication of access points participating in CoMP; and
determine the CRS locations based on the indication.

15. The apparatus of claim 14, wherein the at least one processor is further configured to:
derive rate matching schemes for CRS tone locations of non-serving access points in the CoMP set, based on a serving cell CRS transmission; and
decode data superimposed on CRS tone locations of the non-serving access points.

16. The apparatus of claim 12, wherein the at least one processor configured to decode is further configured to utilize interference cancelation over the signal to cancel tones related to the CRS.

17. An apparatus for wireless communications, comprising:
at least one processor configured to:
determine reference signal (RS) resource locations related to one or more access points in a coordinated multiple point (CoMP) set transmitting a common reference signal (CRS),
map data transmissions initially over a first set of resources that do not correspond to determined RS resource locations, and
map remaining data transmissions over a second set of resources that correspond to determined RS resource locations; and
a memory coupled to the at least one processor.

18. The apparatus of claim 17, wherein the at least one processor configured to map remaining data transmissions is also configured to map remaining data transmissions over resources that correspond to determined RS resource locations only after exhausting resource locations that do not correspond to determined RS resource locations.

19. The apparatus of claim 17, wherein the at least one processor configured to map remaining data transmissions is further configured to map remaining data transmissions initially to resource elements that correspond to determined RS resource locations used by access points in the CoMP set other than a serving access point.

20. The apparatus of claim 17, wherein the at least one processor configured to determine the RS resource locations is further configured to compute the RS resource locations based at least in part on identifiers of the one or more access points or related cells.

21. The apparatus of claim 17, the at least one processor is further configured to provide an indication to one or more access points of access points participating in coordinated multiple point (CoMP) communication.

22. The apparatus of claim 21, wherein the indication is provided via a physical downlink control channel (PDCCH).

23. An apparatus for wireless communications, comprising:
means for receiving a signal from access points in a coordinated multiple point (CoMP) communication set, the signal comprising a common reference signal (CRS) superimposed over data;
means for determining CRS locations in the signal that correspond to the CRS; and
means for decoding data from the signal based at least in part on the determined CRS locations.

24. The apparatus of claim 23, wherein the means for decoding comprises:
means for utilizing joint detection, based on knowledge of the determined CRS locations, over the signal to extract tones related to the CRS.

25. The apparatus of claim 24, further comprising:
means for receiving an indication of access points participating in CoMP; and

means for determining the CRS locations based on the indication.

26. The apparatus of claim **25**, further comprising:

means for deriving rate matching schemes for CRS tone locations of non-serving access points in the CoMP set, based on a serving cell CRS transmission; and

means for decoding data superimposed on CRS tone locations of the non-serving access points.

27. The apparatus of claim **23**, wherein the means for decoding comprises means for utilizing interference cancelation over the signal to cancel tones related to the CRS.

28. An apparatus for wireless communications, comprising:

means for determining reference signal (RS) resource locations related to one or more access points in a coordinated multiple point (CoMP) set transmitting a common reference signal (CRS);

means for mapping data transmissions initially over a first set of resources that do not correspond to determined RS resource locations; and

means for mapping remaining data transmissions over a second set of resources that correspond to determined RS resource locations.

29. The apparatus of claim **28**, wherein the means for mapping remaining data transmissions comprises means for mapping remaining data transmissions over resources that correspond to determined RS resource locations only after exhausting resource locations that do not correspond to determined RS resource locations.

30. The apparatus of claim **28**, wherein the means for mapping remaining data transmissions comprises means for mapping remaining data transmissions initially to resource elements that correspond to determined RS resource locations used by access points in the CoMP set other than a serving access point.

31. The apparatus of claim **28**, wherein the means for determining the RS resource locations comprises means for computing the RS resource locations based at least in part on identifiers of the one or more access points or related cells.

32. The apparatus of claim **28**, further comprising:

means for providing an indication to one or more access points of access points participating in coordinated multiple point (CoMP) communication.

33. The apparatus of claim **32**, wherein the indication is provided via a physical downlink control channel (PDCCH).

34. A computer-program product for wireless communications, comprising a computer readable medium having instructions stored thereon, the instructions being executable by one or more processors and the instructions comprising:

instructions for receiving a signal from access points in a coordinated multiple point (CoMP) communication set, the signal comprising a common reference signal (CRS) superimposed over data;

instructions for determining CRS locations in the signal that correspond to the CRS; and

instructions for decoding data from the signal based at least in part on the determined CRS locations.

35. The computer-program product of claim **34**, wherein the instructions for decoding comprise:

instructions for utilizing joint detection, based on knowledge of the determined CRS locations, over the signal to extract tones related to the CRS.

36. The computer-program product of claim **35**, further comprising:

instructions for receiving an indication of access points participating in CoMP; and

instructions for determining the CRS locations based on the indication.

37. The computer-program product of claim **36**, further comprising:

instructions for deriving rate matching schemes for CRS tone locations of non-serving access points in the CoMP set, based on a serving cell CRS transmission; and

instructions for decoding data superimposed on CRS tone locations of the non-serving access points.

38. The computer-program product of claim **34**, wherein the instructions for decoding comprise instructions for utilizing interference cancelation over the signal to cancel tones related to the CRS.

39. A computer-program product for wireless communications, comprising a computer readable medium having instructions stored thereon, the instructions being executable by one or more processors and the instructions comprising:

instructions for determining reference signal (RS) resource locations related to one or more access points in a coordinated multiple point (CoMP) set transmitting a common reference signal (CRS);

instructions for mapping data transmissions initially over a first set of resources that do not correspond to determined RS resource locations; and

instructions for mapping remaining data transmissions over a second set of resources that correspond to determined RS resource locations.

40. The computer-program product of claim **39**, wherein the instructions for mapping remaining data transmissions comprise instructions for mapping remaining data transmissions over resources that correspond to determined RS resource locations only after exhausting resource locations that do not correspond to determined RS resource locations.

41. The computer-program product of claim **39**, wherein the instructions for mapping remaining data transmissions comprise instructions for mapping remaining data transmissions initially to resource elements that correspond to determined RS resource locations used by access points in the CoMP set other than a serving access point.

42. The computer-program product of claim **39**, wherein the instructions for determining the RS resource locations comprise instructions for computing the RS resource locations based at least in part on identifiers of the one or more access points or related cells.

43. The computer-program product of claim **39**, further comprising:

instructions for providing an indication to one or more access points of access points participating in coordinated multiple point (CoMP) communication.

44. The computer-program product of claim **43**, wherein the indication is provided via a physical downlink control channel (PDCCH).

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18/089,999	**09/25/2024 06:06:40 PM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	67323837	FILING DATE	12/28/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 100

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ZL0205-0002-PCT-US-CON2 RCE amendment.pdf	10	Response After Final Action	115 KB
RCE TRANSMITTAL 2024-8-26.pdf	3	Request for Continued Examination (RCE)	681 KB
ZL0205-0002-PCT-US-CON2_IDS 1.pdf	30	Information Disclosure Statement (IDS) Form (SB08)	605 KB
ZL0205-0002-PCT-US-CON2_IDS 2.pdf	8	Information Disclosure Statement (IDS) Form (SB08)	600 KB
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Digest

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APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**09/25/2024 06:06:40 PM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	67323837	AUTHORIZED BY	-
CUSTOMER #	155075	FILING DATE	12/28/2022
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Xiaobo ZHANG

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
CARD / 9633	**E20249OJ26438003**	**Jialin Zhong**

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
1251	EXTENSION FOR RESPONSE WITHIN FIRST MONTH	220.00	1	220.00
1801	REQUEST FOR CONTINUED EXAMINATION (RCE) - 1ST REQUEST (SEE 37 CFR 1.114)	1360.00	1	1360.00
			TOTAL AMOUNT:	**$1,580.00**

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New International Application Filed with the USPTO as a Receiving Office

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US 20060164981A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2006/0164981 A1

Olsson et al. (43) Pub. Date: Jul. 27, 2006

(54) METHOD FOR PROCESSING TRAFFIC DATA IN A WIRELESS COMMUNICATIONS SYSTEM

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(21) Appl. No.: **11/043,434**

(22) Filed: **Jan. 26, 2005**

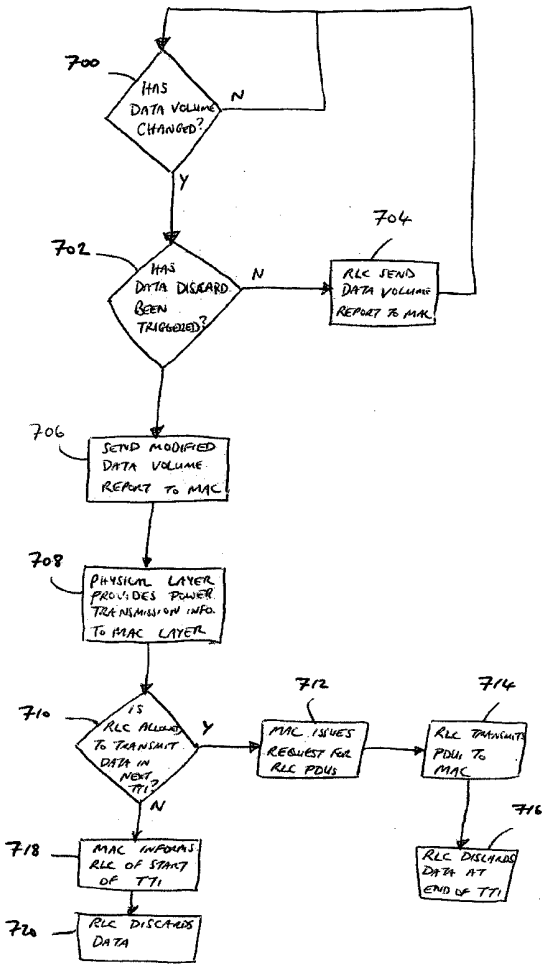
Publication Classification

(51) **Int. Cl.**
H04L 12/26 (2006.01)

(52) **U.S. Cl.** **370/229**; 370/469

(57) **ABSTRACT**

The present invention concerns a method of processing traffic data in Layer 2 of a wireless communications system, whereby the MAC layer is arranged, after receipt of a traffic data volume report from the RLC layer, to process said data volume report and to then issue an acknowledgement message to the RLC layer. The method ensures that the RLC and MAC layers are synchronised with respect to traffic data processing. The MAC layer may be arranged to issue an acknowledgement to the RLC layer only where it determines from processing a data volume report that the RLC layer is not permitted to transmit data in a next or subsequent corresponding TTI. The present invention also concerns a process for data discard in a Radio Link Control (RLC) layer of a Wideband Code Division Multiple Access (WCDMA) wireless communications system such as a Universal Mobile Telecommunications System (UMTS). The process involves, responsive to the triggering of a data discard operation, determining whether the RLC layer is permitted to transmit data. Where it is determined that the RLC layer is not permitted to transmit data in a next or subsequent TTI, the method includes the step of informing the RLC layer that data is not required.



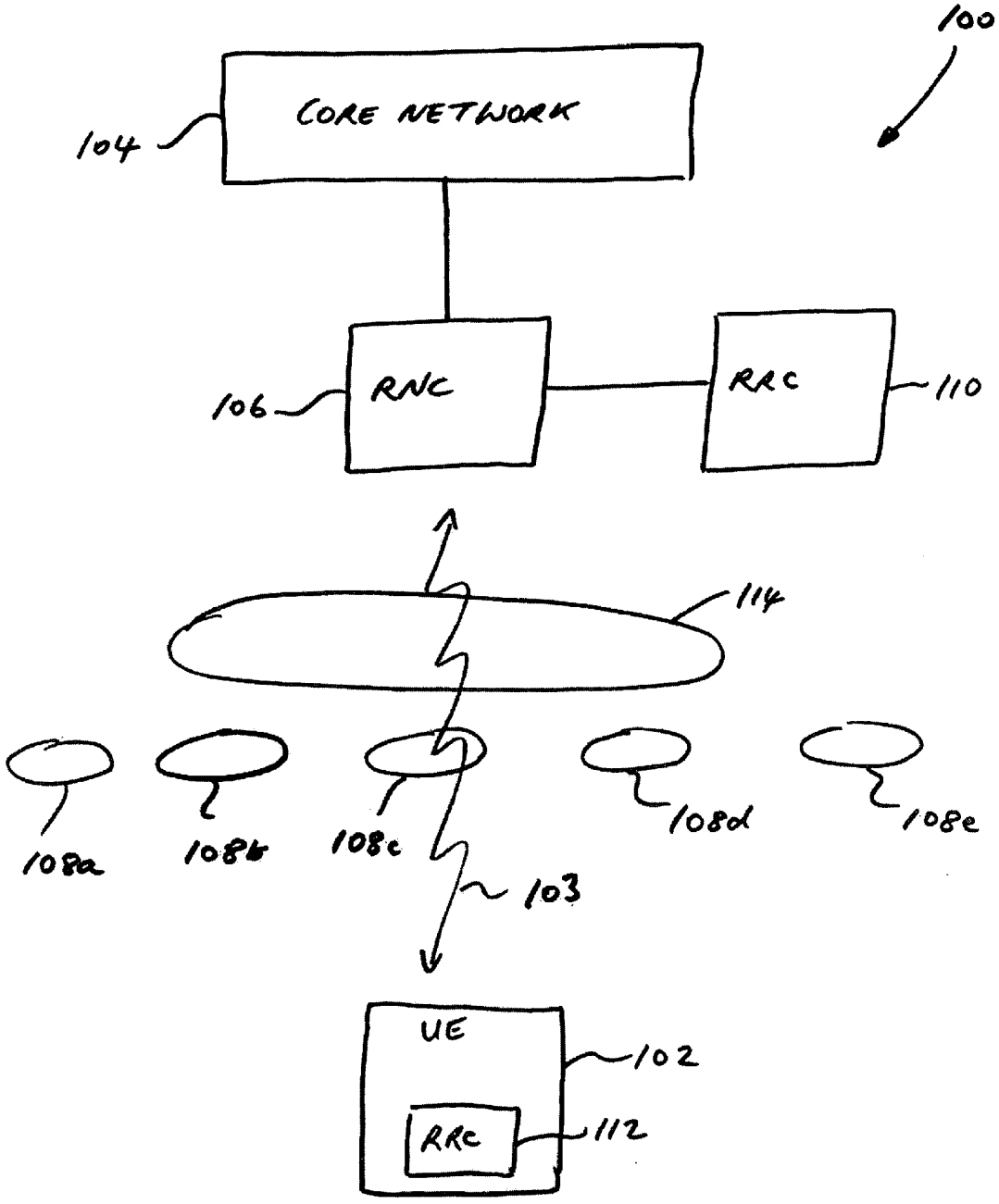

100
CORE NETWORK
104
RNC
106
RRC
110
114
108a
108b
108c
108d
108e
103
UE
102
RRC
112

FIGURE 1.

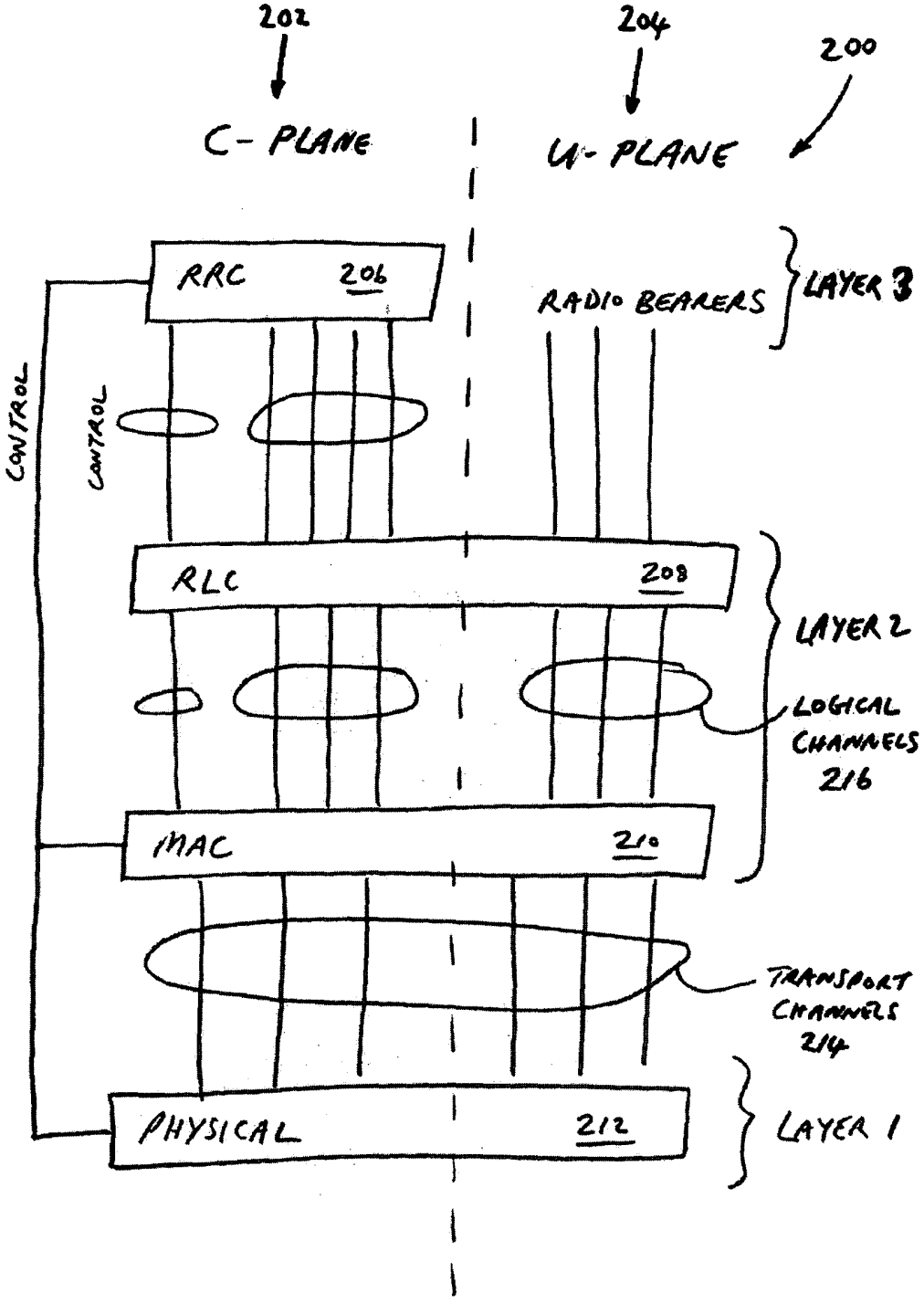

202
204
200
C- PLANE
U- PLANE
RRC 206
RADIO BEARERS
LAYER 3
CONTROL
CONTROL
RLC 208
LAYER 2
LOGICAL CHANNELS 216
MAC 210
TRANSPORT CHANNELS 214
PHYSICAL 212
LAYER 1

FIGURE 2

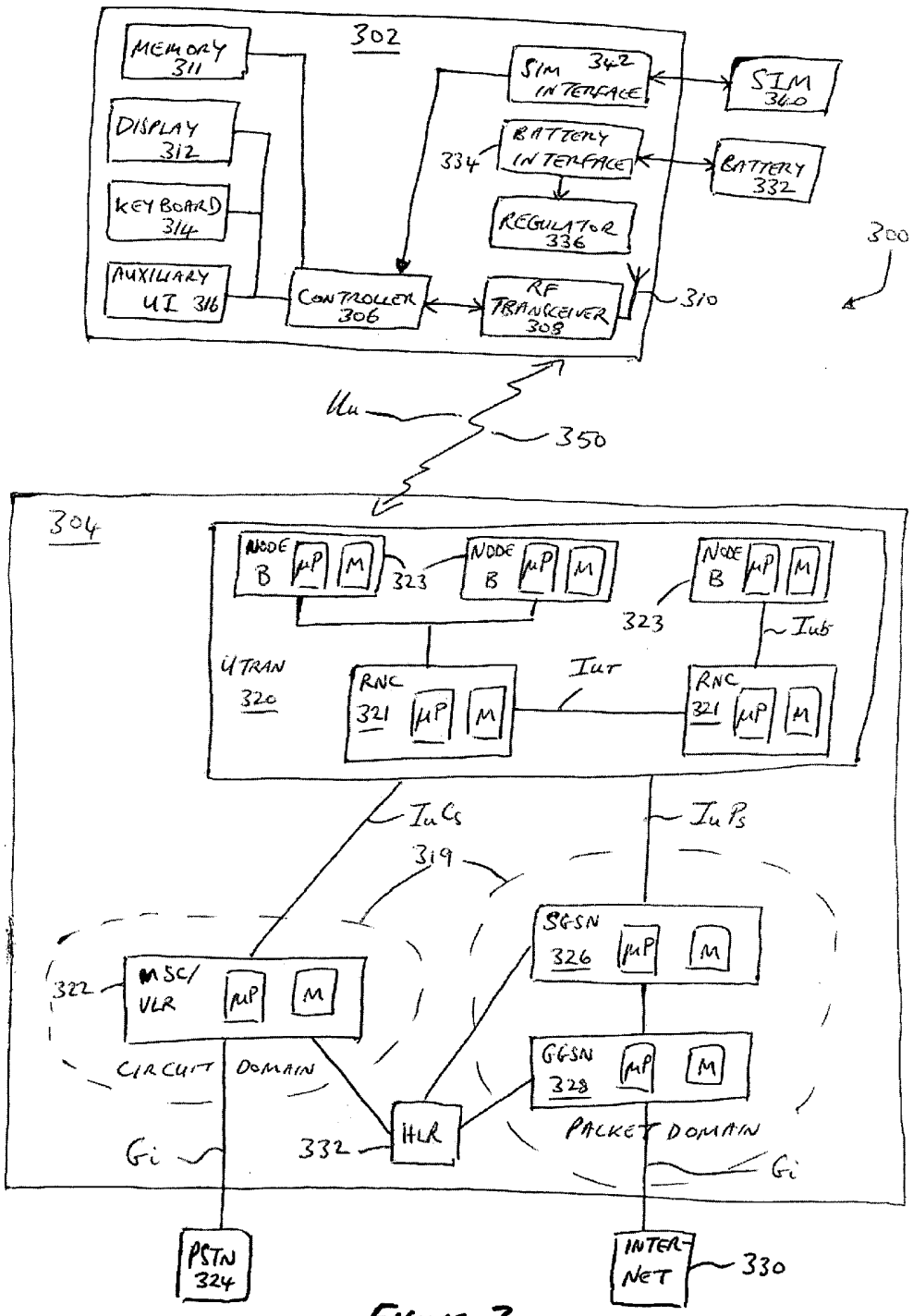

302
MEMORY 311
DISPLAY 312
KEY BOARD 314
AUXILIARY UI 316
CONTROLLER 306
SIM INTERFACE 342
SIM 340
BATTERY INTERFACE 334
BATTERY 332
REGULATOR 336
RF TRANSCEIVER 308
310
300
Uu
350
304
NODE B
323
UTRAN 320
RNC 321
Iur
Iub
IuCs
IuPs
319
MSC/ VLR
322
SGSN 326
GGSN 328
CIRCUIT DOMAIN
PACKET DOMAIN
HLR
332
Gi
PSTN 324
INTERNET
330

FIGURE 3

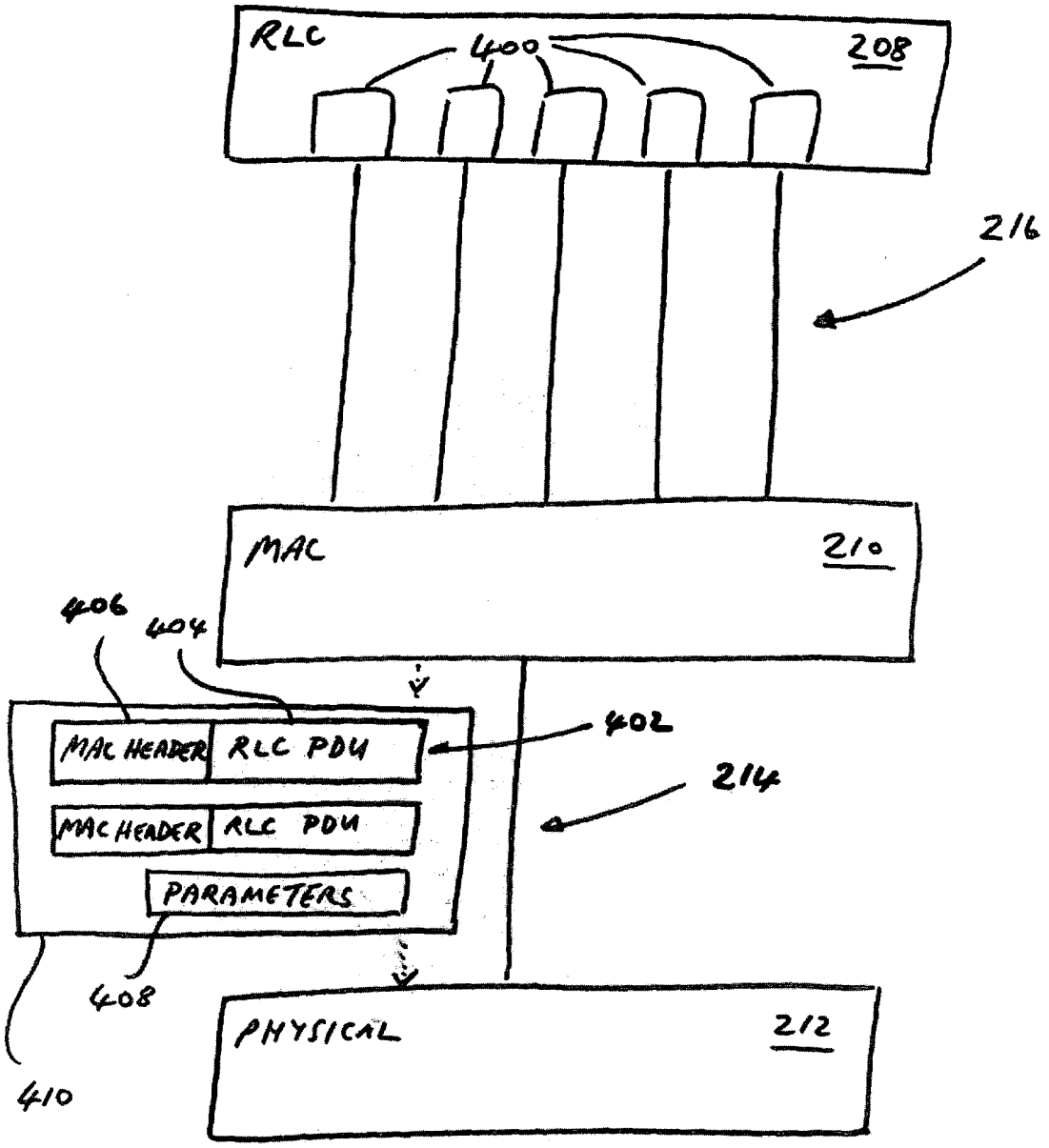

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400
208
216
MAC
210
406
404
MAC HEADER
RLC PDU
402
214
MAC HEADER
RLC PDU
PARAMETERS
408
410
PHYSICAL
212

FIGURE 4

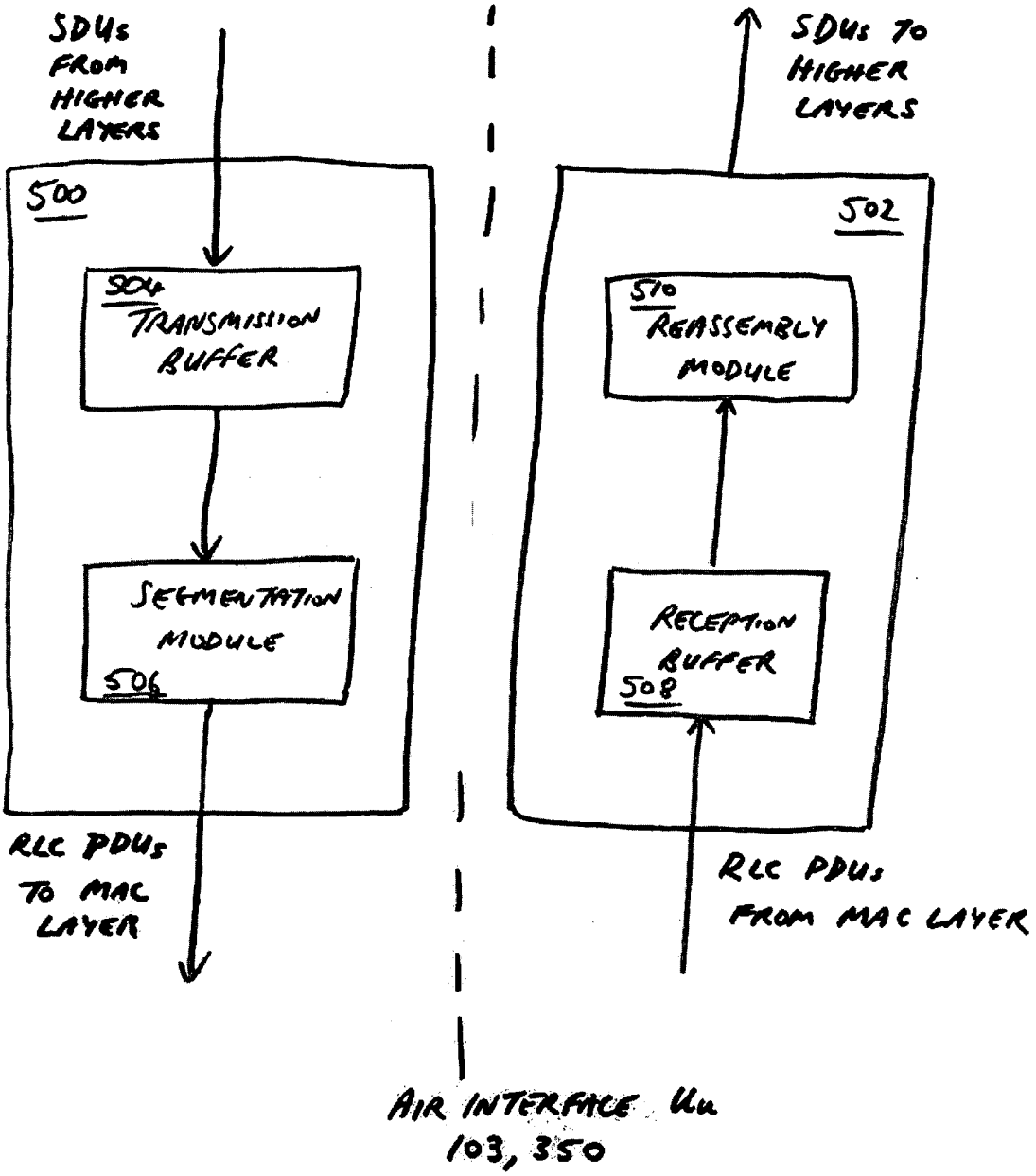

SDUs FROM HIGHER LAYERS
500
504 TRANSMISSION BUFFER
SEGMENTATION MODULE 506
RLC PDUs TO MAC LAYER
SDUs TO HIGHER LAYERS
502
510 REASSEMBLY MODULE
RECEPTION BUFFER 508
RLC PDUs FROM MAC LAYER
AIR INTERFACE Uu 103, 350

FIGURE 5

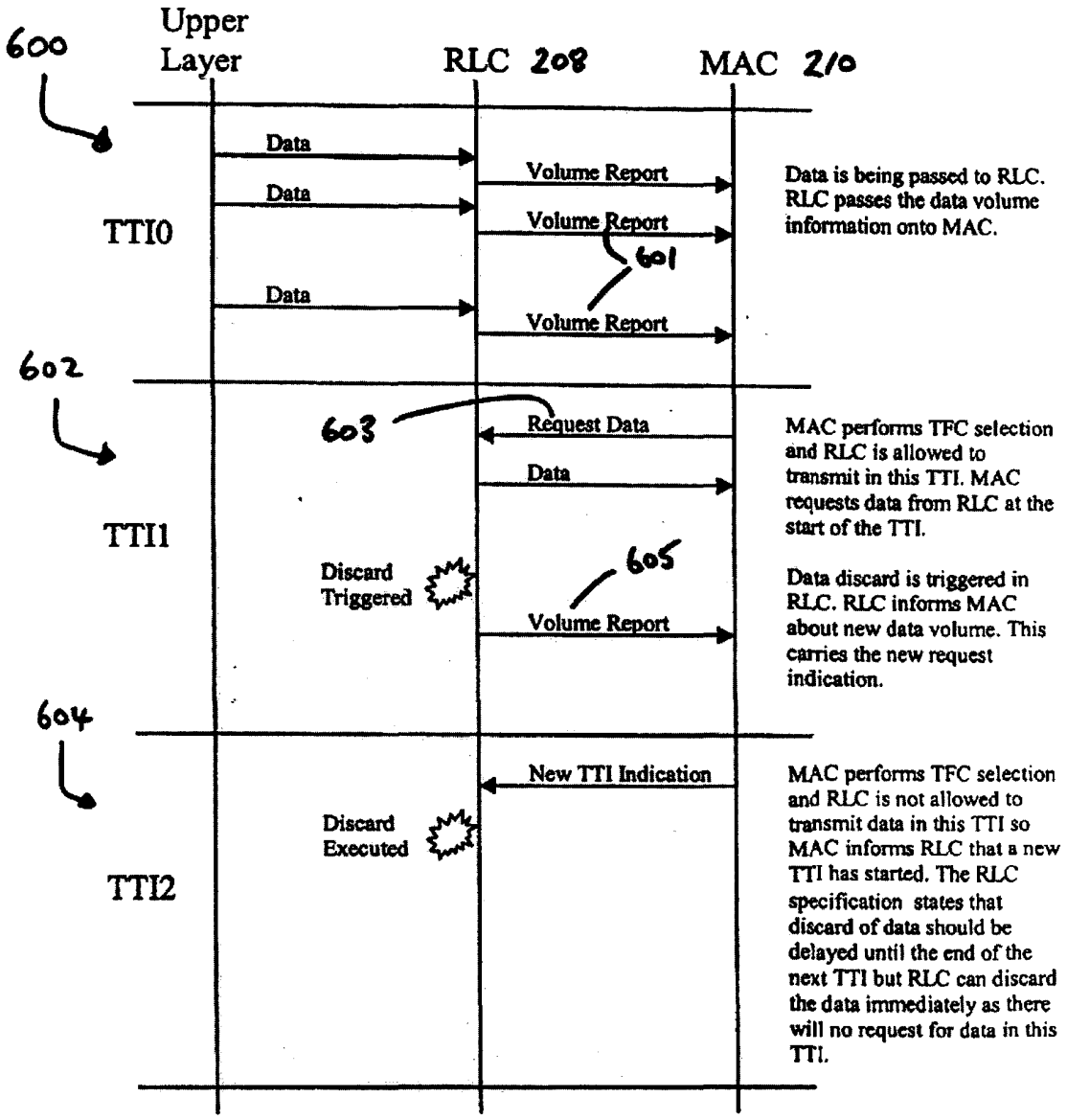

600
Upper Layer
RLC 208
MAC 210
Data
Data
Volume Report
Volume Report
Data is being passed to RLC. RLC passes the data volume information onto MAC.
TTI0
601
Data
Volume Report
602
603
Request Data
Data
MAC performs TFC selection and RLC is allowed to transmit in this TTI. MAC requests data from RLC at the start of the TTI.
TTI1
Discard Triggered
605
Volume Report
Data discard is triggered in RLC. RLC informs MAC about new data volume. This carries the new request indication.
604
New TTI Indication
MAC performs TFC selection and RLC is not allowed to transmit data in this TTI so MAC informs RLC that a new TTI has started. The RLC specification states that discard of data should be delayed until the end of the next TTI but RLC can discard the data immediately as there will no request for data in this TTI.
Discard Executed
TTI2

FIGURE 6.

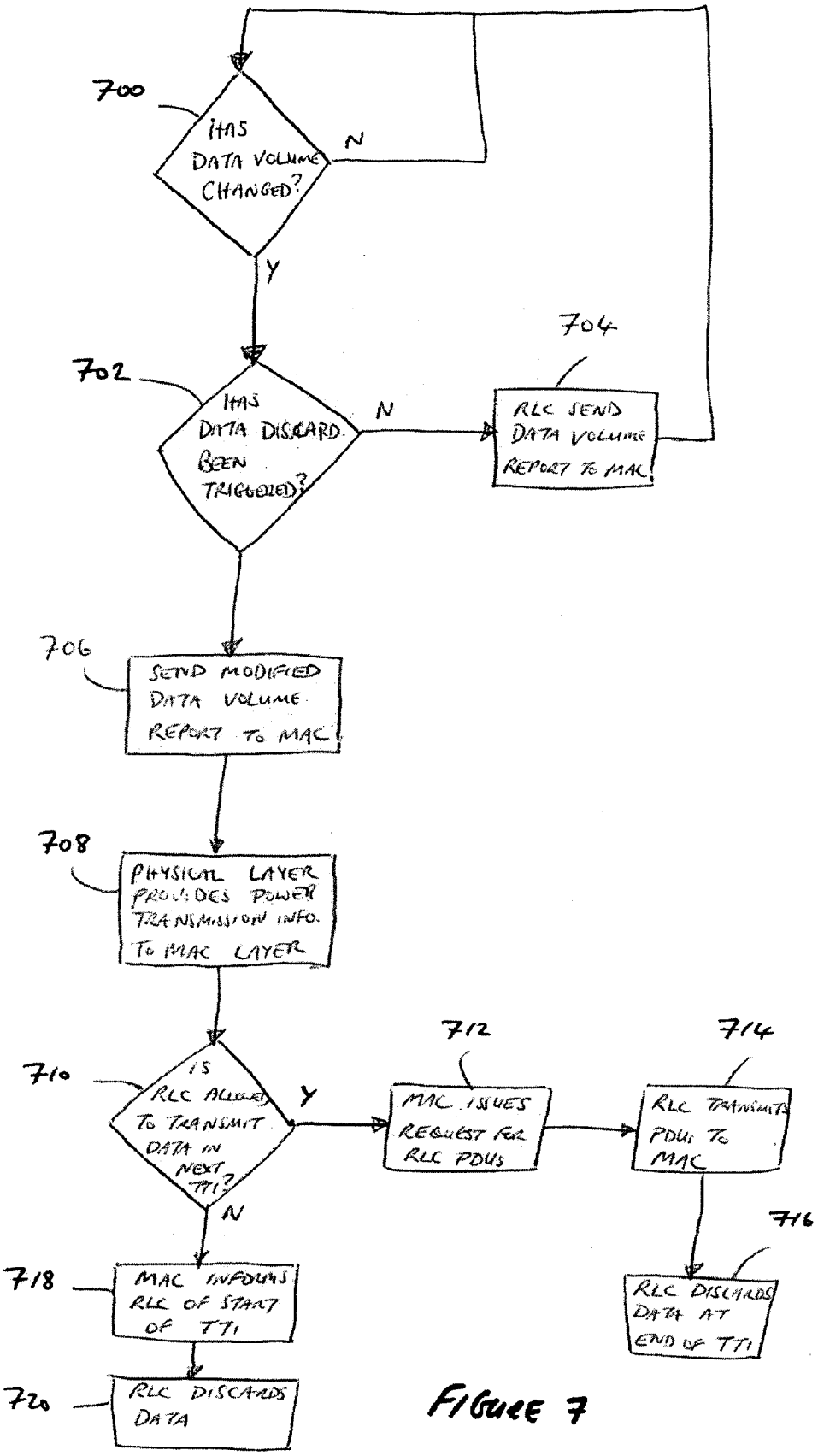

700
HAS DATA VOLUME CHANGED?
N
Y
702
HAS DATA DISCARD BEEN TRIGGERED?
N
704
RLC SEND DATA VOLUME REPORT TO MAC
706
SEND MODIFIED DATA VOLUME REPORT TO MAC
708
PHYSICAL LAYER PROVIDES POWER TRANSMISSION INFO. TO MAC LAYER
710
IS RLC ALLOWED TO TRANSMIT DATA IN NEXT TTI?
Y
N
712
MAC ISSUES REQUEST FOR RLC PDUs
714
RLC TRANSMITS PDUs TO MAC
716
RLC DISCARDS DATA AT END OF TTI
718
MAC INFORMS RLC OF START OF TTI
720
RLC DISCARDS DATA

FIGURE 7

METHOD FOR PROCESSING TRAFFIC DATA IN A WIRELESS COMMUNICATIONS SYSTEM

FIELD OF THE INVENTION

[0001] The present invention comprises an improved method for processing traffic data at Layer 2 in a wireless communications system and particularly, but not exclusively to an improved process for data discard in a Radio Link Control (RLC) layer of a Wideband Code Division Multiple Access (WCDMA) wireless communications system such as a Universal Mobile Telecommunications System (UMTS). Background to the Invention.

[0002] The UMTS network architecture consists of three components, namely the Core Network, the UMTS Terrestrial Radio Access Network (UTRAN) and the User Equipment (UE). In UTRAN, three protocol layers are specified. These comprise: Layer 1, the physical layer which uses WCDMA on the radio link interface; Layer 2, the link layer containing Medium Access Control (MAC), Radio Link Control (RLC) and Packet Data Convergence Protocol (PDCP) sub-layers; and Layer **3**, the Radio Resource Control (RRC) which exists in the control plane only. These layers are mirrored in the UE at the other end of the radio link with the UTRAN.

[0003] The physical layer transforms radio frames between the Node B and the UE. One radio frame, which may include several RLC Packet Data Units (PDUs), is sent during each Transmission Time Interval (TTI). Through an attribute of the transport format, the MAC layer decides by means of a Transport Format Combination (TFC) selection process which PDUs to send in each TTI. Three types of service are provided by the RLC protocol comprising Transparent Mode (TM), Unacknowledged Mode (UM) and Acknowledged Mode (AM). The RRC is responsible for the transport format and also determines the transmission mode of the RLC.

[0004] The RLC performs segmentation/reassembly of RLC Service Data Units (SDUs), into/from smaller RLC PDUs. The three RLC operations needed to make flow control more efficient are a polling mechanism, a status transmission mechanism and a SDU discard mechanism.

[0005] The SDU discard function allows the sender (UTRAN or UE) to discard RLC SDUs when the transmission of the RLC SDUs does not succeed for a period of time or for a number of transmissions. The SDU discard function therefore helps avoid buffer overflow which might result in following RLC SDUs being discarded as a result of the buffer being full. There are several alternative operation modes of the RLC data discard function. Upper layers control which operation mode is used for each RLC entity. The data discard operation modes include, for example, "timer based discard with explicit signalling" applicable to AM transmission only and "timer based discard without explicit signalling" applicable to TM and UM transmission. SDU discard function is always configured for AM transmission, but may not always be configured for TM and UM transmission.

[0006] SDUs buffered in the RLC layer which are to be discarded should not, however, be discarded where the MAC layer has started its TFC selection. When TFC selection has started, the RLC layer delays discarding the data until the end of the next TTI. The problem encountered with this process is that the RLC layer is not made aware of when the MAC layer has started its TFC selection. The RLC layer will receive an indication from the MAC layer when a TFC selection has ended and the RLC layer is required to provide the MAC layer with data for the corresponding TTI. However, when no data from the RLC layer is to be transmitted in that corresponding TTI, the MAC layer does not send any indication of end of TFC selection to the RLC layer. This may occur for a number of consecutive TTIs and thus, since the RLC layer does not receive any indication from the MAC layer of end of TFC selection for the series of TTIs, the RLC layer cannot discard the data during that time. This impacts the Quality of Service (QoS) offered by the RLC layer as data will not be discarded as specified. Also, new data being received in the RLC layer from upper layers may be discarded as a result of RLC buffer overflow whilst the RLC layer awaits an indication from the MAC layer of end of TFC selection.

OBJECT OF THE INVENTION

[0007] It is an object of the invention to mitigate and/or obviate problems associated with the existing arrangement as described above.

[0008] It is a further object of the invention to minimise the time between the RLC layer triggering a data discard operation and actually performing the discard operation.

SUMMARY OF THE INVENTION

[0009] In a first main aspect, the present invention provides a method of processing traffic data in a medium access control (MAC) layer of a wireless communications system, the method comprising the steps of: receiving a traffic data volume report at the MAC layer; processing said data volume report; and following processing of said report, issuing an acknowledgement message to the entity from which the report was received. The entity issuing the data volume report comprises a radio link control (RLC) layer of the wireless communications system.

[0010] Preferably, the MAC layer is arranged to issue an acknowledgement message to the entity from which the report was received only where it is determined from the data volume report that said entity is not permitted to transmit traffic data to the MAC layer in a next or subsequent corresponding transmission time interval (TTI).

[0011] In a second main aspect, the present invention provides a method of discarding data in a radio link control (RLC) layer of a wireless communications system, comprising the steps of: triggering a data discard operation in a first transmission time interval (TTI); determining for a next or a subsequent TTI whether the RLC layer is permitted to transmit data; and where the determination is made that the RLC layer is not permitted to transmit data in the next or subsequent TTI, the method includes the steps of: informing the RLC layer that data is not required; and performing the data discard operation.

[0012] Consequently, the present invention mitigates the problem associated with the current SDU discard process whereby the data discard operation may, in effect, be suspended for a series of consecutive TTIs.

[0013] Preferably, the RLC layer is informed that data is not required for the next or subsequent TTI after completion of a current Transport Format Combination (TFC) selection process.

[0014] Preferably, the data discard operation is performed immediately upon the RLC layer being informed that data is not required.

[0015] Advantageously, this reduces the time delay between a data discard operation being triggered and being performed and reduces the likelihood of following SDUs from upper layers being discarded through RLC buffer overflow.

[0016] The method may include arranging for a Medium Access Control (MAC) layer to inform the RLC layer that data is not required. The indication that data is not required may comprises an indication of the start of the next TTI.

[0017] Preferably, the triggering of the data discard operation in the first TTI causes said RLC layer to issue a request to said MAC layer in said first TTI for the MAC layer to inform the RLC layer that data is not required for the next or subsequent TTI.

[0018] The request issued by said RLC layer in said first TTI may be contained in a data volume report.

[0019] In a third main aspect, the present invention provides a radio network controller (RNC) for a wireless communications network, comprising: means for triggering a data discard operation in a first transmission time interval (TTI); means for determining for a next or a subsequent TTI whether the RLC layer is permitted to transmit data; means responsive to said determining means and being arranged where said determining means determines that the RLC layer is not permitted to transmit data in the next or subsequent TTI to inform the RLC layer that data is not required; and means for performing the data discard operation.

[0020] In a fourth main aspect, the present invention provides a user equipment (UE) for a wireless communications network, comprising: means for triggering a data discard operation in a first transmission time interval (TTI); means for determining for a next or a subsequent TTI whether the RLC layer is permitted to transmit data; means responsive to said determining means and being arranged where said determining means determines that the RLC layer is not permitted to transmit data in the next or subsequent TTI to inform the RLC layer that data is not required; and means for performing the data discard operation.

[0021] The user equipment may comprise a mobile communications device.

[0022] In a fifth main aspect, the present invention provides a computer readable medium comprising code means executable on a processor of the radio network controller in accordance with the third main aspect for implementing the methods of the first and second main aspects.

[0023] In a sixth main aspect, the present invention provides a computer readable medium comprising code means executable on a processor of the user equipment of the fourth main aspect for implementing the methods of the first and second main aspects.

[0024] Further aspects and features of the present invention will be apparent from the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] A description of the present invention will follow with reference to the accompanying drawings, of which:

[0026] **FIG. 1** is a block schematic diagram of a UTRAN system architecture;

[0027] **FIG. 2** is a block schematic diagram illustrating a radio interface protocol architecture for the air interface between a UE and the UTRAN;

[0028] **FIG. 3** is a block schematic diagram which illustrates components of the UE and the UMTS network;

[0029] **FIG. 4** is a is a block schematic diagram illustrating a part of the radio interface protocol architecture of **FIG. 2**;

[0030] **FIG. 5** is a block schematic diagram illustrating the RLC entities for TM transmission;

[0031] **FIG. 6** illustrates messages exchanged between the RLC and MAC layers with respect to successive transmission time intervals (TTIs) in accordance with the data discard process of the present invention; and

[0032] **FIG. 7** is a flow diagram illustrating the steps of the data discard process of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0033] The foregoing and further features of the present invention will be more readily understood from a description of a preferred embodiment, by way of example thereof, with reference to the accompanying figures.

[0034] The so-called third generation mobile communications system is presently evolving. This is a next generation global mobile communications system that is generally based on the core network technology of the existing Global System for Mobile Communications (GSM). Various telecommunications standards bodies and telecommunications equipment vendors from around the world have agreed to collaborate on what is known as the Third Generation Partnership Project (3GPP). The 3GPP encompasses a number of research fields including the Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (UTRAN). UMTS is the European form of the third generation mobile communications system.

[0035] The following description of the UTRAN with reference to FIGS. **1** to **5** is provided as background to the present invention and by way of explanation thereof.

[0036] Referring to **FIG. 1**, a UTRAN **100** connects a User Equipment (UE) **102** over a wireless interface **103** to a core network **104** which provides services to subscribers (users of UEs). The UE **102** may comprise a mobile wireless device as will be familiar to a skilled artisan. The UE **102** is connected to the core network **104** through a Radio Network Controller (RNC) **106** which controls a plurality of cells **108***a-e* within which the UE **102** can operate as it moves within respective geographical areas of said cells **108***a-e*.

The UTRAN **100** comprises a number of RNCs **106** although only one is shown in the figure for reasons of convenience.

[0037] Each of the RNC **106** and the UE **102** has a respective Radio Resource Controller **110**, **112** associated therewith. The RNC RRC **110** provides various functions including establishment, maintenance and release of radio access resources for UEs **102** within the cells controlled by the RNC RRC **110** and may include an information broadcast function for all such UEs **102**. The UE RRC **112** co-operates with the RNC RRC **110** to establish, maintain and release radio access resources allocated to its UE **102**.

[0038] Each cell **108***a-e* comprises a respective geographical area in which radio coverage is provided by a respective base station commonly referred to as a Node B (not shown) located within said cell. The Node B's are controlled by their respective RNCs **110**.

[0039] In the UTRAN **100**, cells **108***a-e* can be grouped to provide what might be considered a higher level cell or geographical coverage. A UTRAN Registration Area (URA) **11** may comprise one or more of cells **108***a-e* controlled by an RNC **110** or a number of cells from different RNCs, although the URA **114** as illustrated in **FIG. 1** is shown as comprising cells **108***b-d* for reasons of convenience. There can be many URAs although only one is illustrated.

[0040] Referring now to **FIG. 2**, shown is a 3GPP radio interface protocol architecture **200** for the air interface **103** between the UE **102** and the RNC **106**. The protocol architecture **200** comprises a control plane (C-plane) **202** and a user plane (U-plane) **204**. The C-plane **202** is used for signalling and the U-plane **204** for transmission of user information. The C-plane **202** includes a RRC layer **206** at Layer **3** of the protocol architecture, a Radio Link Control (RLC) layer **208** and a Medium Access Control (MAC) layer **210** at Layer 2 and a physical layer **212** at Layer 1 thereof. The U-plane **204** shares the RLC layer **208** and the MAC layer **210** at Layer 2.

[0041] The physical layer **212** provides the MAC layer **210** with transport channels **214** whilst the MAC layer **210** provides the RLC layer **208** with logical channels **216**. Logical control channels are provided when information for the C-plane **202** is to be transported and traffic channels are provided when user information on the U-plane **204** is to be transported. The MAC layer **210** also provides a radio resource reconfiguration service when the RNC RRC **110** requests a radio resource reconfiguration or a MAC parameter change.

[0042] The RLC layer **208** provides radio access establishment and release services. The RNC RRC **110** controls the Layer 3 signal processing between the RNC **104** and the UE **102** to establish, maintain and release radio access resources (radio bearers) between the UE **102** and UTRAN **100**.

[0043] The air interface protocol layers as aforedescribed provide many other services and perform many other functions as will be familiar to a skilled artisan and as described in the 3GPP specifications relating to the air interface architecture protocol stack.

[0044] **FIG. 3** is a block diagram of a communication system **300**, which includes a UE **302** that communicates through a wireless communication network **304**. UE **302** preferably includes a visual display **312**, a keyboard **314**, and perhaps one or more auxiliary user interfaces (UI) **316**, each of which is coupled to a controller **306**. Controller **306** is also coupled to radio frequency (RF) transceiver circuitry **308** and an antenna **310**.

[0045] Typically, controller **306** is embodied as a central processing unit (CPU), which runs operating system software in a memory component **311**. Controller **306** will normally control overall operation of UE **302**, whereas signal processing operations associated with communication functions are typically performed in RF transceiver circuitry **308**. Controller **306** interfaces with UE display **312** to display received information, stored information, user inputs, and the like. Keyboard **314**, which may be a telephone type keypad or full alphanumeric keyboard, is normally provided for entering data for storage in UE **302**, information for transmission to network **304**, a telephone number to place a telephone call, commands to be executed on mobile device **302**, and possibly other or different user inputs.

[0046] UE **302** sends communication signals to and receives communication signals from network **304** over a wireless link (air interface) **350** via antenna **310**. RF transceiver circuitry **308** performs functions such as modulation/demodulation and possibly encoding/decoding and encryption/decryption.

[0047] UE **302** includes a battery interface **334** for receiving one or more rechargeable batteries **332**. Battery **332** provides electrical power to electrical circuitry in UE **302**, and battery interface **332** provides for a mechanical and electrical connection for battery **332**. Battery interface **332** is coupled to a regulator **336**, which regulates power to the device. When UE **302** is fully operational, an RF transmitter of RF transceiver circuitry **308** is typically keyed or turned on only when it is sending to a network, and is otherwise turned off to conserve resources. Similarly, an RF receiver of RF transceiver circuitry **308** is typically periodically turned off to conserve power until it is needed to receive signals or information (if at all) during designated time periods.

[0048] UE **302** operates using a Subscriber Identity Module (SIM) **340** which is connected to or inserted in UE **302** at a SIM interface **342**. SIM **340** is one type of a conventional "smart card" used to identify an end user (or subscriber) of UE **302** and to personalize the device, among other things. Without SIM **340**, the UE terminal is not fully operational for communication through wireless network **304**. By inserting SIM **340** into UE **302**, an end user can have access to any and all of his/her subscribed services. SIM **340** generally includes a processor and memory for storing information. Since SIM **340** is coupled to SIM interface **342**, it is coupled to controller **306** through communication lines **344**. In order to identify the subscriber, SIM **340** contains some user parameters such as an International Mobile Subscriber Identity (IMSI). An advantage of using SIM **340** is that end users are not necessarily bound by any single physical mobile device (UE). SIM **340** may store additional user information for the mobile device as well, including datebook (or calendar) information and recent call information.

[0049] UE **302** may consist of a single unit, such as a data communication device, a cellular telephone, a multiple-

function communication device with data and voice communication capabilities, a personal digital assistant (PDA) enabled for wireless communication, or a computer incorporating an internal modem. Alternatively, UE **302** may be a multiple-module unit comprising a plurality of separate components, including but in no way limited to a computer or other device connected to a wireless modem. In particular, for example, in the mobile device block diagram of **FIG. 3**, RF transceiver circuitry **308** and antenna **310** may be implemented as a radio modem unit that may be inserted into a port on a laptop computer. In this case, the laptop computer would include display **312**, keyboard **314**, one or more auxiliary UIs **316**, and controller **306** embodied as the computer's CPU. It is also contemplated that a computer or other equipment not normally capable of wireless communication may be adapted to connect to and effectively assume control of RF transceiver circuitry **308** and antenna **310** of a single-unit device such as one of those described above.

[0050] UE **302** communicates in and through wireless communication network **304**. In the embodiment of **FIG. 3**, wireless network **304** comprises a UMTS network. The UMTS network **304** comprises a UTRAN **320** and a core network **319** comprising a Mobile Switching Center (MSC) **322** (which may include a Visitor Location Register for roaming UEs), a Home Location Register (HLR) **332**, a Serving General Packet Radio Service (GPRS) Support Node (SGSN) **326**, and a Gateway GPRS Support Node (GGSN) **328**. MSC **322** is coupled to UTRAN **320** and to a landline network, such as a Public Switched Telephone Network (PSTN) **324**. SGSN **326** is coupled to UTRAN **320** and to GGSN **328**, which is in turn coupled to a public or private data network **330** (such as the Internet). HLR **332** is coupled to MSC **322**, SGSN **326**, and GGSN **328**. Each of the devices and systems comprising the UTRAN **320** and the core network has a memory (M) and a micro-processor (μP) for respectively storing and executing software code to implement their specified processes and, where appropriate, the improved data discard process in accordance with the invention.

[0051] UTRAN **320** comprises a number of Radio Network Controllers (RNCs) **321** which each serve respective Node Bs **323**, in a manner familiar to the skilled artisan. Also shown in **FIG. 3** are the designations of the interfaces between the various components of the wireless access network **304** using the recognized designations from the GPRS and UMTS specifications.

[0052] Node Bs **323** of UTRAN **320** provide wireless network coverage for UEs **302** within their respective cells under control of their respective RNCs **321** in accordance with UMTS protocols and parameters.

[0053] The wireless link **350** of **FIG. 3** represents one or more different channels, typically radio bearer or logical channels, between UEs **302** and UTRAN **320**.

[0054] Those skilled in the art will appreciate that a wireless network **304** in actual practice may include hundreds of cells, each served by a Node B **323**, depending upon desired overall expanse of network coverage. All pertinent components may be connected by multiple switches and routers (not shown), controlled by multiple network controllers.

[0055] For all UEs **302** registered with a network operator, permanent data (such as UE **302** user's profile) as well as temporary data (such as UE's **102** current location) are stored in HLR **332**. In case of a voice call to UE **302**, HLR **332** is queried to determine the current location of UE **302**. The VLR of MSC **322** is responsible for a group of location areas and stores the data of those UEs that are currently in its area of responsibility. This includes parts of the permanent UE data that have been transmitted from HLR **332** to the VLR for faster access. However, the VLR of MSC **322** may also assign and store local data, such as temporary identifications. Optionally, the VLR of MSC **322** can be enhanced for more efficient co-ordination of GPRS and non-GPRS services and functionality (e.g. paging for circuit-switched calls which can be performed more efficiently via SGSN **326**, and combined GPRS and non-GPRS location updates).

[0056] Serving GPRS Support Node (SGSN) **326** is at the same hierarchical level as MSC **322** and keeps track of the individual locations of UEs. SGSN **326** also performs security functions and access control. Gateway GPRS Support Node (GGSN) **328** provides interworking with external packet-switched networks and is connected with SGSNs (such as SGSN **326**) via an IP-based GPRS backbone network. SGSN **326** performs authentication and cipher setting procedures based on the same algorithms, keys, and criteria as in existing GSM and UMTS as appropriate. In conventional operation, cell selection may be performed autonomously by UE **302** or the RNC **321** responsible for the device **302** instructing it to select a particular cell. UE **302** informs wireless network **304** when it reselects another cell or group of cells, known as a routing area.

[0057] In order to access GPRS services, UE **302** first makes its presence known to wireless network **304** by performing what is known as a GPRS "attach". This operation establishes a logical link between UE **302** and SGSN **326** and makes UE **302** available to receive, for example, pages via SGSN, notifications of incoming data, or SMS messages over GPRS. In order to send and receive data, UE **302** assists in activating the packet data address that it wants to use. This operation makes UE **302** known to GGSN **328** such that interworking with external data networks can thereafter commence. User data may be transferred transparently between UE **302** and the external data networks using, for example, encapsulation and tunneling. Data packets are equipped with GPRS-specific protocol information and transferred between UE **302** and GGSN **328** via UTRAN **320**.

[0058] Those skilled in the art will appreciate that a wireless network may be connected to other systems, possibly including other networks, not explicitly shown in **FIG. 3**. A network will normally be transmitting at the very least some sort of paging and system information on an ongoing basis, even if there is no actual packet data exchanged. Although the network consists of many parts, these parts all work together to result in certain behaviours at the wireless link.

[0059] Referring now to **FIG. 2** and also to **FIG. 4**, in the MAC layer **210**, multiple logical channels **216** from RLC entities **400** can be multiplexed to a single transport channel **214**. The transport channel **214** defines the way traffic from said logical channels **216** is sent to the physical layer **212** for transmission on the air interface **103**, **350** between the node B **323** and UE **102**, **302**. The basic data unit exchanged

between the MAC layer **210** and the physical layer **212** is called a Transport Block (TB) **402**. It comprises one or more RLC PDUs **404** with a MAC header **406**.

[**0060**] A set of TBs **402** and associated parameters **408** exchanged between the MAC layer **210** and the physical layer **212** during a TTI using the same transport channel **214** is called a Transport Block Set (TBS) **410**. Attributes of a TBS **410** such as TB size, TBS size, type/rate of coding and duration of TTI for a specific transport channel comprise a Transport Format (TF). A transport channel **214** can support different instantaneous bit rates, each of which has an associated TF.

[**0061**] For each transport channel **214** at each TTI, the MAC layer **210** will choose an appropriate TF. Normally, there will be a plurality of transport channels **214** and so the combinations of TFs for said channels **214** comprises a Transport Format Combination (TFC) which is identified by a TFC Indicator (TFCI). A set of all TFCs permitted by the network **100**, **304** comprises a TFC Set (TFCS). The network **100**, **304** provides to the UE **102**, **302** the TFCS to be used by the UE on an uplink part of the air interface **103**, **350**.

[**0062**] TFC selection is performed at the MAC layer in both the RNC**106**, **321** and the UE **102**, **302**. In each case, the RNC and UE MAC layers will choose an appropriate TFC for every TTI based on the status of logical channels **216** and the provided radio resources of the transport channels **214**.

[**0063**] Each logical channel **216** is managed by a RLC entity **400** on each side of the air interface **103**, **350**. In the case of TM transmission, each TM RLC channel, as illustrated in **FIG. 5**, embodied in each of the RNC **106**, **321** and UE **102**, **302** may comprise a transmitting TM entity **500** and a receiving TM entity **502**. The transmitting TM entity **500** comprises a transmission buffer **504** which may be embodied as a Random Access Memory (RAM) or the like in each of the RNC **106**, **321** and UE **102**, **302** and a segmentation module **506** which may be embodied as a processor executing suitable software in each of said RNC and UE. The receiving entity **502** comprises a reception buffer **508** which may be embodied as a RAM and a reassembly module **510** which may be embodied as a processor. For each of the RNC and UE, the RAM and processor embodying their respective reception buffers **508** and the reassembly modules **510** may comprise the same RAM and processor used to implement the transmission buffer **504** and the segmentation module **504**.

[**0064**] SDUs from higher layers are received at the RLC layer **208** and buffered in the transmission buffers **504** of the transmitting entities **500**. If segmentation is not configured then such RLC SDUs are transferred as RLC PDUs to the MAC layer **210**. However, if segmentation is configured, then oversized RLC SDUs are segmented into smaller RLC PDUs prior to being transferred. The RLC PDUs are transferred by the RLC entities **400** without the addition of headers. The receiving entities **502** reassemble the RLC SDUs from the RLC PDUs received over the air interface **103**, **350** and buffered in the reception buffers **508** of the receiving TM entities **502**. RLC entities **400** operating TM transmission may be configured to operate SDU discard whereby SDUs received in the RLC TM transmitting entities **500** that are not transmitted within a predetermined period of time are discarded from the transmission buffers **504**.

[**0065**] Accordingly, each such RLC TM transmitting entity **500** starts a timer known as Timer_Discard for each SDU received from upper layers, schedules the RLC SDUs that have been received from upper layers for transmission and notifies the MAC layer **210** of reception of data from the upper layers. If one or more RLC SDUs have been scheduled for transmission, the transmitting entity **500** informs the MAC layer **210** of the number and size of SDUs available for transmission and, when requested, submits to the MAC layer a requested number of TM RLC PDUs or an SDU. RLC SDUs that are not submitted to the MAC layer **210** are buffered in the transmission buffer **504**.

[**0066**] Upon expiry of the timer Timer_Discard in the transmitting entity **500**, the transmitting entity **500** will discard the timed out RLC SDU from the transmission buffer **504**. However, in accordance with the existing 3GPP specifications, in the case where the TFC selection process in the MAC layer **210** has been initiated, the RLC layer is required to wait until after it has transferred the requested RLC PDUs to the MAC layer **210** before discarding timed out RLC SDUs. Therefore, the RLC layer **208** effectively suspends the intended data discard operation until it receives a request from the MAC layer **210** for RLC PDUs indicating that the MAC layer **210** has completed the TFC selection process for the corresponding TTI. The RLC layer **208** may delay discarding the timed out RLC SDUs until the end of a next TTI.

[**0067**] The MAC layer **210** does not provide any indication to the RLC layer **208** of when it has started a TFC selection process for a TTI or when the TTI has commenced. The RLC layer **208** will only receive an indication that the MAC layer **210** has completed a TFC selection process for a TTI when the RLC layer **204** receives from the MAC layer **210** a request for RLC PDUs. Consequently, where the MAC layer **210** does not issue a request for data from the RLC layer **208** for one or more consecutive TTIs, the RLC layer **208** must await such an indication for a subsequent TTI in which the MAC layer **210** does then issue a request for data before completing the suspended data discard operation.

[**0068**] The present invention in a first aspect provides an improved method of processing traffic data in Layer 2 whereby the MAC layer **210** is arranged, after receipt of a traffic data volume report from the RLC layer **208**, to process said data volume report and to then issue an acknowledgement message to the RLC layer **208** indicating that the MAC layer has received and processed that data volume report. This improved method ensures that the RLC and MAC layers are synchronised with respect to traffic data processing whereby each is using the same data volume report in contrast to the conventional method whereby the MAC layer receives data volume reports from the RLC layer, processes them but issues no acknowledgement messages to the RLC layer in respect of such processing. Thus, in the conventional arrangement, the RLC layer asynchronously transmits a series of traffic data volume reports to the MAC layer as and when the data volume changes but receives no indication from the MAC layer of which of the series of such reports it is using for processing traffic data. The MAC layer may be arranged to issue an acknowledgement to the RLC layer only where it determines from processing a data volume report that the RLC layer is not permitted to transmit data in a next or subsequent corresponding TTI. Where the MAC

layer determines from processing a data volume report that the RLC layer is permitted to transmit data, it may be arranged to operate in a conventional manner whereby it does not issue any acknowledgement to the RLC layer that it has received and/or processed said data volume report. In a second aspect, the present invention provides an improved data discard process whereby the MAC layer **210** is arranged, after receipt of a reduced data volume report from the RLC layer **208**, to indicate to the RLC layer **208** whether data from the RLC layer **208** is required or not for a next or subsequent TTI. The indication that data is not required may comprise the acknowledgement from the MAC layer that it has processed the reduced data volume report. It may also comprise an indication that a new TTI has started. Where the MAC layer **210** is currently performing a TFC selection process when a reduced data volume report is received, the indication that data is not required is provided after the TFC selection process is completed. Where, after receiving the reduced data volume report, the MAC layer determines that data is required from the RLC layer for a next or subsequent TTI, the MAC layer may be arranged to issue no acknowledgement to the RLC layer on completion of processing the received reduced data volume report thereby causing the RLC layer to operate in a conventional manner. The improved data discard process of the invention need only be invoked where the MAC layer determines from processing a data volume report from the RLC layer that data is not required from the RLC layer for the next or a specified subsequent TTI and issuing an acknowledgement in respect of processing this report. The improved data discard process of the invention can better be understood with reference to **FIG. 6** which illustrates, by way of example only, messages exchanged between the RLC and MAC layers with respect to successive TTIs.

[**0069**] During a first TTI **600**, designated as "TTI**0**" for convenience, as upper layer SDUs (data) are being received at the RLC layer **208**, the RLC layer **208** sends a data volume report **601** to the MAC layer **210** when the data volume in the TM RLC transmission entity transmission buffers **504** changes. The data volume report may consist of the number of bytes (or bits) available for transmission from that RLC entity. The data volume report may also contain PDU sizes as TFC selection may differ depending on say whether two 20 byte PDUs are available rather than one 40 byte PDU. Several such reports may be issued by the RLC layer during a TTI.

[**0070**] The physical layer **212** is arranged to inform the MAC layer **210** each time it is ready to receive data for a new TTI. The MAC layer **210** executes a TFC selection for this TTI and, if the RLC layer **208** is permitted to transmit data, the MAC layer **210** will issue a request **603** to the RLC layer **208** for such data, as illustrated in a second TTI **602**, designated as "TTI**1**" in **FIG. 6**. The RLC layer **208** responds to the MAC request by transmitting the requested RLC PDUs to the MAC layer. Whilst the execution of the TFC selection process and the provision of data by the RLC layer are illustrated in **FIG. 6** as occurring at the start of TTI**1** (**602**) and a next TTI **604** designated as "TT**12**", it will be appreciated that, in practice, the MAC layer starts a TFC selection process for a corresponding TTI and issues a request for data in advance of the start of said corresponding TTI and the RLC layer also provides the requested data in advance of the start of said TTI. This is necessary to ensure that data requested by the MAC layer is delivered to the physical layer in time for transmission in said corresponding TTI. The TFC selection process and data provision steps may be performed a number of radio frames in advance of said TTI which may comprises one or more TTIs.

[**0071**] When the RLC layer **208** is triggered to discard data through timing out of a RLC SDU, for example, the RLC layer **208** passes a further (reduced) data volume report **605** to the MAC layer **210**. This may include an indication to the MAC layer **210** that the RLC layer **208** is to be informed whether data is required or not in a next or subsequent corresponding TTI. The indication that data is not required may comprise an acknowledgement that MAC has completed processing of this data volume report (and determined that the RLC is not permitted to transmit data for a specified TTI) or an indication of when the next TTI starts. The further reduced data volume report consists of the new amount of data available for transmission and may include a flag to indicate that the RLC needs to know whether data is required or not. The new data volume will not include the bytes for the RLC SDU which is to be discarded, i.e. the data volume will have decreased. The MAC layer **210** may use the flag the next time it starts a TFC selection process. As illustrated in **FIG. 6**, the RLC layer will delay performing the triggered data discard operation until after an indication that MAC does not require data has been received in TT**12** (**604**).

[**0072**] If in TT**12** the RLC layer is permitted to transmit data then the MAC layer may be arranged not to issue an acknowledgement to the RLC layer that it has processed the reduced data volume report thereby causing the RLC layer to behave in a conventional manner. This has no negative impact on traffic data processing since the RLC layer is permitted to transmit data on this occasion. If, on the other hand as illustrated in the figure, in TTI**2** the RLC layer is not permitted to transmit data, then in the conventional arrangement the MAC layer would not issue a request for data to the RLC layer resulting in the RLC layer being unaware that the next TTI **604** has started thereby delaying the data discard operation until at least the occurrence of a subsequent TTI in which the RLC layer is permitted to transmit data and thus receives a request for data from the MAC layer. However, in accordance with the present invention as illustrated by way of example only in **FIG. 6**, where the RLC layer is not permitted to transmit data in a next or subsequent corresponding TTI **604**, the MAC layer responds to the reduced volume report issued by the RLC layer after data discard was triggered by informing the RLC layer, after its next TFC selection process for the next or a subsequent TTI **604**, whether data from the RLC layer is required for this TTI **604**. In this example where the RLC is not permitted to transmit data, the MAC layer informs the RLC layer that data is not required for this TTI **604**. The data not required indication comprises, in this example, an indication that the TTI **604** has started, but it may comprise any indication that results in the RLC layer determining that data is not required for that TTI. The RLC layer is arranged to then perform the data discard operation at least before the end of that TTI **604** and preferably immediately upon being informed of the start of that TTI **604**. The RLC layer is able to immediately discard the data to be discarded since it knows that the MAC layer will not request any RLC PDUs for that TTI **604**. Consequently, the delay in discarding data is significantly

reduced and also the problem of RLC data discard being effectively suspended for a series of consecutive TTIs is obviated.

[0073] In the case where the MAC layer **210** receives the reduced data volume report **605** from the RLC layer **208** between TFC selection processes, the MAC layer **210** may be arranged to respond immediately to the flag contained in the reduced data volume report rather than after a next TFC selection to indicate to the RLC layer **208** that data is not required for the next or a subsequent TTI. The RLC layer can then immediately perform the data discard operation in that same TTI.

[0074] Referring now to **FIG. 7**, shown is a flow diagram representative of the improved data discard process in accordance with the invention.

[0075] In a first step **700**, a determination is made as to whether data volumes in the RLC transmission entity transmission buffers **504** have changed. The determination step may be triggered by the arrival of upper layer SDUs at the RLC layer **208** or by the triggering of a data discard operation.

[0076] If it is determined that the data volume of a transmission entity transmission buffer **504** has changed, then in a next step **702** a determination is made as to whether a data discard operation has been triggered by timing out of a buffered SDU, for example. In the case where it is determined that a data discard operation has not been triggered, the method comprises, as a next step **704**, sending a data volume report from the RLC layer to the MAC layer. The method then returns to step **700**.

[0077] However, if it is determined at step **702** that a data discard has been triggered then, as a next step **706**, a modified (reduced) data volume report is sent to the MAC layer. The modified data volume report contains a request (flag) from the RLC layer to the MAC layer to inform it whether data will be required or not from the RLC for a next or a subsequent corresponding TTI, the MAC layer being arranged to inform the RLC of whether data is required or not after it has completed a next TFC selection process for that TTI. In the following description of the process illustrated by **FIG. 7**, it will be assumed that an indication that data is not required comprises an indication of the start of the next TTI.

[0078] In a next step **708**, the physical layer provides the MAC layer with transmission power information which is used by the MAC layer when performing a TFC selection process for the next or subsequent corresponding TTI. In a next step **710**, the MAC layer determines whether the RLC layer is permitted to transmit data in that TTI. In the case that the determination is true, i.e. that the RLC layer is permitted to transmit data, the MAC layer issues a request (step **712**) to the RLC layer for RLC PDUs. The RLC layer transmits (step **714**) the requested PDUs to the MAC layer and discards (step **716**) the data at the end of that TTI.

[0079] However, where it is determined at step **708** that the RLC layer is not permitted to transmit data, the MAC layer informs (step **718**) the RLC layer of commencement of the TTI and the RLC layer performs (step **720**) the discard operation before the end of the TTI. Preferably, the RLC layer performs the data discard operation immediately upon being informed of the start of the TTI.

[0080] The foregoing description of a RLC transmitting entity and the improved RLC data discard process in accordance with the invention was provided in relation to the RLC operating in TM transmission. It should be noted, however, that in the case of UM transmission, the UM RLC entities (not shown) managing the logical channels **216** perform the same basic operations of buffering, segmentation and reassembly as the TM RLC entities **400**. Whilst, the UM RLC entities may also be arranged to perform additional operations such as concatenation, ciphering/deciphering and to add a header to each RLC PDU transferred to the MAC layer **210**, the improved process of the present invention is equally applicable to UM transmission. Similarly, in the case of AM transmission, whilst the AM RLC entity (not shown) comprises a single entity having a transmitting side and a receiving side and whilst the arrangement and operations performed by the single AM RLC entity are more complex than either of the TM RLC entities **400** or the UM RLC entities, it still performs the same basic operations of buffering, segmentation and reassembly and thus the improved process of the present invention is equally applicable thereto.

[0081] It should also be noted that the improved process of the present invention is not limited to RLC arrangements where data discard is triggered by timing out of a buffered SDU, but is applicable to any mechanism of triggering SDU discard such as failure to transmit an SDU within a predetermined number of transmissions, for example.

[0082] In summary, the present invention concerns a method of processing traffic data in Layer 2 of a wireless communications system, whereby the MAC layer is arranged, after receipt of a traffic data volume report from the RLC layer, to process said data volume report and to then issue an acknowledgement message to the RLC layer indicating that the MAC layer has received and processed that data volume report. The method ensures that the RLC and MAC layers are synchronised with respect to traffic data processing whereby each is using the same data volume report in contrast to the conventional method whereby the MAC layer receives data volume reports from the RLC layer, processes them but issues no acknowledgement messages to the RLC layer in respect of such processing. Thus, in the conventional arrangement, the RLC layer asynchronously transmits a series of traffic data volume reports to the MAC layer as and when the data volume changes but receives no indication from the MAC layer of which of the series of such reports it is using for processing traffic data. The MAC layer may be arranged to issue an acknowledgement to the RLC layer only where it determines from processing a data volume report that the RLC layer is not permitted to transmit data in a next or subsequent corresponding TTI. Where the MAC layer determines from processing a data volume report that the RLC layer is permitted to transmit data, it may be arranged to operate in a conventional manner whereby it does not issue any acknowledgement to the RLC layer that it has received and/or processed said data volume report. The present invention also concerns a process for data discard in a Radio Link Control (RLC) layer of a Wideband Code Division Multiple Access (WCDMA) wireless communications system such as a Universal Mobile Telecommunications System (UMTS). The process involves, responsive to the triggering of a data discard operation, determining whether the RLC layer is permitted to transmit data. Where it is deter-

mined that the RLC layer is not permitted to transmit data in a next or subsequent TTI, the method includes the steps of informing the RLC layer that data is not required. This may comprise informing the RLC of the start of the next TTI and performing the data discard operation before the end of said next TTI. Preferably, the data discard operation is performed immediately the RLC layer is informed that data is not required for that TTI. The process of the invention reduces the time delay between the triggering of a data discard operation and the performance of said operation. It also mitigates the problem associated with the conventional discard process whereby the discard operation is, in effect, suspended for a series of consecutive TTIs where the RLC layer is not permitted to transmit data.

1. A method of processing traffic data in a medium access control (MAC) layer of a wireless communications system, the method comprising the steps of:

receiving a traffic data volume report at the MAC layer;

processing said data volume report; and

following processing of said report, issuing an acknowledgement message to the entity from which the report was received.

2. The method of claim 1, wherein the entity issuing the data volume report comprises a radio link control (RLC) layer of the wireless communications system.

3. The method of claim 1, wherein the MAC layer is arranged to issue an acknowledgement message to the entity from which the report was received only where it is determined from the data volume report that said entity is not permitted to transmit traffic data to the MAC layer in a subsequent corresponding transmission time interval (TTI).

4. A method of discarding data in a radio link control (RLC) layer of a wireless communications system, comprising the steps of:

triggering a data discard operation in a first transmission time interval (TTI);

determining for a subsequent TTI whether the RLC layer is permitted to transmit data; and

where the determination is made that the RLC layer is not permitted to transmit data in the subsequent TTI, the method includes the steps of:

informing the RLC layer that data is not required; and

performing the data discard operation.

5. A method as claimed in claim 4, wherein the RLC layer is informed that data is not required for the subsequent TTI after completion of a current Transport Format Combination (TFC) selection process.

6. A method as claimed in claim 4, wherein the RLC layer is informed that data is not required during a next TTI and the data discard operation is performed before the end of said TTI.

7. A method as claimed in claim 4, wherein the step of informing the RLC layer that data is not required for the subsequent TTI comprises informing the RLC layer of the start of the next TTI.

8. A method as claimed in claim 4, wherein the data discard operation is performed immediately upon the RLC layer being informed that data is not required.

9. A method as claimed in claim 4, wherein a Medium Access Control (MAC) layer (**210**) informs the RLC layer that data is not required.

10. A method as claimed in claim 9, wherein the triggering of the data discard operation in the first TTI causes said RLC layer to issue a request to said MAC layer in said first TTI for the MAC layer to inform the RLC layer whether data is required or not in the subsequent TTI.

11. A method as claimed in claim 10, wherein said request issued by said RLC layer in said first TTI is contained in a data volume report.

12. A radio network controller (RNC) for a wireless communications system for processing traffic data in a medium access control (MAC) layer thereof, comprising:

means for receiving a traffic data volume report at the MAC layer;

means for processing said data volume report; and

means for issuing an acknowledgement message to the entity from which the report was received following processing of said report.

13. The radio network controller of claim 12, wherein the entity issuing the data volume report comprises a radio link control (RLC) layer of the RNC.

14. The radio network controller of claim 12, wherein the MAC layer is arranged to issue an acknowledgement message to the entity from which the report was received only where it is determined from the data volume report that said entity is not permitted to transmit traffic data to the MAC layer in a next or subsequent corresponding transmission time interval (TTI).

15. A radio network controller (RNC) for a wireless communications network, comprising:

means for triggering a data discard operation in a first transmission time interval (TTI);

means for determining for a subsequent TTI whether the RLC layer is permitted to transmit data;

means responsive to said determining means and being arranged where said determining means determines that the RLC layer is not permitted to transmit data in the subsequent TTI to inform the RLC layer that data is not required for that TTI; and

means for performing the data discard operation.

16. A radio network controller as claimed in claim 15, wherein the means responsive to the determining means informs the RLC layer that data is not required for the subsequent TTI after completion of a current Transport Format Combination (TFC) selection process.

17. A radio network controller as claimed in claim 15, wherein the means responsive to the determining means informs the RLC layer that data is not required during the next TTI.

18. A radio network controller as claimed claim 15, wherein the means responsive to the determining means is arranged to inform the RLC layer that data is not required in the subsequent TTI by way of informing the RLC layer of the start of the next TTI.

19. A radio network controller as claimed in claim 15 wherein said means for performing the data discard operation is arranged to perform said discard operation immediately upon the RLC layer being informed that data is not required.

20. A radio network controller as claimed in claim 18, wherein the means responsive to said determining means and for informing the RLC layer that data is not required comprises a Medium Access Control (MAC) layer (**210**) of a radio protocol architecture (**100**) of the radio network controller.

21. A radio network controller as claimed in claim 20, wherein the RLC layer is arranged to issue a request to said MAC layer in said first TTI for the MAC layer to inform the RLC layer whether data is required or not in said subsequent TTI in response to the triggering of the data discard operation in the first TTI.

22. A radio network controller as claimed in claim 21, wherein said request issued by said RLC layer in said first TTI is contained in a data volume report.

23. User equipment (UE) for a wireless communications network for processing traffic data in a medium access control (MAC) layer thereof, comprising:

means for receiving a traffic data volume report at the MAC layer;

means for processing said data volume report; and

means for issuing an acknowledgement message to the entity from which the report was received following processing of said report.

24. User equipment as claimed in claim 23, wherein the entity issuing the data volume report comprises a radio link control (RLC) layer of the RNC.

25. User equipment as claimed in claim 23, wherein the MAC layer is arranged to issue an acknowledgement message to the entity from which the report was received only where it is determined from the data volume report that said entity is not permitted to transmit traffic data to the MAC layer in a next or subsequent corresponding transmission time interval (TTI).

26. User equipment (UE) for a wireless communications network, comprising:

means for triggering a data discard operation in a first transmission time interval (TTI);

means for determining for a subsequent TTI whether the RLC layer is permitted to transmit data;

means responsive to said determining means and being arranged where said determining means determines that the RLC layer is not permitted to transmit data in the subsequent TTI to inform the RLC layer that data is not required; and

means for performing the data discard operation.

27. User equipment as claimed in claim 26, wherein the means responsive to the determining means informs the RLC layer that data is not required for the subsequent TTI after completion of a current Transport Format Combination (TFC) selection process.

28. User equipment as claimed in claim 26, wherein the means responsive to the determining means informs the RLC layer that data is not required during said next TTI.

29. User equipment as claimed in claim 26, wherein the means responsive to the determining means is arranged to inform the RLC layer that data is not required by way of informing the RLC layer of the start of said next TTI.

30. User equipment as claimed in claim 26, wherein said means for performing the data discard operation is arranged to perform said discard operation immediately upon the RLC layer being informed that data is not required.

31. User equipment as claimed in claim 29, wherein the means responsive to said determining means and for informing the RLC layer that data is not required comprises a Medium Access Control (MAC) layer (**210**) of a radio protocol architecture of the user equipment.

32. User equipment as claimed in claim 31, wherein the RLC layer is arranged to issue a request to said MAC layer in said first TTI for the MAC layer to inform the RLC layer whether data is required or not for said subsequent TTI in response to the triggering of the data discard operation in the first TTI.

33. User equipment as claimed in claim 32, wherein said request issued by said RLC layer in said first TTI is contained in a data volume report.

34. User equipment as claimed in claim 26 to **33**, wherein said user equipment comprises a mobile communications device.

35. A computer readable medium comprising program code executable on a processor of a radio network controller (RNC) of a wireless communications system to process traffic data in a medium access control (MAC) layer of the wireless communications system, the program code enabling said RNC to:

receive a traffic data volume report at the MAC layer;

process said data volume report; and

following processing of said report, issue an acknowledgement message to the entity from which the report was received

36. A computer readable medium comprising program code executable on a processor of a user equipment (UE) a wireless communications system to process traffic data in a medium access control (MAC) layer of the wireless communications system, the program code enabling said UE to:

receive a traffic data volume report at the MAC layer;

process said data volume report; and

following processing of said report, issue an acknowledgement message to the entity from which the report was received

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(54) **METHOD FOR TRANSMITTING DOWNLINK CONTROL INFORMATION IN WIRELESS COMMUNICATION SYSTEM**

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§ 371 (c)(1),
(2) Date: **Nov. 30, 2018**

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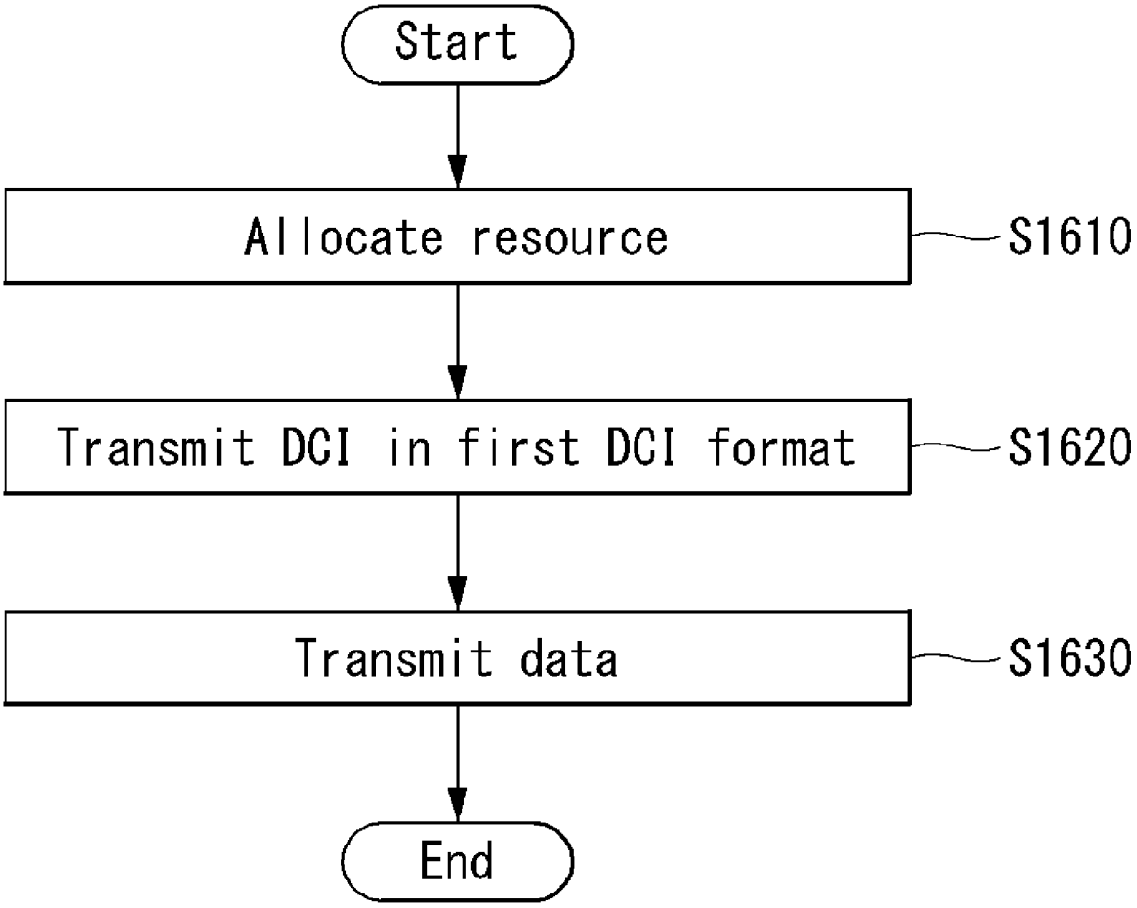
H04W 72/04	(2006.01)
H04L 5/00	(2006.01)
H04W 72/12	(2006.01)

(52) **U.S. Cl.**

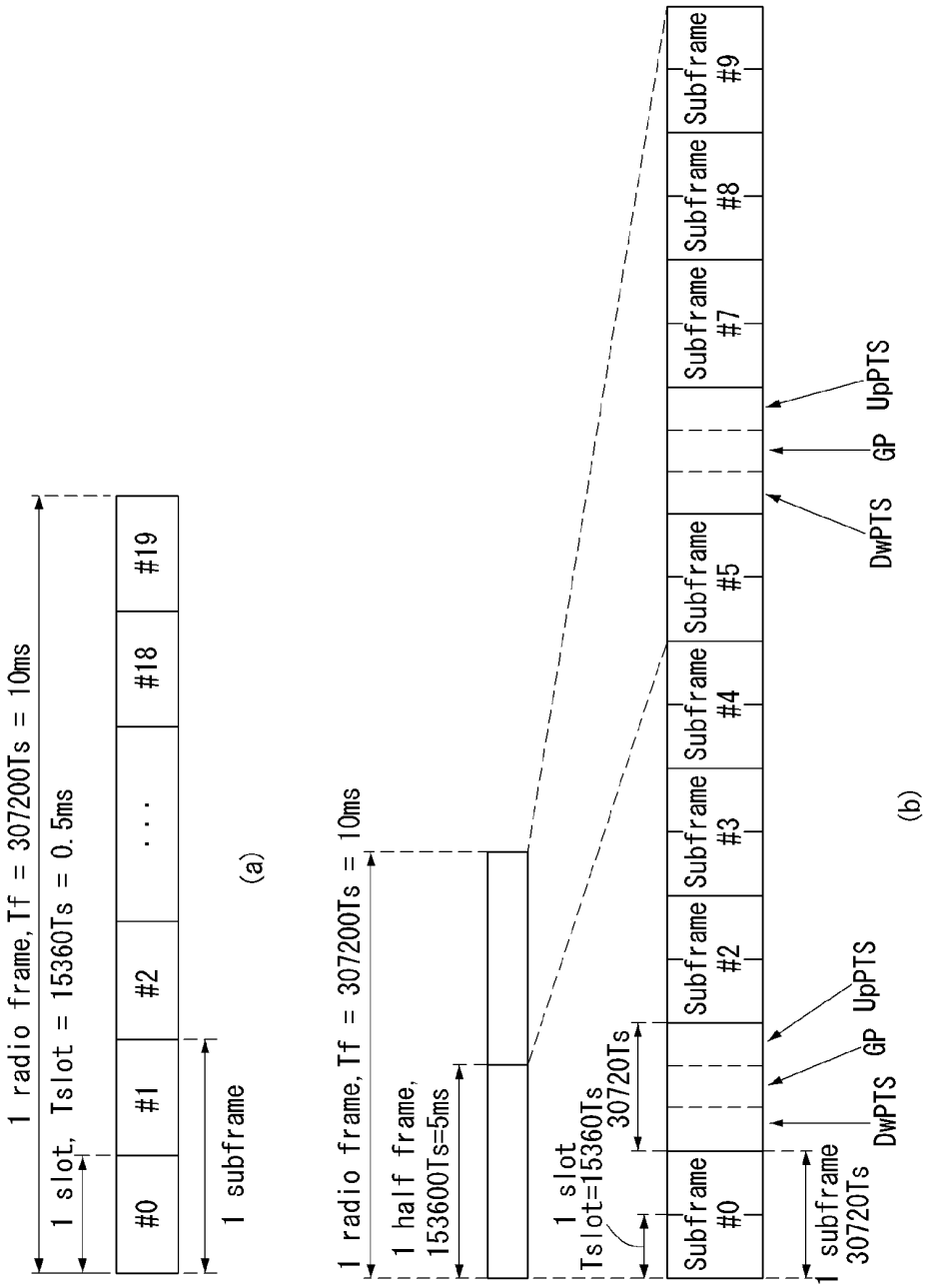
CPC ***H04W 72/042*** (2013.01); ***H04L 5/0053*** (2013.01); ***H04L 5/0044*** (2013.01); ***H04W 72/1273*** (2013.01); ***H04L 5/005*** (2013.01); ***H04W 72/1278*** (2013.01)

(57) **ABSTRACT**

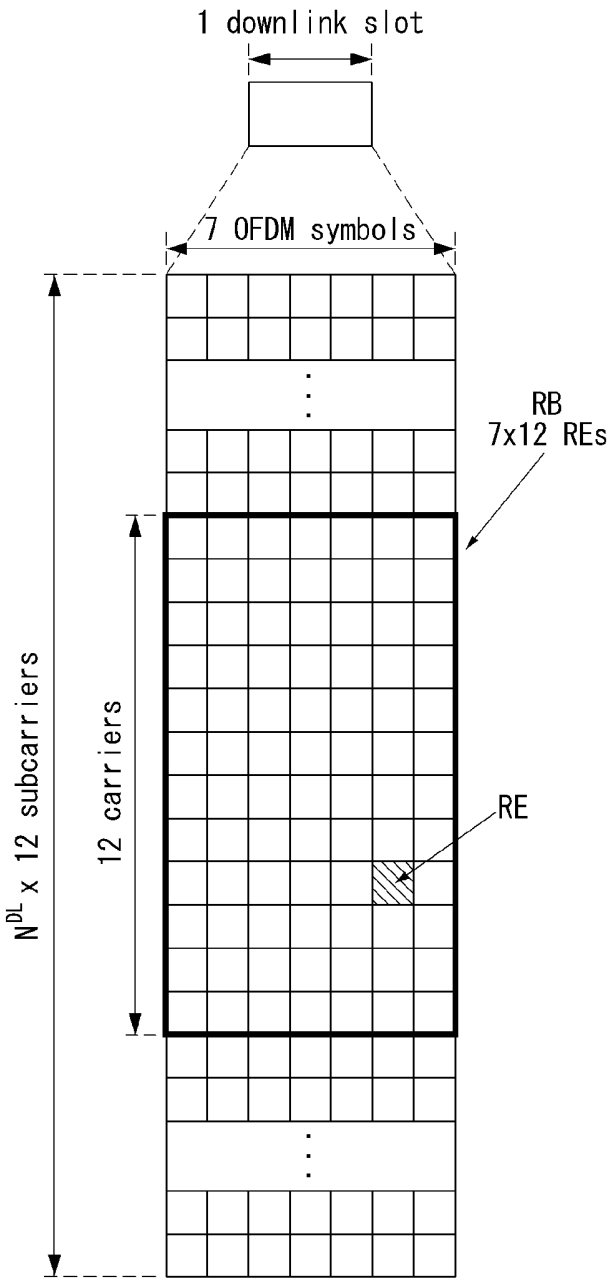
A method for transmitting DCI by a base station in a wireless communication system according to an embodiment of the present invention may comprise the steps of: allocating a resource for data transmission; transmitting, in a first DCI format, DCI including scheduling information associated with the allocated resource; and transmitting data according to the scheduling information, wherein a payload size of the first DCI format may be adjusted to be the same as that of a pre-configured second DCI format and transmitted through a CSS when the DCI includes scheduling information relating to multicast/broadcast data, and the payload size of the first DCI format may be transmitted, without being adjusted, through a USS when the DCI includes scheduling information relating to unicast data.



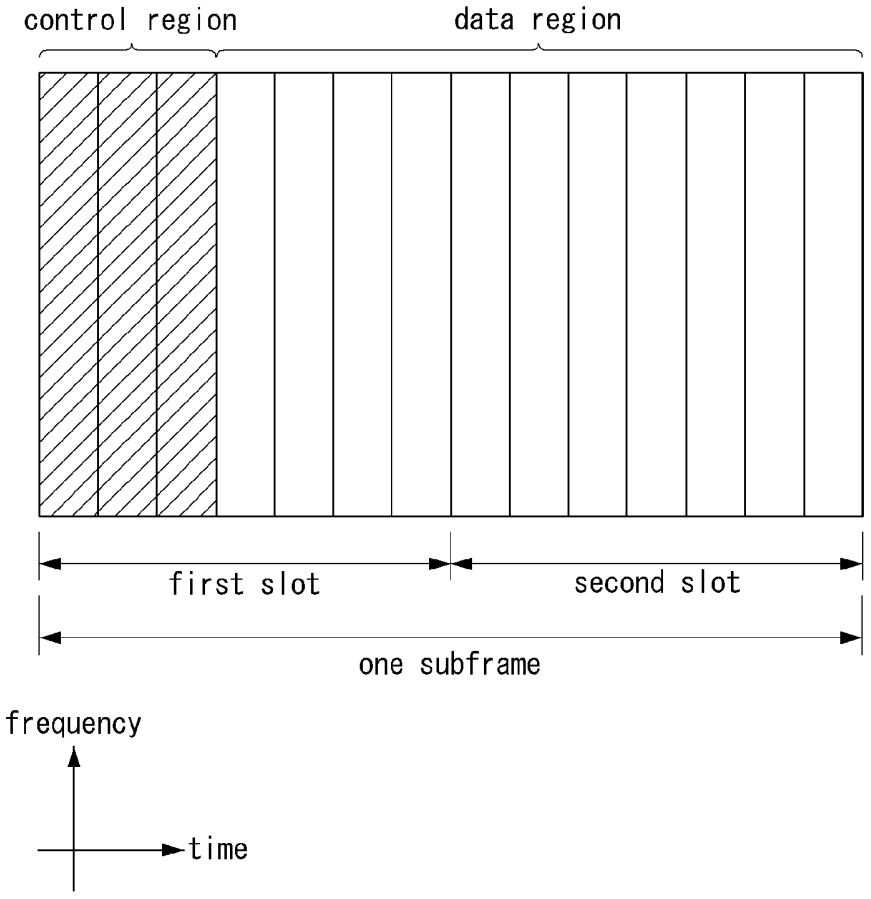
【Fig. 1】


1 radio frame, Tf = 307200Ts = 10ms
1 slot, Tslot = 15360Ts = 0.5ms
#0
#1
#2
...
#18
#19
1 subframe
(a)
1 radio frame, Tf = 307200Ts = 10ms
1 half frame, 153600Ts=5ms
1 slot Tslot=15360Ts
30720Ts
Subframe #0
Subframe #2
Subframe #3
Subframe #4
Subframe #5
Subframe #7
Subframe #8
Subframe #9
DwPTS
GP
UpPTS
DwPTS
GP
UpPTS
1 subframe 30720Ts
(b)

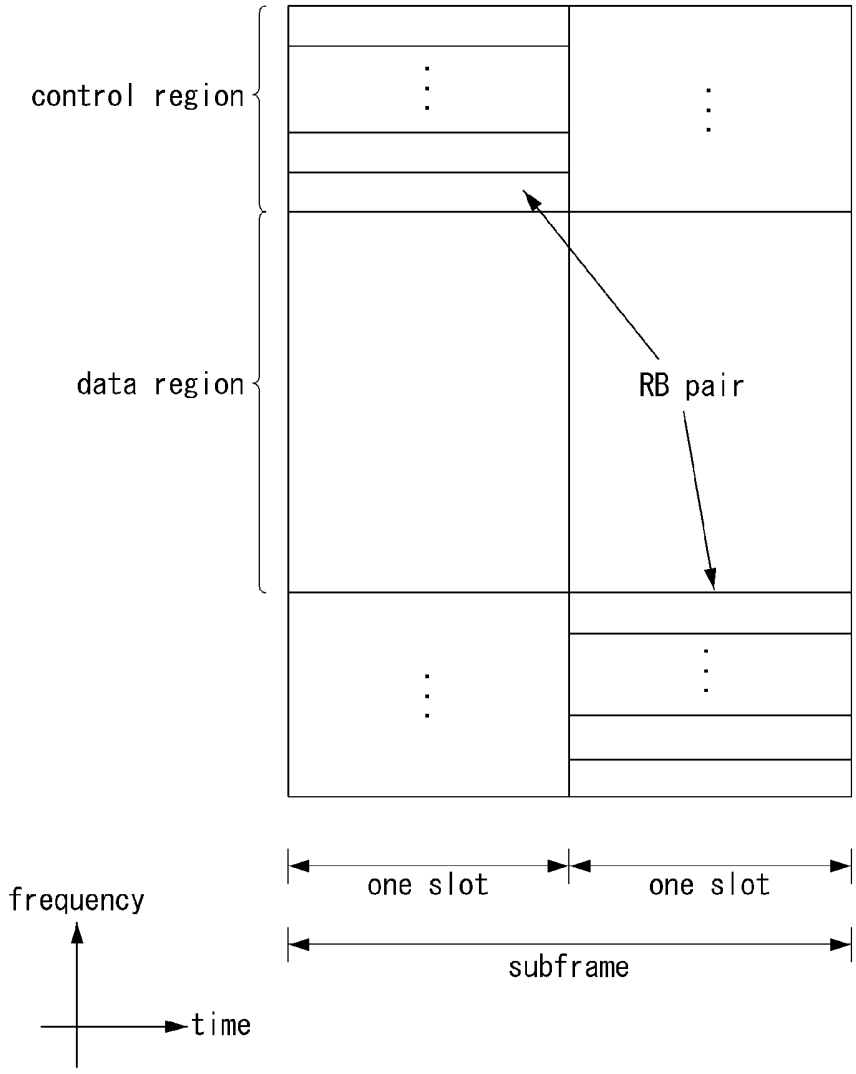
【Fig. 2】


1 downlink slot
7 OFDM symbols
RB
7x12 REs
RE
12 carriers
N^{DL} x 12 subcarriers

【Fig. 3】

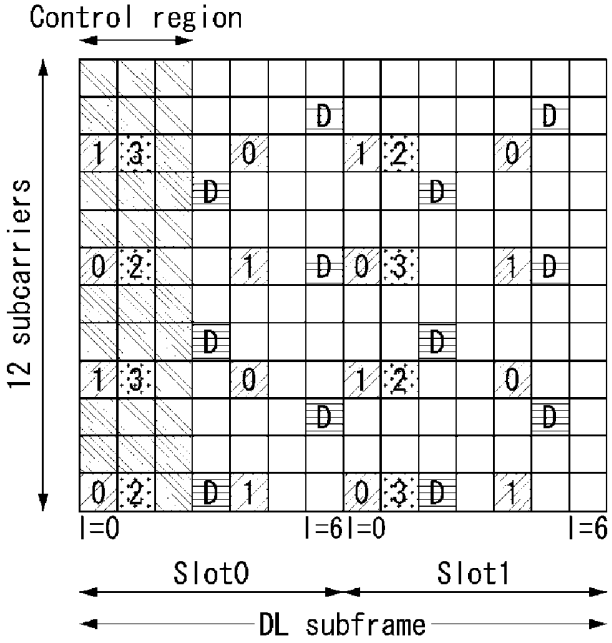

control region
data region
first slot
second slot
one subframe
frequency
time

【Fig. 4】

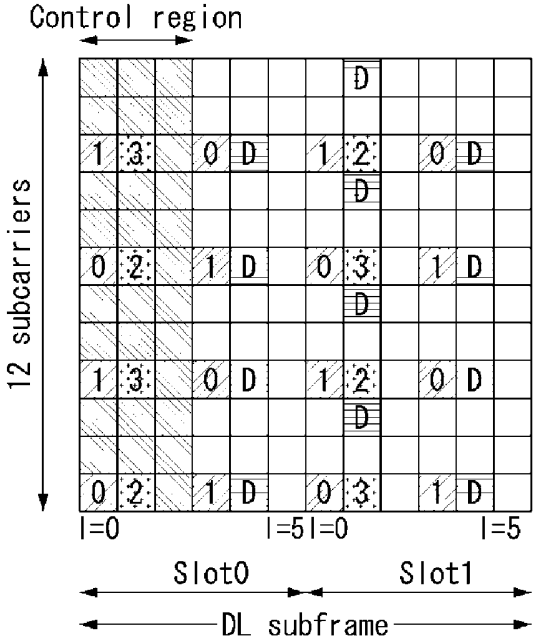

control region
data region
RB pair
one slot
one slot
subframe
frequency
time

【Fig. 5】

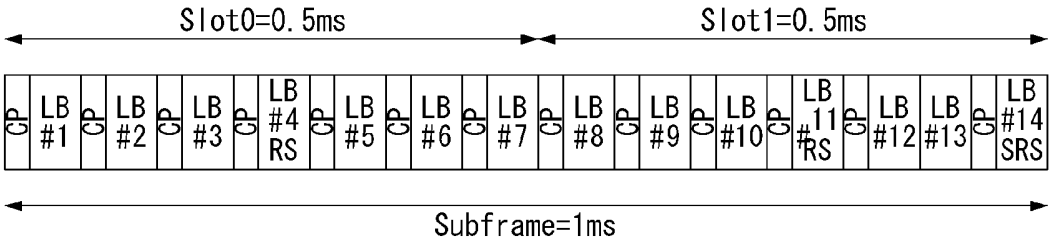
(a)


Control region
12 subcarriers
l=0
l=6
l=0
l=6
Slot0
Slot1
DL subframe

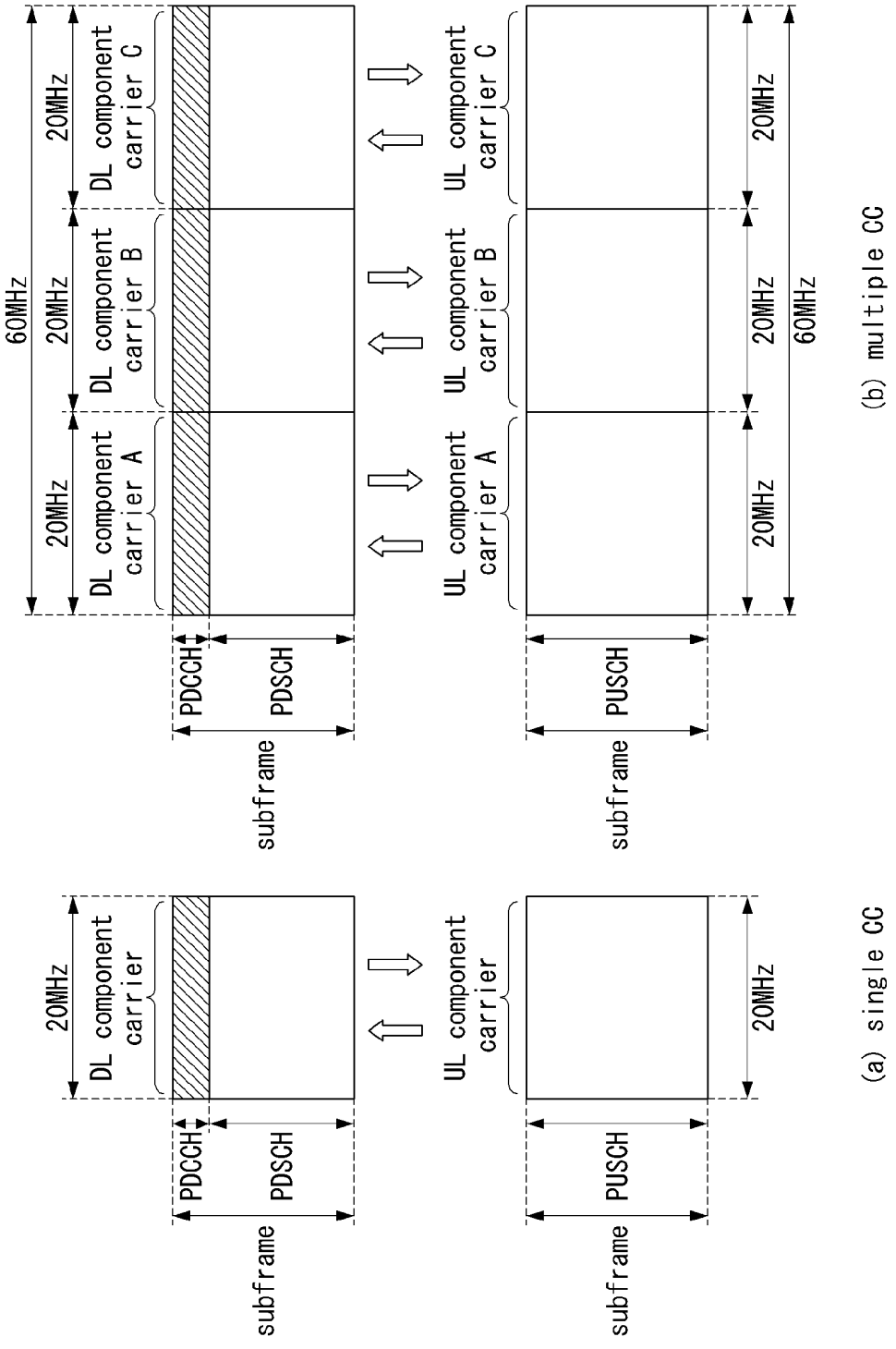
(b)


Control region
12 subcarriers
l=0
l=5
l=0
l=5
Slot0
Slot1
DL subframe

【Fig. 6】

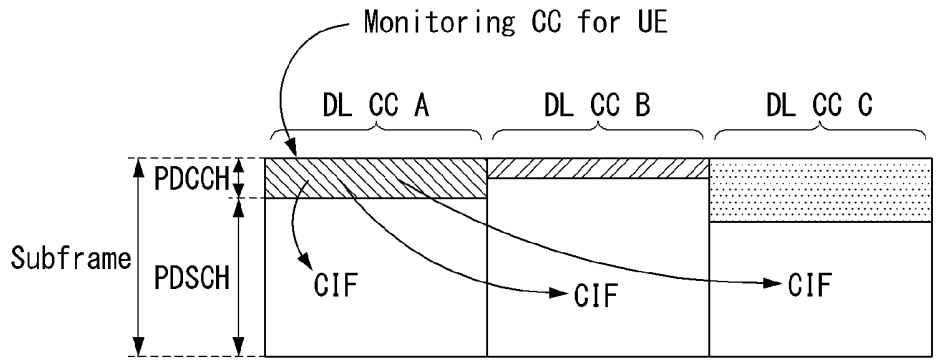

Slot0=0.5ms
Slot1=0.5ms
CP
LB #1
LB #2
LB #3
LB #4 RS
LB #5
LB #6
LB #7
LB #8
LB #9
LB #10
LB #11 RS
LB #12
LB #13
LB #14 SRS
Subframe=1ms

【Fig. 7】

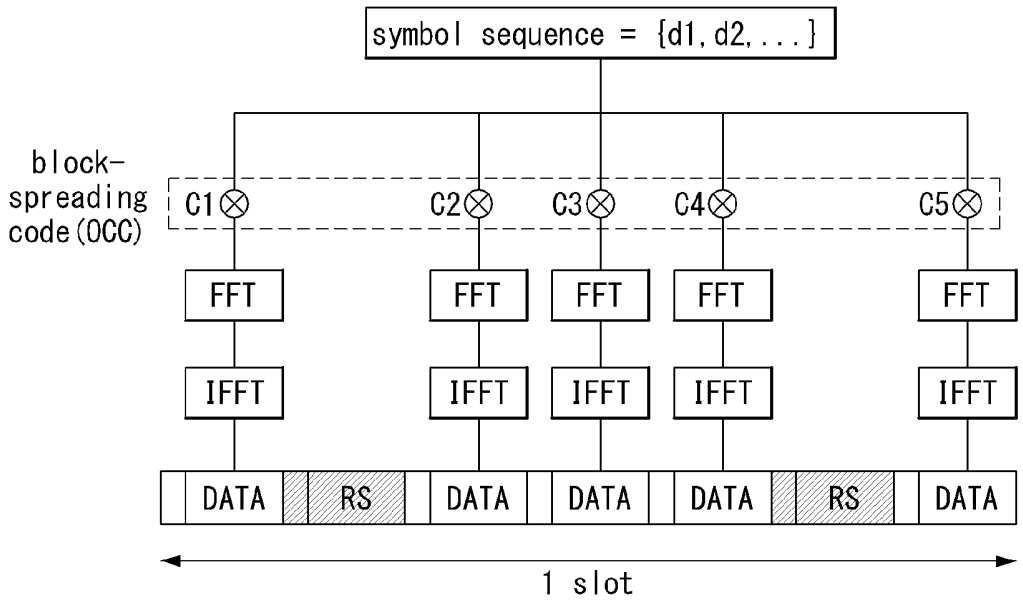

60MHz
20MHz
20MHz
20MHz
DL component carrier A
DL component carrier B
DL component carrier C
PDCCH
PDSCH
subframe
UL component carrier A
UL component carrier B
UL component carrier C
PUSCH
(b) multiple CC
20MHz
DL component carrier
UL component carrier
(a) single CC

752

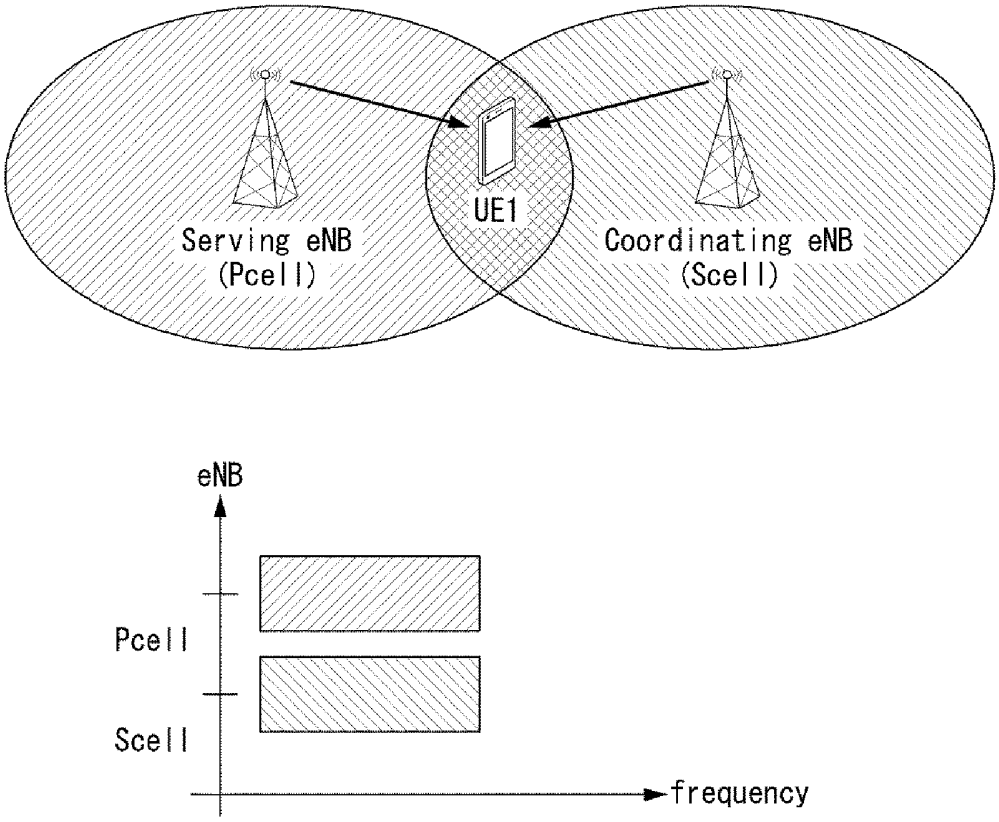
【Fig. 8】


Monitoring CC for UE
DL CC A
DL CC B
DL CC C
PDCCH
Subframe
PDSCH
CIF
CIF
CIF

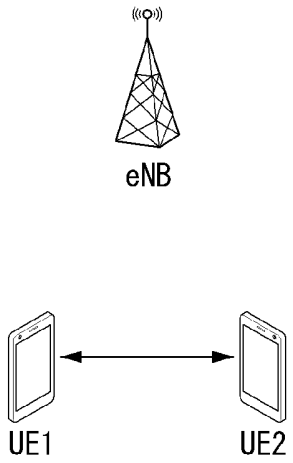
【Fig. 9】


symbol sequence = {d1, d2, ...}
block-spreading code (OCC)
C1
C2
C3
C4
C5
FFT
IFFT
DATA
RS
1 slot

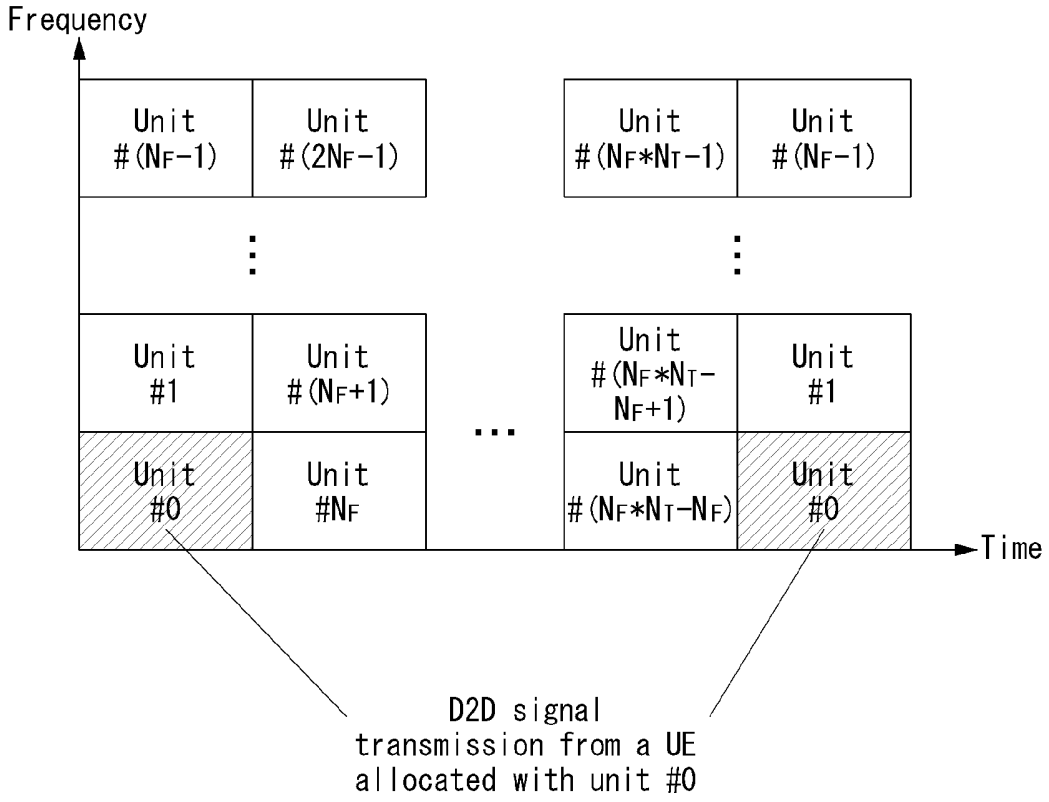
【Fig. 10】


Serving eNB
(Pcell)
UE1
Coordinating eNB
(Scell)
eNB
Pcell
Scell
frequency

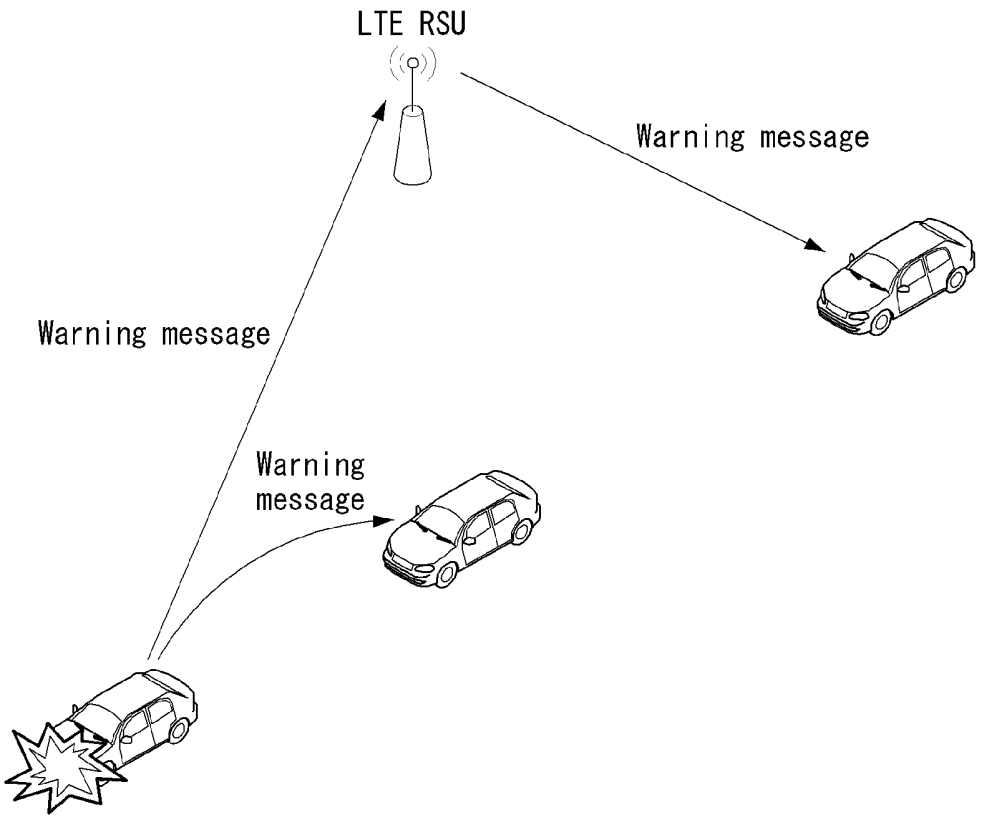
【Fig. 11】


eNB
UE1
UE2

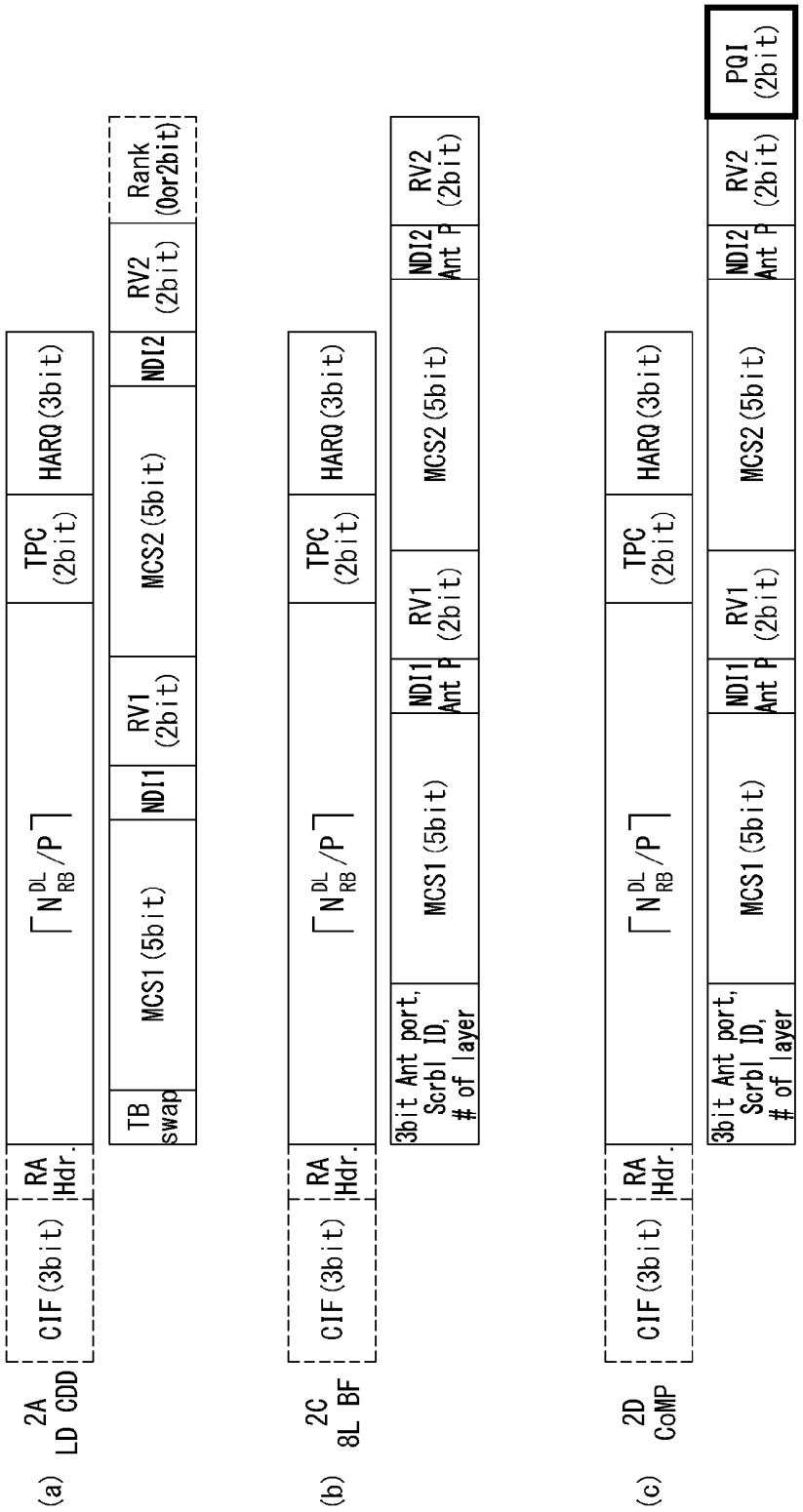
【Fig. 12】


Frequency
Unit #(NF-1)
Unit #(2NF-1)
Unit #(NF*NT-1)
Unit #(NF-1)
Unit #1
Unit #(NF+1)
Unit #(NF*NT-NF+1)
Unit #1
Unit #0
Unit #NF
Unit #(NF*NT-NF)
Unit #0
Time
D2D signal transmission from a UE allocated with unit #0

【Fig. 13】

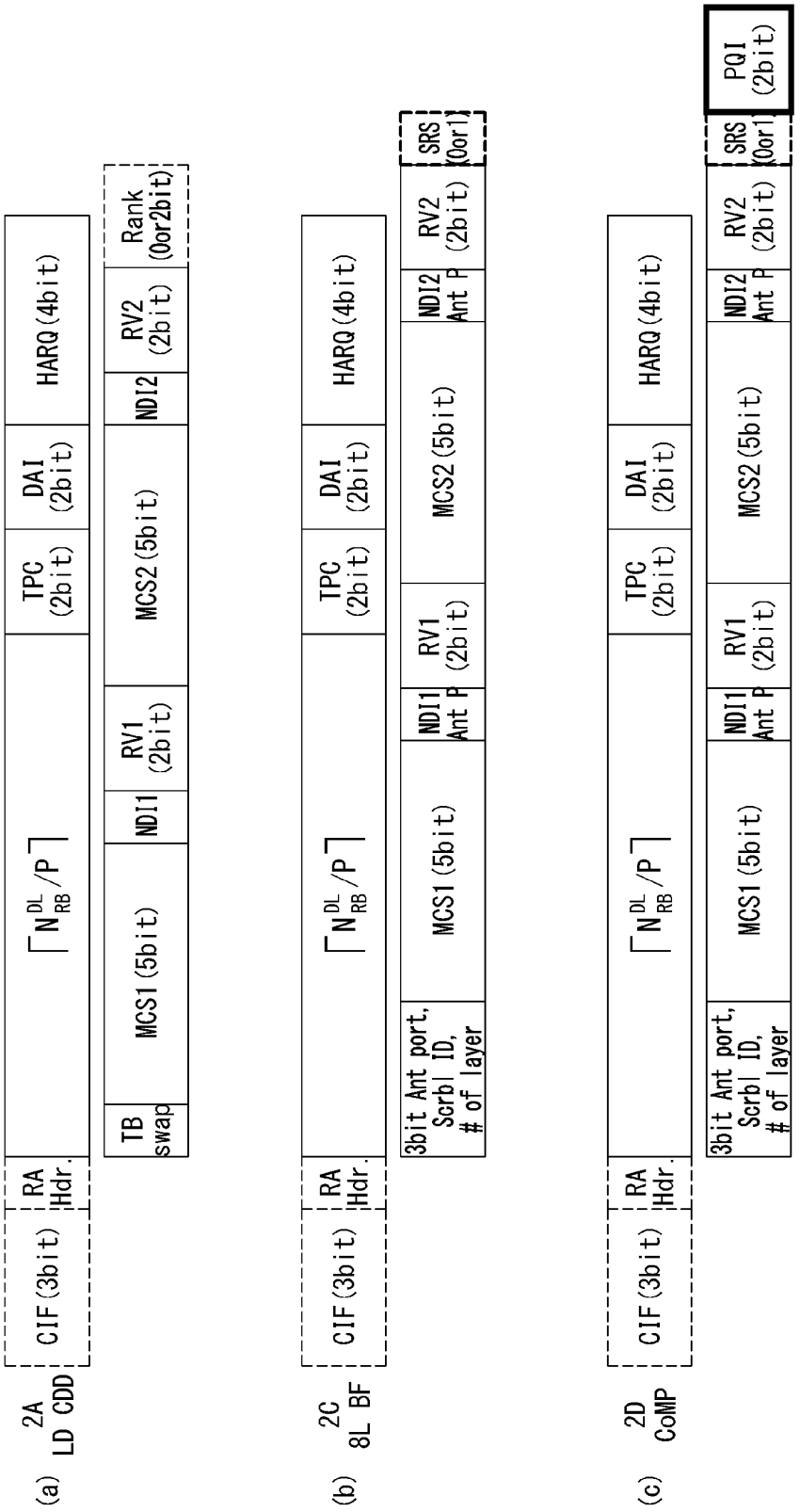


【Fig. 14】


(a) 2A LD CDD
CIF (3bit)
RA Hdr.
$\lceil N_{RB}^{DL}/P \rceil$
TPC (2bit)
HARQ (3bit)
TB swap
MCS1 (5bit)
NDI1
RV1 (2bit)
MCS2 (5bit)
NDI2
RV2 (2bit)
Rank (0or2bit)
(b) 2C 8L BF
CIF (3bit)
RA Hdr.
$\lceil N_{RB}^{DL}/P \rceil$
TPC (2bit)
HARQ (3bit)
3bit Ant port, Scrbl ID, # of layer
MCS1 (5bit)
NDI1 Ant P
RV1 (2bit)
MCS2 (5bit)
NDI2 Ant P
RV2 (2bit)
(c) 2D CoMP
CIF (3bit)
RA Hdr.
$\lceil N_{RB}^{DL}/P \rceil$
TPC (2bit)
HARQ (3bit)
3bit Ant port, Scrbl ID, # of layer
MCS1 (5bit)
NDI1 Ant P
RV1 (2bit)
MCS2 (5bit)
NDI2 Ant P
RV2 (2bit)
PQI (2bit)

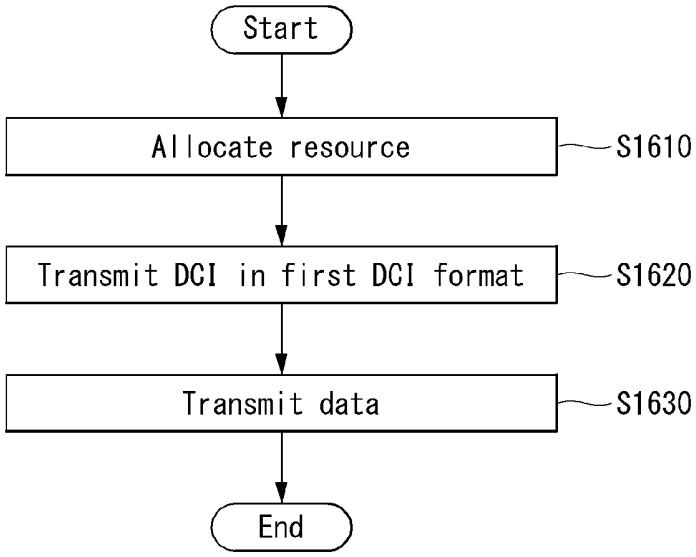
757

【Fig. 15】

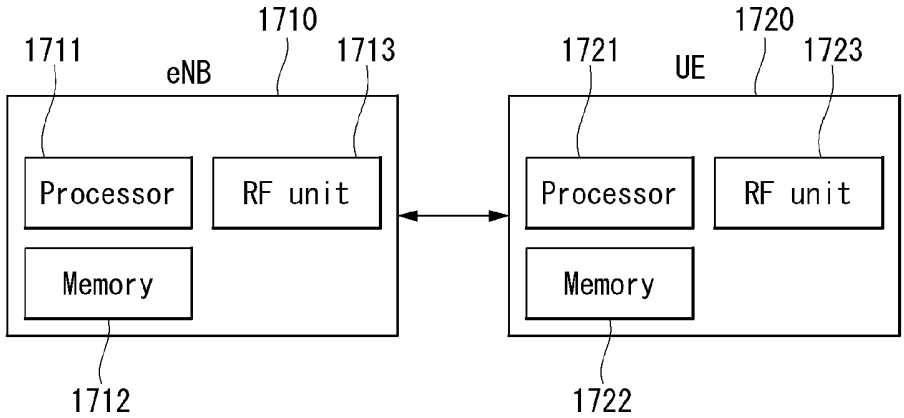

(a) 2A LD CDD
CIF (3bit)
RA Hdr.
$\lceil N_{RB}^{DL}/P \rceil$
TPC (2bit)
DAI (2bit)
HARQ (4bit)
TB swap
MCS1 (5bit)
NDI1
RV1 (2bit)
MCS2 (5bit)
NDI2
RV2 (2bit)
Rank (0or2bit)
(b) 2C 8L BF
CIF (3bit)
RA Hdr.
$\lceil N_{RB}^{DL}/P \rceil$
TPC (2bit)
DAI (2bit)
HARQ (4bit)
3bit Ant port, Scrbl ID, # of layer
MCS1 (5bit)
NDI1 Ant P
RV1 (2bit)
MCS2 (5bit)
NDI2 Ant P
RV2 (2bit)
SRS (0or1)
(c) 2D CoMP
CIF (3bit)
RA Hdr.
$\lceil N_{RB}^{DL}/P \rceil$
TPC (2bit)
DAI (2bit)
HARQ (4bit)
3bit Ant port, Scrbl ID, # of layer
MCS1 (5bit)
NDI1 Ant P
RV1 (2bit)
MCS2 (5bit)
NDI2 Ant P
RV2 (2bit)
SRS (0or1)
PQI (2bit)

758

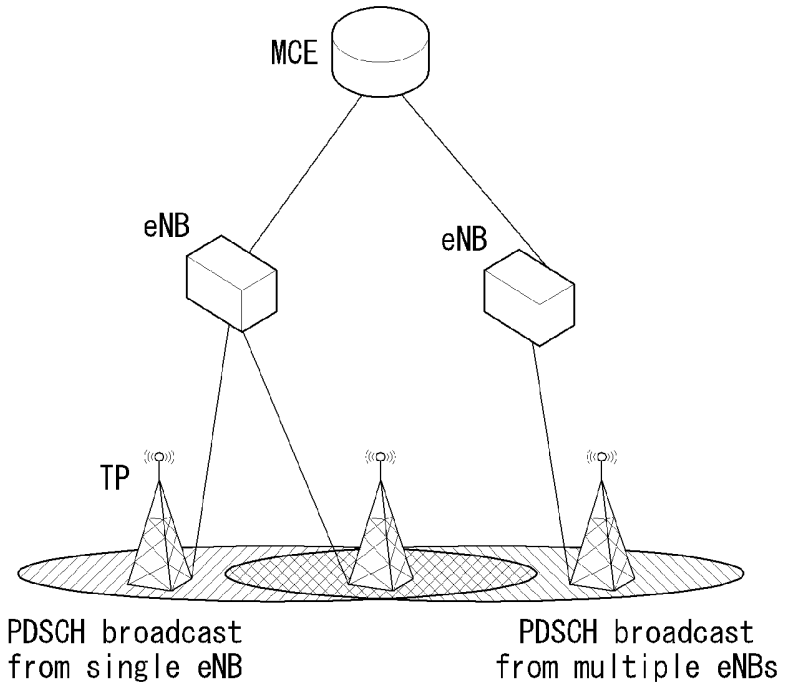
【Fig. 16】


Start
Allocate resource
S1610
Transmit DCI in first DCI format
S1620
Transmit data
S1630
End

【Fig. 17】


1710
1711
eNB
1713
Processor
RF unit
Memory
1712
1720
1721
UE
1723
Processor
RF unit
Memory
1722

【Fig. 18】


MCE
eNB
eNB
TP
PDSCH broadcast
from single eNB
PDSCH broadcast
from multiple eNBs

METHOD FOR TRANSMITTING DOWNLINK CONTROL INFORMATION IN WIRELESS COMMUNICATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is the National Stage filing under 35 U.S.C. 371 of International Application No. PCT/KR2016/011055, filed on Oct. 4, 2016, which claims the benefit of U.S. Provisional Applications No. 62/236,848, filed on Oct. 2, 2015, No. 62/335,643, filed on May 12, 2016, the contents of which are all hereby incorporated by reference herein in their entirety.

TECHNICAL FIELD

[0002] The present invention relates to a wireless communication system and, more particularly, to a method for transmitting and receiving Downlink control Information (DCI) in a wireless communication system and an apparatus for implementing the method.

BACKGROUND ART

[0003] Mobile communication systems have been developed to provide voice services, while guaranteeing user activity. Service coverage of mobile communication systems, however, has extended even to data services, as well as voice services, and currently, an explosive increase in traffic has resulted in shortage of resource and user demand for a high speed services, requiring advanced mobile communication systems.

[0004] The requirements of the next-generation mobile communication system may include supporting huge data traffic, a remarkable increase in the transfer rate of each user, the accommodation of a significantly increased number of connection devices, very low end-to-end latency, and high energy efficiency. To this end, various techniques, such as small cell enhancement, dual connectivity, massive Multiple Input Multiple Output (MIMO), in-band full duplex, non-orthogonal multiple access (NOMA), supporting super-wide band, and device networking, have been researched.

DISCLOSURE

Technical Problem

[0005] The object of the present invention is to enable a base station to adjust payload sizes to be identical when transmitting different DCI formats, thereby minimizing the number of times for a user equipment (UE) to perform blind detection.

[0006] Such an efficient method is also applicable to a wireless communication system supporting a V2X (Vehicle to everything) service.

[0007] The technical problems solved by the present invention are not limited to the above technical problems and those skilled in the art may understand other technical problems from the following description.

Technical Solution

[0008] In one general aspect of the present invention, there is provided a method for transmitting Downlink Control Information (DCI) by a base station in a wireless communication system, the method including: allocating a resource for data transmission; transmitting, in a first DCI format, DCI including scheduling information about the allocated resource; and transmitting data according to the scheduling information, wherein the first DCI format is transmitted in a payload size, which is adjusted to be identical to a payload size of a pre-configured second DCI format, through a Common Search Space (CSS) when the DCI includes scheduling information about multicast/broadcast data, and wherein the first DCI format is transmitted in a payload size, which is not adjusted, through a UE-specific Search Space (USS) when the DCI includes scheduling information about unicast data.

[0009] The payload size of the first DCI format may be adjusted to be identical to the payload size of the second DCI format by deleting at least one field of fields included in the payload of the first DCI format or by reducing a bit size of the at least one field.

[0010] The second DCI format may be DCI format 2A and the first DCI format may be DCI format 2C.

[0011] The first DCI format may be scrambled by a Point to Multipoint-Radio Network Temporary Identifier (PTM-RNTI), which is newly defined for multicast/broadcast transmission, and the scrambled first DCI format is transmitted.

[0012] When the first and second DCI formats are transmitted in a Frequency Division Duplex (FDD) scheme and a bit size of a Rank field included in a payload of the second DCI format is set to 0 bit, at least one field of a New Data Indicator (NDI) field, a Modulation and Coding Scheme (MCS) 2 field, a Redundancy Version (RV) 2 field, a Hybrid Automatic Repeat Request (HARQ) field, a Transmit Power Control (TPC) field, and a Carrier Indicator Field (CIF) included in the payload of the first DCI format may be deleted or a bit size of the at least one field may be reduced.

[0013] When the first and second DCI formats are transmitted in a Time Division Duplex (TDD) scheme and a bit size of a rank field included in the second DCI format is set to 2 bits, a Sound Reference Signal (SRS) field is deleted from the payload of the first DCI format and the payload of the first DCI format is transmitted.

[0014] When the first and second DCI formats are transmitted in a TDD method and a bit size of a Rank field included in the payload of the second DCI format is set to 0 bit, an SRS field is deleted from the payload of the first DCI format, the payload of the first DCI format is transmitted and, additionally, at least one field of an NDI field, an MCS 2 field, a RV 2 field, an HARQ field, a TPC field, a Downlink Assignment Index (DAI) field, and a CIF may be deleted or a bit size of the at least one field may be reduced.

[0015] The second DCI format may be DCI format 2A and the first DCI format may be DCI format 2D.

[0016] When the first and second DCI formats are transmitted in an FDD scheme and a bit size of a Rank field included in the payload of the second DCI format is set to 0 bits a PDSCH RE Mapping and Quasi-co-location Indicator (PQI) field may be deleted from the payload of the first DCI format and the payload of the first DCI format is transmitted.

[0017] When a PTM-RNTI for indicating PQI information included in the deleted PQI field is separately defined, the first DCI format may be scrambled by the PTM-RNTI and transmitted.

[0018] Information about a PTM-RNTI corresponding to the PQI information may be transmitted via higher layer signaling.

[0019] When the first and second DCI formats are transmitted in a TDD scheme and a bit size of a Rank field included in the payload of the second DCI format is set to 2 bits, a PQI field and a SRS field may be deleted from the payload of the first DCI format and the payload of the first DCI format is transmitted.

[0020] When the first and second DCI formats are transmitted in a TDD scheme and a bit size of a Rank field included in the payload of the second DCI format is set to 0 bit, a PQI field and a SRS field may be deleted from the payload of the first DCI format, the payload of the first DCI format is transmitted and, additionally, at least one field selected from among an NDI field, an MCS 2 field, an RV 2 field, an HARQ field, a TPC field, a DAI field, and a CIF may be deleted or a bit size of the at least one field may be reduced.

[0021] When a PTM-TNTI is separately defined to indicate PQI information included in the deleted PQI field, the first DCI format may be scrambled by the PTM-RNTI and transmitted.

[0022] Information about the PTM-RNTI corresponding to the PQI information may be transmitted via higher layer signaling.

[0023] In another general aspect of the present invention, there is provided a method for transmitting Downlink Control Information (DCI) by a base station in a wireless communication system, the method including: a Radio Frequency (RF) unit configured to transmit and receive a radio signal; and a processor configured to control the RF unit, wherein the base station is configured to: allocate a resource for data transmission; transmit, in a first DCI format, DCI including scheduling information about the allocated resource; and transmit data according to the scheduling information, wherein, when the DCI includes scheduling information about multicast/broadcast data, the DCI is transmitted in a payload size, which is adjusted to be identical to a payload size of a preset second DCI format, through a Common Search Space (CSS), and wherein, when the DCI includes scheduling information about unicast data, the first DCI format is transmitted in a payload size, which is not adjusted, through a UE-specific Search Space (USS).

Advantageous Effects

[0024] According to an embodiment of the present invention, it is possible to minimize the number of times for a UE to perform Blind Detection (BD) of different-format DCI which is transmitted through a Common Search Space (CSS).

[0025] It will be appreciated by persons skilled in the art that that the effects that could be achieved with the present invention are not limited to what has been particularly described hereinabove and other advantages of the present invention will be more clearly understood by a person skilled in the art to which the present invention pertains, from the following detailed description.

DESCRIPTION OF DRAWINGS

[0026] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention.

[0027] FIG. **1** shows the structure of a radio frame in a wireless communication system to which an embodiment of the present invention may be applied.

[0028] FIG. **2** is a diagram illustrating a resource grid for one downlink slot in a wireless communication system to which an embodiment of the present invention may be applied.

[0029] FIG. **3** shows the structure of a downlink subframe in a wireless communication system to which an embodiment of the present invention may be applied.

[0030] FIG. **4** shows the structure of an uplink subframe in a wireless communication system to which an embodiment of the present invention may be applied.

[0031] FIG. **5** shows patterns of reference signals mapped to pairs of downlink resource blocks in a wireless communication system to which an embodiment of the present invention may be applied.

[0032] FIG. **6** shows an uplink subframe including sounding reference signal symbols in a wireless communication system to which an embodiment of the present invention may be applied.

[0033] FIG. **7** shows an example of component carriers and carrier aggregation in a wireless communication system to which an embodiment of the present invention may be applied.

[0034] FIG. **8** shows an example of a structure of a subframe according to cross-carrier scheduling in a wireless communication system to which an embodiment of the present invention may be applied.

[0035] FIG. **9** shows one example of generating and transmitting 5 SC-FDMA symbols during one slot in the wireless communication system to which the present invention may be applied

[0036] FIG. **10** shows a carrier aggregation-based CoMP system in a wireless communication system to which an embodiment of the present invention may be applied.

[0037] FIG. **11** shows elements regarding a scheme of direct communication between terminals (D2D).

[0038] FIG. **12** shows an embodiment of configuration of resource units.

[0039] FIG. **13** shows V2X communication according to an embodiment of the present invention.

[0040] FIG. **14** is a diagram showing Downlink Control Information (DCI) formats (2A, 2C, and 2D) in Frequency Division Duplex (FDD).

[0041] FIG. **15** is a diagram showing DCI formats (2A, 2C, and 2D (in Time Division Duplex (TDD).

[0042] FIG. **16** is a flowchart illustrating a Single-Cell Point-to-Multiple point (SC-PTM) transmission method according to an embodiment of the present invention.

[0043] FIG. **17** shows a block configuration of a wireless communication apparatus according to an embodiment of the present invention.

[0044] FIG. **18** is a diagram illustrating an example of one TP set in which multiple TPs transmitting physical downlink shared channels (PDSCHs) is included.

BEST MODE FOR INVENTION

[0045] Some embodiments of the present invention are described in detail with reference to the accompanying drawings. A detailed description to be disclosed along with

the accompanying drawings are intended to describe some exemplary embodiments of the present invention and are not intended to describe a sole embodiment of the present invention. The following detailed description includes more details in order to provide full understanding of the present invention. However, those skilled in the art will understand that the present invention may be implemented without such more details.

[0046] In some cases, in order to avoid that the concept of the present invention becomes vague, known structures and devices are omitted or may be shown in a block diagram form based on the core functions of each structure and device.

[0047] In this specification, a base station (BS) (or eNB) has the meaning of a terminal node of a network over which the base station directly communicates with a device. In this document, a specific operation that is described to be performed by a base station may be performed by an upper node of the base station according to circumstances. That is, it is evident that in a network including a plurality of network nodes including a base station, various operations performed for communication with a device may be performed by the base station or other network nodes other than the base station. The base station (BS) may be substituted with another term, such as a fixed station, a Node B, an eNB (evolved-NodeB), a Base Transceiver System (BTS), or an access point (AP). Furthermore, the device may be fixed or may have mobility and may be substituted with another term, such as User Equipment (UE), a Mobile Station (MS), a User Terminal (UT), a Mobile Subscriber Station (MSS), a Subscriber Station (SS), an Advanced Mobile Station (AMS), a Wireless Terminal (WT), a Machine-Type Communication (MTC) device, a Machine-to-Machine (M2M) device, or a Device-to-Device (D2D) device.

[0048] Hereinafter, downlink (DL) means communication from an eNB to UE, and uplink (UL) means communication from UE to an eNB. In DL, a transmitter may be part of an eNB, and a receiver may be part of UE. In UL, a transmitter may be part of UE, and a receiver may be part of an eNB.

[0049] Specific terms used in the following description have been provided to help understanding of the present invention, and the use of such specific terms may be changed in various forms without departing from the technical sprit of the present invention.

[0050] The following technologies may be used in a variety of wireless communication systems, such as Code Division Multiple Access (CDMA), Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Orthogonal Frequency Division Multiple Access (OFDMA), Single Carrier Frequency Division Multiple Access (SC-FDMA), and Non-Orthogonal Multiple Access (NOMA). CDMA may be implemented using a radio technology, such as Universal Terrestrial Radio Access (UTRA) or CDMA2000. TDMA may be implemented using a radio technology, such as Global System for Mobile communications (GSM)/General Packet Radio Service (GPRS)/Enhanced Data rates for GSM Evolution (EDGE). OFDMA may be implemented using a radio technology, such as Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, or Evolved UTRA (E-UTRA). UTRA is part of a Universal Mobile Telecommunications System (UMTS). 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE) is part of an Evolved UMTS (E-UMTS) using evolved UMTS Terrestrial Radio Access (E-UTRA), and it adopts OFDMA in downlink and adopts SC-FDMA in uplink. LTE-Advanced (LTE-A) is the evolution of 3GPP LTE.

[0051] Embodiments of the present invention may be supported by the standard documents disclosed in at least one of IEEE 802, 3GPP, and 3GPP2, that is, radio access systems. That is, steps or portions that belong to the embodiments of the present invention and that are not described in order to clearly expose the technical spirit of the present invention may be supported by the documents. Furthermore, all terms disclosed in this document may be described by the standard documents.

[0052] In order to more clarify a description, 3GPP LTE/LTE-A is chiefly described, but the technical characteristics of the present invention are not limited thereto.

[0053] General System to which the Present Invention May be Applied

[0054] FIG. **1** shows the structure of a radio frame in a wireless communication system to which an embodiment of the present invention may be applied.

[0055] 3GPP LTE/LTE-A support a radio frame structure type 1 which may be applicable to Frequency Division Duplex (FDD) and a radio frame structure which may be applicable to Time Division Duplex (TDD).

[0056] FIG. **1**(*a*) illustrates the radio frame structure type 1. A radio frame consists of 10 subframes. One subframe consists of 2 slots in a time domain. The time taken to send one subframe is called a Transmission Time Interval (TTI). For example, one subframe may have a length of 1 ms, and one slot may have a length of 0.5 ms.

[0057] One slot includes a plurality of Orthogonal Frequency Division Multiplexing (OFDM) symbols in the time domain and includes a plurality of Resource Blocks (RBs) in a frequency domain. In 3GPP LTE, OFDM symbols are used to represent one symbol period because OFDMA is used in downlink. An OFDM symbol may be called one SC-FDMA symbol or symbol period. An RB is a resource allocation unit and includes a plurality of contiguous subcarriers in one slot.

[0058] FIG. **1**(*b*) illustrates the frame structure type 2. The radio frame structure type 2 consists of 2 half frames. Each of the half frames consists of 5 subframes, a Downlink Pilot Time Slot (DwPTS), a Guard Period (GP), and an Uplink Pilot Time Slot (UpPTS). One subframe consists of 2 slots. The DwPTS is used for initial cell search, synchronization, or channel estimation in UE. The UpPTS is used for channel estimation in an eNB and to perform uplink transmission synchronization with UE. The guard period is an interval in which interference generated in uplink due to the multi-path delay of a downlink signal between uplink and downlink is removed.

[0059] In the frame structure type 2 of a TDD system, an uplink-downlink configuration is a rule indicating whether

uplink and downlink are allocated (or reserved) to all subframes. Table 1 shows the uplink-downlink configuration.

TABLE 1

Uplink-Downlink configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

[0060] Referring to Table 1, in each subframe of the radio frame, "D" is indicative of a subframe for downlink transmission, "U" is indicative of a subframe for uplink transmission, and "S" is indicative of a special subframe including three types of a DwPTS, GP, and UpPTS. An uplink-downlink configuration may be classified into 7 types. The positions and/or number of downlink subframes, special subframes, and uplink subframe are different in each configuration.

[0061] A point of time at which a change is performed from downlink to uplink or a point of time at which a change is performed from uplink to downlink is called a switching point. The periodicity of the switching point means a cycle in which an uplink subframe and a downlink subframe are changed is identically repeated. Both 5 ms and 10 ms are supported in the periodicity of a switching point. If the periodicity of a switching point has a cycle of a 5 ms downlink-uplink switching point, the special subframe S is present in each half frame. If the periodicity of a switching point has a cycle of a 5 ms downlink-uplink switching point, the special subframe S is present in the first half frame only.

[0062] In all the configurations, 0 and 5 subframes and a DwPTS are used for only downlink transmission. An UpPTS and a subframe subsequent to a subframe are always used for uplink transmission.

[0063] Such uplink-downlink configurations may be known to both an eNB and UE as system information. An eNB may notify UE of a change of the uplink-downlink allocation state of a radio frame by transmitting only the index of uplink-downlink configuration information to the UE whenever the uplink-downlink configuration information is changed. Furthermore, configuration information is kind of downlink control information and may be transmitted through a Physical Downlink Control Channel (PDCCH) like other scheduling information. Configuration information may be transmitted to all UEs within a cell through a broadcast channel as broadcasting information.

[0064] Table 2 below shows a configuration (length of DwPTS/GP/UpPTS) of a special subframe.

TABLE 2

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
		UpPTS			UpPTS	
	DwPTS	Normal cyclic prefix in uplink	Extended cyclic prefix in uplink	DwPTS	Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			—	—	—
8	$24144 \cdot T_s$			—	—	—

[0065] The structure of a radio frame is only one example. The number of subcarriers included in a radio frame or the number of slots included in a subframe and the number of OFDM symbols included in a slot may be changed in various ways.

[0066] FIG. **2** is a diagram illustrating a resource grid for one downlink slot in a wireless communication system to which an embodiment of the present invention may be applied.

[0067] Referring to FIG. **2**, one downlink slot includes a plurality of OFDM symbols in a time domain. It is described herein that one downlink slot includes 7 OFDMA symbols and one resource block includes 12 subcarriers for exemplary purposes only, and the present invention is not limited thereto.

[0068] Each element on the resource grid is referred to as a resource element, and one resource block (RB) includes 12×7 resource elements. The number of RBs NDL included in a downlink slot depends on a downlink transmission bandwidth.

[0069] The structure of an uplink slot may be the same as that of a downlink slot.

[0070] FIG. **3** shows the structure of a downlink subframe in a wireless communication system to which an embodiment of the present invention may be applied.

[0071] Referring to FIG. **3**, a maximum of three OFDM symbols located in a front portion of a first slot of a subframe correspond to a control region in which control channels are allocated, and the remaining OFDM symbols correspond to a data region in which a physical downlink shared channel (PDSCH) is allocated. Downlink control channels used in 3GPP LTE include, for example, a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), and a physical hybrid-ARQ indicator channel (PHICH).

[0072] A PCFICH is transmitted in the first OFDM symbol of a subframe and carries information about the number of OFDM symbols (i.e., the size of a control region) which is used to transmit control channels within the subframe. A PHICH is a response channel for uplink and carries an acknowledgement (ACK)/not-acknowledgement (NACK) signal for a Hybrid Automatic Repeat Request (HARQ). Control information transmitted in a PDCCH is called Downlink Control Information (DCI). DCI includes uplink resource allocation information, downlink resource allocation information, or an uplink transmission (Tx) power control command for a specific UE group.

[0073] A PDCCH may carry information about the resource allocation and transport format of a downlink shared channel (DL-SCH) (this is also called an "downlink grant"), resource allocation information about an uplink shared channel (UL-SCH) (this is also called a "uplink grant"), paging information on a PCH, system information on a DL-SCH, the resource allocation of a higher layer control message, such as a random access response transmitted on a PDSCH, a set of transmission power control commands for individual UE within specific UE group, and the activation of a Voice over Internet Protocol (VoIP), etc. A plurality of PDCCHs may be transmitted within the control region, and UE may monitor a plurality of PDCCHs. A PDCCH is transmitted on a single Control Channel Element (CCE) or an aggregation of some contiguous CCEs. A CCE is a logical allocation unit that is used to provide a PDCCH with a coding rate according to the state of a radio channel. A CCE corresponds to a plurality of resource element groups. The format of a PDCCH and the number of available bits of a PDCCH are determined by an association relationship between the number of CCEs and a coding rate provided by CCEs.

[0074] An eNB determines the format of a PDCCH based on DCI to be transmitted to UE and attaches a Cyclic Redundancy Check (CRC) to control information. A unique identifier (a Radio Network Temporary Identifier (RNTI)) is masked to the CRC depending on the owner or use of a PDCCH. If the PDCCH is a PDCCH for specific UE, an identifier unique to the UE, for example, a Cell-RNTI (C-RNTI) may be masked to the CRC. If the PDCCH is a PDCCH for a paging message, a paging indication identifier, for example, a Paging-RNTI (P-RNTI) may be masked to the CRC. If the PDCCH is a PDCCH for system information, more specifically, a System Information Block (SIB), a system information identifier, for example, a System Information-RNTI (SI-RNTI) may be masked to the CRC. A Random Access-RNTI (RA-RNTI) may be masked to the CRC in order to indicate a random access response which is a response to the transmission of a random access preamble by UE.

[0075] FIG. **4** shows the structure of an uplink subframe in a wireless communication system to which an embodiment of the present invention may be applied.

[0076] Referring to FIG. **4**, the uplink subframe may be divided into a control region and a data region in a frequency domain. A physical uplink control channel (PUCCH) carrying uplink control information is allocated to the control region. A physical uplink shared channel (PUSCH) carrying user data is allocated to the data region. In order to maintain single carrier characteristic, one UE does not send a PUCCH and a PUSCH at the same time.

[0077] A Resource Block (RB) pair is allocated to a PUCCH for one UE within a subframe. RBs belonging to an RB pair occupy different subcarriers in each of 2 slots. This is called that an RB pair allocated to a PUCCH is frequency-hopped in a slot boundary.

[0078] Reference Signal (RS)

[0079] In a wireless communication system, data is transmitted via a wireless channel, and thus, a signal may be distorted during transmission. In order for a receiving end to accurately receive, distortion of the received signal should be corrected using channel information. In order to detect channel information, a method of transmitting a signal known to both a transmitting side and the receiving side and a method of detecting channel information using a degree of distortion when a signal is transmitted through a channel are largely used. The afore-mentioned signal is called a pilot signal or a reference signal (RS).

[0080] Also, recently, most mobile communication systems uses a method for enhancing transmission/reception data efficiency by adopting multiple transmit antennas and multiple receive antennas in order to transmit a packet, moving away from the conventional use of a single transmit antenna and a single receive antenna. When data is transmitted or received using multiple input/output antennas, a channel state between the transmit antennas and the receive antennas should be detected to accurately receive a signal. Therefore, each transmit antenna should have a separate reference signal.

[0081] In a mobile communication system, an RS may be classified into two types according to its purpose. There are an RS for acquiring channel information and an RS used for data demodulation. The former aims at acquiring channel information by a UE to downlink, and thus, the former RS should be transmitted in a broadband, and even a UE, which does not receive downlink data in a specific subframe, should receive and measure the RS. Also, the former RS is used for measurement such as handover, or the like. The latter RS is an RS transmitted together in a corresponding resource when a base station (BS) transmits it to downlink. Upon receiving the corresponding RS, the UE may be able to perform channel estimation, and thus, demodulate data. The latter RS should be transmitted in a region in which data is transmitted.

[0082] Five types of downlink RS are defined as follows.

[0083] CRS: cell-specific reference signal

[0084] MBSFN RS: multicast-broadcast single-frequency network reference signal

[0085] UE-specific RS or demodulation RS (DM-RS)

[0086] PRS: positioning reference signal

[0087] CSI-RS: channel state information reference signal

[0088] One RS is transmitted for each downlink antenna port.

[0089] The CRS is transmitted in every downlink subframe within a cell supporting PDSCH transmission. The CRS is transmitted in one or more of antenna ports 0 to 3. The CRS is defined only in Δf=15 kHz.

[0090] The MBSFN RS is transmitted in an MBSFN region of an MBSFN subframe only when a physical multicast channel (PMCH) is transmitted. The MBSFN RS is transmitted in antenna port 4. The MBSFN RS is defined only in an extended CP.

[0091] The DM-RS is supported for transmission of a PDSCH and is transmitted in antenna ports p=5, p=7, p=8 or p=7, 8, . . . , u+6. Here, u is the number of layers used for transmission of the PDSCH. The DM-RS is present and valid for PDSCH demodulation only when PDSCH transmission is associated in a corresponding antenna port. The DM-RS is transmitted only in a resource block (RB) to which the corresponding PDSCH is mapped.

[0092] Regardless of the antenna port p, when any one of a physical channel and a physical signal other than the DM-RS is transmitted using an RE of the same index pair (k,l) in which the DM-RS is transmitted, the DM-RS is not transmitted in the RE of the corresponding index pair (k,l).

[0093] The PRS is transmitted only in a resource block within a downlink subframe set for PRS transmission.

[0094] When both a general subframe and an MBSFN subframe are set as positioning subframes within one cell, OFDM symbols within the MBSFN subframe set for PRS transmission use the same CP as that of subframe #0. When only the MBSFN subframe is set as a positioning subframe within one cell, OMDM symbols set for the PRS within the MBSFN region of the corresponding subframe use an extended CP.

[0095] Within the subframe set for PRS transmission, a starting point of an OFDM symbol set for PRS transmission is the same as a starting point of a subframe having the same CP length as that of every OFDM symbol set for the RPS transmission.

[0096] The PRS is transmitted in antenna port 6.

[0097] The PRS is not mapped to an RE (k,l) allocated to a physical broadcast channel (PBCH), a PSS, or SSS, regardless of the antenna port p.

[0098] The PRS is defined only in Δf=15 kHz.

[0099] The CSI-RS is transmitted in 1, 2, 4, or 8 number of antenna ports using p=15, p=15, 16, p=15, . . . , 18, and p=15, . . . , 22, respectively.

[0100] The CSI-RS is defined only in Δf=15 kHz.

[0101] The reference signal (RS) will be described in more detail.

[0102] The CRS is an RS for obtaining information regarding a state of a channel shared by every terminal within a cell and measuring handover, or the like. The DM-RS is used for data demodulation only for a specific UE. Information for demodulation and channel measurement may be provided using such reference signals. That is, the DM-RS is used only for data demodulation, and the CRS is used for both purposes of channel information obtaining and data demodulation.

[0103] The receiving side (i.e., UE) measures a channel state from the CRS, and feeds back an indicator related to channel quality such as a CQI (Channel Quality Indicator), a PMI (Precoding Matrix Index), a PTI (Precoding Type Indicator) and/or an RI (Rank Indicator) to the transmitting side (i.e., Base Station). Meanwhile, a reference signal related to feedback of channel state information (CSI) may be defined as a CSI-RS.

[0104] The DM-RS may be transmitted through resource elements when data on a PDSCH is required to be demodulated. The UE may receive whether a DM-RS is present through a higher layer, and may be valid only when the corresponding PDSCH is mapped. The DM-RS may be called a UE-specific RS or a demodulation RS (DMRS).

[0105] FIG. **5** illustrates a reference signal pattern mapped to a downlink resource block pair in a wireless communication system to which an embodiment of the present invention may be applied.

[0106] Referring to FIG. **5**, a downlink resource block pair, that is, a unit in which a reference signal is mapped unit, may be represented in the form of one subframe in a time domain×12 subcarriers in a frequency domain. That is, in a time axis (i.e., x axis), one resource block pair has a length of 14 OFDM symbols in the case of a normal Cyclic Prefix (CP) (FIG. **10**(*a*)) and has a length of 12 OFDM symbols in the case of an extended CP (FIG. **10**(*b*)). In the resource block lattice, Resource Elements (REs) indicated by "0", "1", "2", and "3" mean the positions of the CRSs of antenna port indices "0", "1", "2", and "3", and REs indicated by "D" denotes the position of a DRS.

[0107] A CRS is described in detail below. The CRS is used to estimate the channel of a physical antenna and is a reference signal which may be received by all UEs located in a cell in common. The CRS is distributed to the entire frequency bandwidth. Furthermore, the CRS may be used for Channel Quality Information (CQI) and data demodulation.

[0108] The CRS is defined in various formats depending on an antenna array on the transmission side (i.e., an eNB). In a 3GPP LTE system (e.g., release-8), various antenna arrays are supported, and the transmission side of a downlink signal has three types of antenna arrays, such as 3 single transmission antennas, 2 transmission antennas, and 4 transmission antennas. If an eNB uses a single transmission antenna, reference signals for a single antenna port are arrayed. If an eNB uses 2 transmission antennas, reference signals for 2 transmission antenna ports are arrayed using a Time Division Multiplexing (TDM) method and/or a Frequency Division Multiplexing (FDM) method. That is, different time resources and/or different frequency resources are allocated so that reference signals for 2 antenna ports are distinguished from each other.

[0109] Furthermore, if an eNB uses 4 transmission antennas, reference signals for 4 transmission antenna ports are arrayed using the TDM and/or FDM methods. Channel information measured by the reception side (i.e., UE) of a downlink signal may be used to demodulate data transmitted using a transmission method, such as single transmission antenna transmission, transmission diversity, closed-loop spatial multiplexing, open-loop spatial multiplexing, or an multi-User-multi-input/output (MIMO) antennas.

[0110] If a multi-input/output antenna is supported, when a reference signal is transmitted by a specific antenna port, the reference signal is transmitted in the positions of resource elements specified depending on the pattern of the reference signal and is not transmitted in the positions of resource elements specified for other antenna ports. That is, reference signals between different antennas do not overlap.

[0111] Sounding Reference Signal (SRS)

[0112] An SRS is mostly used in the measurement of channel quality in order to perform uplink frequency-selective scheduling and is not related to the transmission of uplink data and/or control information, but the present invention is not limited thereto. The SRS may be used for various other purposes for improving power control or various startup functions of UEs which have not been recently scheduled. The startup functions may include an initial Modulation and Coding Scheme (MCS), initial power control for data transmission, a timing advance, and frequency semi-selective scheduling, for example. In this case, the frequency semi-selective scheduling means selectively allocating a frequency resource to the first slot of a subframe and pseudo-randomly hopping to another frequency in the second slot of the subframe and allocating frequency resources.

[0113] Furthermore, the SRS may be used to measure downlink channel quality, assuming that a radio channel is reciprocal between uplink and downlink. Such an assumption is particularly valid when the same frequency spectrum is shared between uplink and downlink and in Time Division Duplex (TDD) systems separated in a time domain.

[0114] The subframes of an SRS transmitted by UE within a cell may be represented by a cell-specific broadcasting signal. A 4-bit cell-specific parameter "srsSubframeConfiguration" indicates 15 available subframe arrays in which an SRS may be transmitted though respective radio frames. In accordance with such arrays, the flexibility of control of SRS overhead may be provided according to a deployment scenario.

[0115] A sixteenth array completely turns off the switch of an SRS within a cell, which is mostly suitable for a serving cell which provides service to high-speed UEs.

[0116] FIG. **6** illustrates an uplink subframe including the symbols of a Sounding Reference Signal (SRS) in a wireless communication system to which an embodiment of the present invention may be applied.

[0117] Referring to FIG. **6**, an SRS is always transmitted through the last SC-FDMA symbol in an arrayed subframe. Accordingly, an SRS and DMRS are placed in different SC-FDMA symbols.

[0118] The transmission of PUSCH data is not permitted in a specific SC-FDMA symbol for SRS transmission. As a result, if sounding overhead is the highest, that is, although an SRS symbol is included in all subframes, sounding overhead does not exceed about 7%.

[0119] Each SRS symbol is generated based on a base sequence (i.e., a random sequence or a sequence set based on Zadoff-Ch (ZC)) regarding a given time unit and frequency bandwidth. All UEs within the same cell use the same base sequence. In this case, the transmissions of SRSs from a plurality of UEs within the same cell in the same frequency bandwidth and the same time are orthogonal to each other by different cyclic shifts of a base sequence and are distinguished from each other.

[0120] SRS sequences from different cells may be distinguished from each other because different base sequences are allocated to respective cells, but orthogonality between the different base sequences is not guaranteed.

[0121] General Carrier Aggregation

[0122] A communication environment taken into consideration in embodiments of the present invention includes a multi-carrier support environment. That is, a multi-carrier system or Carrier Aggregation (CA) system that is used in an embodiment of the present invention refers to a system in which one or more Component Carriers (CCs) having a smaller bandwidth than a target bandwidth are aggregated and used when the target wideband is configured in order to support a wideband.

[0123] In an embodiment of the present invention, a multi-carrier means of an aggregation of carriers (or a carrier aggregation). In this case, an aggregation of carriers means both an aggregation between contiguous carriers and an aggregation between discontinuous (or non-contiguous) carriers. Furthermore, the number of CCs aggregated between downlink and uplink may be different. A case where the number of downlink CCs (hereinafter called "DL CCs") and the number of uplink CCs (hereinafter called "UL CCs") are the same is called a symmetric aggregation. A case where the number of DL CCs is different from the number of UL CCs is called an asymmetric aggregation. Such the term of a carrier aggregation may be replaced with terms, such as a carrier aggregation, bandwidth aggregation, or spectrum aggregation.

[0124] An object of a carrier aggregation configured by aggregating two or more component carriers is to support up to a 100 MHz bandwidth in an LTE-A system. When one or more carriers having a smaller bandwidth than a target bandwidth are aggregated, the bandwidth of the aggregated carriers may be restricted to a bandwidth which is used in an existing system in order to maintain backward compatibility with an existing IMT system. For example, in an existing 3GPP LTE system, {1.4, 3, 5, 10, 15, 20} MHz bandwidths may be supported. In a 3GPP LTE-advanced system (i.e., LTE-A), bandwidths greater than the bandwidth 20 MHz may be supported using only the bandwidths for a backward compatibility with existing systems. Furthermore, in a carrier aggregation system used in an embodiment of the present invention, new bandwidths may be defined regardless of the bandwidths used in the existing systems in order to support a carrier aggregation.

[0125] An LTE-A system uses the concept of a cell in order to manage radio resources.

[0126] The aforementioned carrier aggregation environment may also be called a multi-cell environment. A cell is defined as a combination of a pair of a downlink resource (DL CC) and an uplink resource (UL CC), but an uplink resource is not an essential element. Accordingly, a cell may consist of a downlink resource only or a downlink resource and an uplink resource. If specific UE has a single configured serving cell, it may have 1 DL CC and 1 UL CC. If specific UE has two or more configured serving cells, it has DL CCs corresponding to the number of cells, and the number of UL CCs may be the same as or smaller than the number of DL CCs.

[0127] In some embodiments, a DL CC and an UL CC may be configured in an opposite way. That is, if specific UE has a plurality of configured serving cells, a carrier aggregation environment in which the number of UL CCs is greater than the number of DL CCs may also be supported. That is, a carrier aggregation may be understood as being an aggregation of two or more cells having different carrier frequency (the center frequency of a cell). In this case, the "cell" should be distinguished from a "cell", that is, a region commonly covered by an eNB.

[0128] A cell used in an LTE-A system includes a Primary Cell (PCell) and a Secondary Cell (SCell). A PCell and an

SCell may be used as serving cells. In the case of UE which is in an RRC_CONNECTED state, but in which a carrier aggregation has not been configured or which does not support a carrier aggregation, only one serving cell configured as only a PCell is present. In contrast, in the case of UE which is in the RRC_CONNECTED state and in which a carrier aggregation has been configured, one or more serving cells may be present. A PCell and one or more SCells are included in each serving cell.

[0129] A serving cell (PCell and SCell) may be configured through an RRC parameter. PhysCellId is the physical layer identifier of a cell and has an integer value from 0 to 503. SCellIndex is a short identifier which is used to identify an SCell and has an integer value of 1 to 7. ServCellIndex is a short identifier which is used to identify a serving cell (PCell or SCell) and has an integer value of 0 to 7. The value 0 is applied to a PCell, and SCellIndex is previously assigned in order to apply it to an SCell. That is, in ServCellIndex, a cell having the smallest cell ID (or cell index) becomes a PCell.

[0130] A PCell means a cell operating on a primary frequency (or primary CC). A PCell may be used for UE to perform an initial connection establishment process or a connection re-establishment process and may refer to a cell indicated in a handover process. Furthermore, a PCell means a cell that belongs to serving cells configured in a carrier aggregation environment and that becomes the center of control-related communication. That is, UE may receive a PUCCH allocated only in its PCell and send the PUCCH and may use only the PCell to obtain system information or to change a monitoring procedure. An Evolved Universal Terrestrial Radio Access Network (E-UTRAN) may change only a PCell for a handover procedure using the RRC connection reconfiguration (RRCConnectionReconfiguration) message of a higher layer including mobility control information (mobilityControlInfo) for UE which supports a carrier aggregation environment.

[0131] An SCell may mean a cell operating on a secondary frequency (or secondary CC). Only one PCell is allocated to specific UE, and one or more SCells may be allocated to the specific UE. An SCell may be configured after RRC connection is established and may be used to provide additional radio resources. A PUCCH is not present in the remaining cells, that is, SCells that belong to serving cells configured in a carrier aggregation environment and that do not include a PCell. When adding an SCell to UE supporting a carrier aggregation environment, an E-UTRAN may provide all types of system information related to the operation of a related cell in the RRC_CONNECTED state through a dedicated signal. A change of system information may be controlled by releasing and adding a related SCell. In this case, the RRC connection reconfiguration (RRCConnectionReconfigutaion) message of a higher layer may be used. An E-UTRAN may send dedicated signaling having a different parameter for each UE instead of broadcasting within a related SCell.

[0132] After an initial security activation process is started, an E-UTRAN may configure a network including one or more SCells by adding to a PCell that is initially configured in a connection establishing process. In a carrier aggregation environment, a PCell and an SCell may operate respective component carriers. In the following embodiments, a Primary Component Carrier (PCC) may be used as the same meaning as a PCell, and a Secondary Component Carrier (SCC) may be used as the same meaning as an SCell.

[0133] FIG. **7** shows an example of component carriers and carrier aggregation in a wireless communication system to which an embodiment of the present invention may be applied.

[0134] (a) of FIG. **7** illustrates a single carrier structure used in an LTE system. Component carriers include a DL CC and a UL CC. One CC may have a frequency range of 20 MHz.

[0135] (b) of FIG. **7** illustrates a carrier aggregation structure used in an LTE_A system. (b) of FIG. **7** illustrates a case in which three CCs having a frequency size of 20 MHz are combined. Three DL CCs and three UL CCs are provided, but there is no limitation in the number of DL CCs and UL CCs. In the case of carrier aggregation, the UE may simultaneously monitor three CCs, receive downlink signal/data, and transmit uplink signal/data.

[0136] If N DL CCs are managed in a specific cell, a network may allocate M ($M \leq N$) DL CCs to UE. In this case, the UE may monitor only the M limited DL CCs and receive a DL signal. Furthermore, a network may give priority to L ($L \leq M \leq N$) DL CCs and allocate major DL CCs to UE. In this case, the UE must monitor the L DL CCs. Such a method may be applied to uplink transmission in the same manner.

[0137] A linkage between a carrier frequency (or DL CC) of a downlink resource and a carrier frequency (or UL CC) of an uplink resource may be indicated by a higher layer message, such as an RRC message, or system information. For example, a combination of DL resources and UL resources may be configured by a linkage defined by System Information Block Type2 (SIB2). Specifically, the linkage may mean a mapping relationship between a DL CC in which a PDCCH carrying an UL grant is transmitted and an UL CC in which the UL grant is used and may mean a mapping relationship between a DL CC (or UL CC) in which data for an HARQ is transmitted and an UL CC (or DL CC) in which an HARQ ACK/NACK signal is transmitted.

[0138] Cross-Carrier Scheduling

[0139] In a carrier aggregation system, there are two methods, that is, a self-scheduling method and a cross-carrier scheduling method form the point of view of scheduling for a carrier or a serving cell. Cross-carrier scheduling may also be called cross-component carrier scheduling or cross-cell scheduling.

[0140] Cross-carrier scheduling means that a PDCCH (DL grant) and a PDSCH are transmitted in different DL CCs or that a PUSCH transmitted according to a PDCCH (UL grant) transmitted in a DL CC is transmitted through an UL CC different from an UL CC that is linked to the DL CC through which the UL grant has been received.

[0141] Whether cross-carrier scheduling will be performed may be activated or deactivate in a UE-specific way, and each UE may be notified through high layer signaling (e.g., RRC signaling) semi-statically.

[0142] If cross-carrier scheduling is activated, there is a need for a Carrier Indicator Field (CIF) providing notification that a PDSCH/PUSCH indicated by a PDCCH is transmitted through which DL/UL CC. For example, a PDCCH may allocate a PDSCH resource or PUSCH resource to any one of a plurality of component carriers using a CIF. That is, if a PDCCH on a DL CC allocates a PDSCH or PUSCH resource to one of multi-aggregated DL/UL CCs, a CIF is configured. In this case, a DCI format of LTE-A Release-8 may be extended according to the CIF. In this case, the configured CIF may be fixed to a 3-bit field,

and the position of the configured CIF may be fixed regardless of the size of the DCI format. Furthermore, a PDCCH structure (resource mapping based on the same coding and the same CCE) of LTE-A Release-8 may be reused.

[0143] In contrast, if a PDCCH on a DL CC allocates a PDSCH resource on the same DL CC or allocates a PUSCH resource on a single-linked UL CC, a CIF is not configured. In this case, the same PDCCH structure (resource mapping based on the same coding and the same CCE) and DCI format as those of LTE-A Release-8 may be used.

[0144] If cross-carrier scheduling is possible, UE needs to monitor a PDCCH for a plurality of pieces of DCI in the control region of a monitoring CC based on a transmission mode and/or bandwidth corresponding to each CC. Accordingly, there is a need for the configuration of a search space and PDCCH monitoring capable of supporting such monitoring.

[0145] In a carrier aggregation system, a UE DL CC set is indicative of a set of DL CCs scheduled so that UE receives a PDSCH. A UE UL CC set is indicative of a set of UL CCs scheduled so that UE transmits a PUSCH. Furthermore, a PDCCH monitoring set is indicative of a set of one or more DL CCs for performing PDCCH monitoring. A PDCCH monitoring set may be the same as a UE DL CC set or may be a subset of a UE DL CC set. A PDCCH monitoring set may include at least one of DL CCs within a UE DL CC set. Alternatively, a PDCCH monitoring set may be separately defined regardless of a UE DL CC set. DL CCs included in a PDCCH monitoring set may be configured so that self-scheduling for a linked UL CC is always possible. Such a UE DL CC set, UE UL CC set, and PDCCH monitoring set may be configured in a UE-specifically, UE group-specifically, or cell-specifically.

[0146] If cross-carrier scheduling is deactivated, it means that a PDCCH monitoring set is always the same as UE DL CC set. In this case, there is no indication, such as separate signaling for a PDCCH monitoring set. However, if cross-carrier scheduling is activated, a PDCCH monitoring set may be defined in a UE DL CC set. That is, in order to schedule a PDSCH or PUSCH for UE, an eNB transmits a PDCCH through a PDCCH monitoring set only.

[0147] FIG. **8** shows an example of a structure of a subframe according to cross-carrier scheduling in a wireless communication system to which an embodiment of the present invention may be applied.

[0148] Referring to FIG. **8**, in a DL subframe for an LTE-A UE, three DL CCs are combined and DL CC 'A' indicates a case set with a PDCCH monitoring DL CC. In case where a CIF is not used, each DL CC may transmit a PDCCH scheduling a PDSCH thereof without a CIF. Meanwhile, in case where the CIF is used through higher layer signaling, only one DL CC 'A' may transmit the PDCCH scheduling a PDSCH thereof or a PDSCH of another CC using the CIF. Here, DL CC 'B' and 'C' not set as PDCCH monitoring DL CCs do not transmit the PDCCH.

[0149] PDCCH Transmission

[0150] The eNB determines a PDCCH format according to a DCI to be transmitted to the UE, and attaches a CRC (Cyclic Redundancy Check) to control information. A unique identifier (which is called an RNTI (Radio Network Temporary Identifier)) is masked to the CRC according to an owner of the PDCCH or a purpose thereof. In the case of a PDCCH for a specific UE, a unique identifier of a UE, e.g., a C-RNTI (Cell-RNTI), may be masked to the CRC. Or, in the case of a PDCCH for a paging message, a paging indication identifier, e.g., a P-RNTI (Paging-RNTI) may be masked to the CRC. In the case of a PDCCH for system information, specifically, a system information block (SIB), a system information identifier or an SI-RNTI (system information RNTI) may be masked to the CRC. In order to indicate a random access response, a response with respect to transmission of a random access preamble of a UE, an RA-RNTI (random access-RNTI) may be masked to the CRC.

[0151] Thereafter, the BS performs channel coding on CRC-added control information to generate coded data. Here, the BS may perform channel coding at a code rate according to an MCS level. The BS may perform rate matching according to a CCE aggregation level allocated to a PDCCH format, and modulates the coded data to generate modulated symbols. Here, a modulation order according to the MCS level may be used. A CCE aggregation level of modulated symbols forming one PDCCH may be one of 1, 2, 4 and 8. Thereafter, the BS maps the modulated symbols to physical resource elements (CCE to RE mapping).

[0152] A plurality of PDCCHs may be transmitted in one subframe. That is, a control region of one subframe includes a plurality of CCEs having an index 0~N_(CCE,k)−1. Here, N(CCE, k) denotes a total number of CCE s within a control region of a kth subframe. The UE monitors a plurality of PDCCHs in each subframe.

[0153] Here, monitoring refers to UE attempting to decode PDCCHs according to a monitored PDCCH format. In a control region allocated within a subframe, the BS does not provide information regarding where a corresponding PDCCH is present. In order to receive a control channel transmitted from the BS, the UE searches for a PDCCH thereof by monitoring an aggregation of PDCCH candidates within a subframe because the UE does not know in which position, at which CCE aggregation level, or in which DCI format, the PDCCH thereof is transmitted. This is called blind decoding/detection (BD). Blind decoding refers to a method by which the UE de-masks a UE ID thereof in a CRC portion and checks a CRC error to determine whether a corresponding PDCCH is a control channel of the UE.

[0154] In the active mode, the UE monitors a PDCCH of each subframe to receive data transmitted to the UE. In a DRX mode, the UE wakes up in a monitoring section of each DRX period to monitor a PDCCH in a subframe corresponding to a monitoring section. A subframe in which PDCCH is monitored is called a non-DRX subframe.

[0155] In order to receive the PDCCH transmitted to the UE, the UE should perform blind decoding on all CCEs present in the control region of the non-DRX subframe. Since the UE does not know which PDCCH format will be transmitted, the UE should decode all PDCCHs at a possible CCE aggregation level until the blind decoding of the PDCCH is successful in every non-DRX subframe. Since the UE does not know how many CCEs the PDCCH for itself uses, the UE should attempt detection at all possible CCE aggregation levels until the blind decoding of the PDCCH is successful. That is, the UE performs blind decoding by each CCE aggregation level. That is, the UE first attempts at decoding at a CCE aggregation level unit by 1. If decoding fails, the UE attempts at decoding at the CCE aggregate level unit by 2. Thereafter, the UE attempts at decoding the CCE aggregation level unit by 4 and the CCE aggregation level unit by 8 again. Also, the UE attempts at

blind decoding on all four C-RNTI, P-RNTI, SI-RNTI and RA-RNTI. In addition, the UE attempts at blind decoding on all DCI formats to be monitored.

[0156] In this manner, if the UE attempts at blind decoding by every CCE aggregation level for all DCI formats to be monitored for all possible RNTIs, the number of detection attempts will be excessively increase, and thus, in the LTE system, a search space (SS) concept is defined for blind decoding of the UE. Search space refers to a PDCCH candidate set for monitoring, and may have a different size according to each PDCCH format.

[0157] The search space may include a common search space (CSS) and a UE-specific/dedicated search space (USS). In the case of the common search space, all terminals may know a size of the common search space, but the UE-specific search space may be set individually for each terminal. Accordingly, the UE should monitor both the UE-specific search space and the common search space in order to decode the PDCCH, and thus, the UE performs blind decoding (BD) at a maximum of 44 times in one sub-frame. Here, blind decoding performed in accordance with different CRC values (e.g., C-RNTI, P-RNTI, SI-RNTI, RA-RNTI) is not included.

[0158] Due to the small search space, it may happen that eNB fails to secure the CCE resources for transmitting the PDCCH to all the UEs to which the PDCCH is to be transmitted within a given subframe. This is because resources remaining after the CCE location are allocated may not be included in the search space of the specific UE. In order to minimize such barriers that may continue in a next sub-frame, a UE-specific hopping sequence may be applied to a starting point of the UE-specific search space.

[0159] Table 3 shows a size of the common search space, and a size of the UE-specific search space.

TABLE 3

PDCCH format	Number of CCEs (n)	Number of candidates in common search space	Number of candidates in dedicated search space
0	1	—	6
1	2	—	6
2	4	4	2
3	8	2	2

[0160] In order to alleviate the computational load of the UE according to the number of attempts at blind decoding, the UE does not simultaneously perform search according to all defined DCI formats. In detail, the UE may always perform search for DCI format 0 and 1A in the UE-specific search space. At this time, DCI formats 0 and 1A have the same size, but the UE may differentiate between the DCI format using a flag (for format 0/format 1A differentiation) used for differentiating between DCI formats 0 and 1A included in the PDCCH. Also, according to the PDSCH transmission mode set by the eNB, a DCI format other than the DCI formats 0 and 1A may be required for the terminal. For example, there are DCI formats 1, 1B, and 2.

[0161] In the common search space, the UE may search the DCI formats 1A and 1C. Also, the UE may be configured to search for DCI format 3 or 3A, and DCI formats 3 and 3A have the same size as DCI formats 0 and 1A, but the UE may differentiate the DCI formats using the CRC scrambled by an identifier other than a UE-specific identifier.

[0162] A search space S_k^(L) refers to a PDCCH candidate set according to an aggregation level $L\in\{1,2,4,8\}$. A CCE according to a PDCCH candidate set m of a search space may be determined by Equation 4 below.

$$L\cdot\{(Y_k+m)\bmod\lfloor N_{CCE,k}/L\rfloor\}+i \quad \text{[Equation 1]}$$

[0163] Here, M_(L) denotes the number of PDCCH candidates according to a CCE aggregation level L for monitoring, and m=0~M^(L)−1. i denotes an index designating an individual CCE in each PDCCH candidate, and i=0~L−1.

[0164] As described above, the UE monitors both the UE-specific search space and the common search space to decode the PDCCH. Here, the common search space (CSS) supports PDCCHs having an aggregation level {4, 8}, and the UE-specific search space (USS) supports PDCCHs having an aggregation level {1, 2, 4, 8}

[0165] Table 4 shows PDCCH candidates monitored by the UE.

TABLE 4

	Search space $S_k^{(L)}$		Number of PDCCH
Type	Aggregation level L	Size [in CCEs]	candidates $M^{(L)}$
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

[0166] Referring to Equation 1, in the case of the CSS, k is set to 0 for two aggregation levels L=4 and L=8. Meanwhile, in the case of the UE-specific SS (USS), Y_k is defined as expressed by Equation 5 for an aggregation level L.

$$Y_k=(A\cdot Y_{k-1})\bmod D \quad \text{[Equation 2]}$$

[0167] Here, $Y_{-1}=n_{RNTI}\neq 0$, and an RNTI value used for n_{RNTI} may be defined as one of identifiers of the UE. Also, A=39827, D=65537, and $k=\lfloor n_s/2\rfloor$. Here, n_s denotes a slot number (or index) in a radio frame.

[0168] Block Spreading Technique

[0169] The block spreading technique is a scheme that modulates transmission of the control signal by using the SC-FDMA scheme unlike the existing PUCCH format 1 series or 2 series. As illustrated in FIG. **11**, a symbol sequence may be spread and transmitted on the time domain by using an orthogonal cover code (OCC). The control signals of the plurality of terminals may be multiplexed on the same RB by using the OCC. In the case of PUCCH format 2 described above, one symbol sequence is transmitted throughout the time domain and the control signals of the plurality of terminals are multiplexed by using the cyclic shift (CS) of the CAZAC sequence, while in the case of a block spreading based on PUCCH format (for example, PUCCH format 3), one symbol sequence is transmitted throughout the frequency domain and the control signals of the plurality of terminals are multiplexed by using the time domain spreading using the OCC.

[0170] FIG. **9** illustrates one example of generating and transmitting 5 SC-FDMA symbols during one slot in the wireless communication system to which the present invention may be applied.

[0171] In FIG. **9**, an example of generating and transmitting 5 SC-FDMA symbols (that is, data part) by using an

OCC having the length of 5 (alternatively, SF=5) in one symbol sequence during one slot. In this case, two RS symbols may be used during one slot.

[0172] In the example of FIG. **9**, the RS symbol may be generated from a CAZAC sequence to which a specific cyclic shift value is applied and transmitted in a type in which a predetermined OCC is applied (alternatively, multiplied) throughout a plurality of RS symbols. Further, in the example of FIG. **8**, when it is assumed that 12 modulated symbols are used for each OFDM symbol (alternatively, SC-FDMA symbol) and the respective modulated symbols are generated by QPSK, the maximum bit number which may be transmitted in one slot becomes 24 bits (=12×2). Accordingly, the bit number which is transmittable by two slots becomes a total of 48 bits. When a PUCCH channel structure of the block spreading scheme is used, control information having an extended size may be transmitted as compared with the existing PUCCH format 1 series and 2 series.

[0173] CA-Based CoMP Operation

[0174] In system subsequent to LTE, cooperative multi-point (CoMP) transmission may be implemented using a carrier aggregation (CA) function in LTE.

[0175] FIG. **10** is a diagram illustrating a carrier aggregation-based CoMP system in a wireless communication system to which an embodiment of the present invention may be applied.

[0176] FIG. **10** illustrates that a primary cell (PCell) carrier and a secondary cell (SCell) carrier use the same frequency band on a frequency axis and are respectively allocated to two eNBs that are geographically spaced apart from each other.

[0177] A serving eNB allocates a PCell to UE1, and an neighboring eNB providing much interference allocates an SCell, so that Various DL/UL CoMP operations such as JT, CS/CB, and dynamic cell selection may be performed.

[0178] FIG. **10** shows an example in which UE aggregates two eNBs as a PCell and an SCell, respectively. Practically, UE may aggregate three or more cells, and a CoMP operation on some of the three cells in the same frequency band may be performed and a simple CA operation on other cells in a different frequency band may be performed. In this case, the PCell does not need to take part in the CoMP operation.

[0179] UE Procedure for Receiving PDSCH

[0180] When UE detects a PDCCH of a serving cell on which a DCI format 1, 1A, 1 B, 1C, 1D, 2, 2A, 2B or 2C intended for the UE is carried other than a subframe(s) indicated by a higher layer parameter "mbsfn-SubframeConfigList", the UE decodes a corresponding PDSCH in the same subframe with the restriction of the number of transport blocks defined in a higher layer.

[0181] UE decodes a PDSCH according to a detected PDCCH with CRC scrambled by an SI-RNTI or P-RNTI on which a DCI format 1A, 1C intended for the UE is carried, and assumes that a PRS is not present in a resource block (RB) on which the corresponding PDSCH is carried.

[0182] UE in which a carrier indicator field (CIF) for a serving cell is configured assumes that a CIF is not present in any PDCCH of a serving cell within a common search space.

[0183] Otherwise, when PDCCH CRC is scrambled by a C-RNTI or an SPS C-RNTI, UE in which a CIF is configured assumes that a CIF for a serving cell is present in a PDCCH that is located within a UE-specific search space.

[0184] When UE is configured by a higher layer so that it decodes a PDCCH with CRC scrambled by an SI-RNTI, the UE decodes the PDCCH and a corresponding PDSCH according to a combination defined in Table 3 below. The PDSCH corresponding to the PDCCH(s) is scrambling-initialized by the SI-RNTI.

[0185] Table 5 illustrates a PDCCH and PDSCH configured by an SI-RNTI.

TABLE 5

DCI FORMAT	SEARCH SPACE	METHOD FOR SENDING PDSCH CORRESPONDING TO PDCCH
DCI format 1C	common	If the number of PBCH antenna ports is 1, a single antenna port, a port 0 is used, and if not, transmit diversity
DCI format 1A	common	If the number of PBCH antenna ports is 1, a single antenna port, a port 0 is used, and if not, transmit diversity

[0186] If UE is configured by a higher layer so that it decodes a PDCCH with CRC scrambled by a P-RNTI, the UE decodes the PDCCH and a corresponding PDSCH according to a combination defined in Table 4 below. The PDSCH corresponding to the PDCCH(s) is scrambling-initialized by the P-RNTI.

[0187] Table 6 illustrates a PDCCH and PDSCH configured by a P-RNTI.

TABLE 6

DCI FORMAT	SEARCH SPACE	METHOD FOR SENDING PDSCH CORRESPONDING TO PDCCH
DCI format 1C	common	If the number of PBCH antenna ports is 1, a single antenna port, a port 0 is used, and if not, transmit diversity
DCI format 1A	common	If the number of PBCH antenna ports is 1, a single antenna port, a port 0 is used, and if not, transmit diversity

[0188] If UE is configured by a higher layer so that it decodes a PDCCH with CRC scrambled by an RA-RNTI, the UE decodes the PDCCH and a corresponding PDSCH according to a combination defined in Table 5 below. The PDSCH corresponding to the PDCCH(s) is scrambling-initialized by the RA-RNTI.

[0189] Table 7 illustrates a PDCCH and PDSCH configured by an RA-RNTI.

TABLE 7

DCI FORMAT	SEARCH SPACE	METHOD FOR SENDING PDSCH CORRESPONDING TO PDCCH
DCI format 1C	common	If the number of PBCH antenna ports is 1, a single antenna port, a port 0 is used, and if not, transmit diversity
DCI format 1A	common	If the number of PBCH antenna ports is 1, a single antenna port, a port 0 is used, and if not, transmit diversity

[0190] UE may be semi-statically configured through higher layer signaling so that it receives PDSCH data transmission signaled through a PDCCH in accordance with any one of 9 transmission modes, including a mode 1 to a mode 9.

[0191] In the case of the frame structure type 1,

[0192] UE does not receive a PDSCH RB transmitted in the antenna port 5 even in any subframe in which the number of OFDM symbols for a PDCCH having a common CP is 4.

[0193] If any one of 2 physical resource blocks (PRBs) to which a virtual resource block (VRB) pair is mapped overlaps a frequency in which a PBCH or a primary or secondary synchronous signal is transmitted within the same subframe, UE does not receive a PDSCH RB transmitted in the antenna port 5, 7, 8, 9, 10, 11, 12, 13 or 14 in the corresponding 2 PRBs.

[0194] UE does not receive a PDSCH RB transmitted in the antenna port 7 to which distributed VRB resource allocation has been assigned.

[0195] UE may skip the decoding of a transport block if it does not receive all of allocated PDSCH RBs. If the UE skips the decoding, a physical layer indicates that the transport block has not been successfully decoded for a higher layer.

[0196] In the case of the frame structure type 2,

[0197] UE does not receive a PDSCH RB transmitted in the antenna port 5 even in any subframe in which the number of OFDM symbols for a PDCCH having a common CP is 4.

[0198] If any one of 2 PRBs to which a VRB pair is mapped overlaps a frequency in which a PBCH is transmitted within the same subframe, UE does not receive a PDSCH RB transmitted in the antenna port 5 in the corresponding 2 PRBs.

[0199] If any one of 2 PRBs to which a VRB pair is mapped overlaps a frequency in which a primary or secondary synchronous signal is transmitted within the same subframe, UE does not receive a PDSCH RB transmitted in the antenna port 7, 8, 9, 10, 11, 12, 13 or 14 in the corresponding 2 PRBs.

[0200] If a common CP is configured, UE does not receive a PDSCH in the antenna port 5 in which distributed VRB resource allocation has been assigned within a special subframe in an uplink-downlink configuration #1 or #6.

[0201] UE does not receive a PDSCH transmitted in the antenna port 7 to which distributed VRB resource allocation has been assigned.

[0202] UE may skip the decoding of a transport block if it does not receive all of allocated PDSCH RBs. If the UE skips the decoding, a physical layer indicates that the transport block has not been successfully decoded for a higher layer.

[0203] If UE is configured by a higher layer so that it decodes a PDCCH with CRC scrambled by a C-RNTI, the UE decodes the PDCCH and a corresponding PDSCH according to each combination defined in Table 6 below. The PDSCH corresponding to the PDCCH(s) is scrambling-initialized by the C-RNTI.

[0204] If a CIF for a serving cell is configured in UE or UE is configured by a higher layer so that it decodes a PDCCH with CRC scrambled by a C-RNTI, the UE decodes the PDSCH of a serving cell indicated by a CIF value within the decoded PDCCH.

[0205] When UE of the transmission mode 3, 4, 8 or 9 receives DCI format 1A assignment, the UE assumes that PDSCH transmission is related to a transport block 1 and a transport block 2 is disabled.

[0206] If UE is set as the transmission mode 7, a UE-specific reference signal corresponding to a PDCCH(s) is scrambling-initialized by a C-RNTI.

[0207] If an extended CP is used in downlink, UE does not support the transmission mode 8.

[0208] If UE is set as the transmission mode 9, when the UE detects a PDCCH with CRC scrambled by a C-RNTI on which the DCI format 1A or 2C intended for the UE is carried, the UE decodes a corresponding PDSCH in a subframe indicated by a higher layer parameter "mbsfn-SubframeConfigList." However, the subframe configured by a higher layer to decode a PMCH or, the subframe configured by a higher layer to be part of a PRS occasion and the PRS occasion is configured only within an MBSFN subframe and the length of a CP used in a subframe #0 is a common CP is excluded.

[0209] Table 8 illustrates a PDCCH and PDSCH configured by a C-RNTI.

TABLE 8

TRANSMISSION MODE	DCI FORMAT	SEARCH SPACE	METHOD FOR SENDING PDSCH CORRESPONDING TO PDCCH
Mode 1	DCI format 1A	common and UE-specific by a C-RNTI	a single antenna port, a port 0
	DCI format 1	UE-specific by a C-RNTI	a single antenna port, a port 0
Mode 2	DCI format 1A	common and UE-specific by a C-RNTI	transmit diversity
	DCI format 1	UE-specific by a C-RNTI	transmit diversity
Mode 3	DCI format 1A	common and UE-specific by a C-RNTI	transmit diversity
	DCI format 2A	UE-specific by a C-RNTI	large delay CDD or transmit diversity
Mode 4	DCI format 1A	common and UE-specific by a C-RNTI	transmit diversity
	DCI format 2	UE-specific by a C-RNTI	closed-loop spatial multiplexing or transmit diversity
Mode 5	DCI format 1A	common and UE-specific by a C-RNTI	transmit diversity
	DCI format 1D	UE-specific by a C-RNTI	multi-user MIMO
Mode 6	DCI format 1A	common and UE-specific by a C-RNTI	transmit diversity
	DCI format 1B	UE-specific by a C-RNTI	closed-loop spatial multiplexing using a single transport layer
Mode 7	DCI format 1A	common and UE-specific by a C-RNTI	If the number of PBCH antenna ports is 1, a single antenna port, a port 0 is used, and if not, transmit diversity
	DCI format 1	UE-specific by a C-RNTI	Single antenna port, a port 5
Mode 8	DCI format 1A	common and UE-specific by a C-RNTI	If the number of PBCH antenna ports is 1, a single antenna port, a port 0 is used, and if not, transmit diversity
	DCI format 2B	UE-specific by a C-RNTI	dual layer transmission, ports 7 and 8 or a single antenna port, a port 7 or 8

TABLE 8-continued

TRANSMISSION MODE	DCI FORMAT	SEARCH SPACE	METHOD FOR SENDING PDSCH CORRESPONDING TO PDCCH
Mode 9	DCI format 1A	common and UE-specific by a C-RNTI	Non-MBSFN subframe: if the number of PBCH antenna ports is 1, a single antenna port, a port 0 is used, and if not, transmit diversity MBSFN subframe: a single antenna port, a port 7 layer transmission up to a maximum of 8, ports 7-14
	DCI format 2C	UE-specific by a C-RNTI	

[0210] If UE is configured by a higher layer so that it decodes a PDCCH with CRC scrambled by an SPS C-RNTI, the UE decodes a PDCCH of a primary cell and a corresponding PDSCH of the primary cell according to each combination defined in Table 7 below. If a PDSCH is transmitted without a corresponding PDCCH, the same PDSCH-related configuration is applied. The PDSCH corresponding to the PDCCH and the PDSCH not having a PDCCH is scrambling-initialized by the SPS C-RNTI.

[0211] If UE is set as the transmission mode 7, a PDCCH (s) and a corresponding UE-specific reference signal is scrambling-initialized by an SPS C-RNTI.

[0212] If UE is set as the transmission mode 9, when the UE detects a PDCCH with CRC scrambled by an SPS C-RNTI on which the DCI format 1A or 2C intended for the UE is carried or a PDSCH configured without a PDCCH intended for the UE, the UE decodes a corresponding PDSCH in a subframe indicated by a higher layer parameter "mbsfn-SubframeConfigList." However, the subframe configured a higher layer to decode a PMCH or, the subframe configured by a higher layer to be part of a PRS occasion and the PRS occasion is configured only within an MBSFN subframe and the CP length used in a subframe #0 is a common CP is excluded.

[0213] Table 9 illustrates a PDCCH and PDSCH configured by an SPS C-RNTI.

TABLE 9

TRANSMISSION MODE	DCI FORMAT	SEARCH SPACE	METHOD FOR SENDING PDSCH CORRESPONDING TO PDCCH
Mode 1	DCI format 1A	common and UE-specific by a C-RNTI	a single antenna port, a port 0
	DCI format 1	UE-specific by a C-RNTI	a single antenna port, a port 0
Mode 2	DCI format 1A	common and UE-specific by a C-RNTI	transmit diversity
	DCI format 1	UE-specific by a C-RNTI	transmit diversity
Mode 3	DCI format 1A	common and UE-specific by a C-RNTI	transmit diversity
	DCI format 2A	UE-specific by a C-RNTI	transmit diversity
Mode 4	DCI format 1A	common and UE-specific by a C-RNTI	transmit diversity
	DCI format 2	UE-specific by a C-RNTI	transmit diversity
Mode 5	DCI format 1A	common and UE-specific by a C-RNTI	transmit diversity
Mode 6	DCI format 1A	common and UE-specific by a C-RNTI	transmit diversity
Mode 7	DCI format 1A	common and UE-specific by a C-RNTI	a single antenna port, a port 5
	DCI format 1	UE-specific by a C-RNTI	a single antenna port, a port 5
Mode 8	DCI format 1A	common and UE-specific by a C-RNTI	a single antenna port, a port 7
	DCI format 2B	UE-specific by a C-RNTI	a single antenna port, a port 7 or 8
Mode 9	DCI format 1A	common and UE-specific by a C-RNTI	a single antenna port, a port 7
	DCI format 2C	UE-specific by a C-RNTI	a single antenna port, a port 7 or 8

[0214] If UE is configured by a higher layer so that it decodes a PDCCH with CRC scrambled by a temporary C-RNTI and is configured to not decode a PDCCH with CRC scrambled by a C-RNTI, the UE decodes a PDCCH and a corresponding PDSCH according to a combination defined in Table 9. The PDSCH corresponding to the PDCCH(s) is scrambling-initialized by the temporary C-RNTI.

[0215] Table 10 illustrates a PDCCH and a PDSCH configured by a temporary C-RNTI.

TABLE 10

DCI FORMAT	SEARCH SPACE	METHOD FOR SENDING PDSCH CORRESPONDING TO PDCCH
DCI format 1A	common and UE-specific by a temporary C-RNTI	If the number of PBCH antenna ports is 1, a single antenna port, a port 0 is used, and if not, transmit diversity
DCI format 1	UE-specific by a temporary C-RNTI	If the number of PBCH antenna ports is 1, a single antenna port, a port 0 is used, and if not, transmit diversity

[0216] Quasi Co-Located (QCL) Between Antenna Ports

[0217] Quasi co-located and quasi co-location (QC/QCL) may be defined as follows.

[0218] If two antenna ports have a QC/QCL relation (or subjected to QC/QCL), UE may assume that the large-scale property of a signal transferred through one antenna port may be inferred from a signal transferred through the other antenna port. In this case, the large-scale property includes one or more of Delay spread, Doppler spread, Frequency shift, Average received power, and Received timing.

[0219] Furthermore, the following may be defined. Assuming that two antenna ports have a QC/QCL relation (or subjected to QC/QCL), UE may assume that the large-scale property of a channel of which one symbol is transferred through one antenna port may be inferred from a wireless channel of which one symbol is transferred through the other antenna port. In this case, the large-scale property

includes one or more of Delay spread, Doppler spread, Doppler shift, Average gain, and Average delay.

[0220] That is, if two antenna ports have a QC/QCL relation (or subjected to QC/QCL), it means that the large-scale property of a wireless channel from one antenna port is the same as the large-scale property of a wireless channel from the other antenna port. Assuming that a plurality of antenna ports in which an RS is transmitted is taken into consideration, if antenna ports on which two types of different RSs are transmitted have a QCL relation, the large-scale property of a wireless channel from one antenna port may be replaced with the large-scale property of a wireless channel from the other antenna port.

[0221] In this specification, the QC/QCL-related definitions are not distinguished. That is, the QC/QCL concept may comply with one of the definitions. In a similar other form, the QC/QCL concept definition may be changed in a form in which antenna ports having an established QC/QCL assumption may be assumed to be transmitted at the same location (i.e., co-location) (e.g., UE may assume antenna ports to be antenna ports transmitted at the same transmission point). The spirit of the present invention includes such similar modifications. In an embodiment of the present invention, the QC/QCL-related definitions are interchangeably used, for convenience of description.

[0222] In accordance with the concept of the QC/QCL, UE may not assume the same large-scale property between wireless channels from corresponding antenna ports with respect to non-QC/QCL antenna ports. That is, in this case, UE may perform independent processing on timing acquisition and tracking, frequency offset estimation and compensation, delay estimation, and Doppler estimation for each configured non-QC/QCL antenna port.

[0223] There are advantages in that UE may perform the following operations between antenna ports capable of an assuming QC/QCL:

[0224] With respect to the Delay spread and Doppler spread, UE may identically apply the results of a power-delay profile, Delay spread and Doppler spectrum, and Doppler spread estimation for a wireless channel from any one antenna port to a Wiener filter which is used upon channel estimation for a wireless channel from other antenna ports.

[0225] With respect to the Frequency shift and received timing, UE may perform time and frequency synchronization on any one antenna port and then apply the same synchronization to the demodulation of other antenna ports.

[0226] With respect to the Average received power, UE may average reference signal received power (RSRP) measurement for two or more antenna ports.

[0227] For example, if a DMRS antenna port for downlink data channel demodulation has been subjected to QC/QCL with the CRS antenna port of a serving cell, UE may apply the large-scale property of a wireless channel estimated from its own CRS antenna port upon channel estimation through the corresponding DMRS antenna port, in the same manner, thereby improving reception performance of a DMRS-based downlink data channel.

[0228] The reason for this is that an estimation value regarding a large-scale property may be more stably obtained from a CRS because the CRS is a reference signal that is broadcasted with relatively high density every subframe and in a full bandwidth. In contrast, a DMRS is transmitted in a UE-specific manner with respect to a specific scheduled RB, and the precoding matrix of a precoding resource block group (PRG) unit that is used by an eNB for transmission may be changed. Thus, a valid channel received by UE may be changed in a PRG unit. Accordingly, although a plurality of PRGs has been scheduled in the UE, performance deterioration may occur when the DMRS is used to estimate the large-scale property of a wireless channel over a wide band. Furthermore, a CSI-RS may also have a transmission cycle of several~several tens of ms, and each resource block has also low density of 1 resource element for each antenna port in average. Accordingly, the CSI-RS may experience performance deterioration if it is used to estimate the large-scale property of a wireless channel.

[0229] That is, UE may perform the detection/reception, channel estimation, and channel state report of a downlink reference signal through a QC/QCL assumption between antenna ports.

[0230] D2D (Device-to-Device) Communication

[0231] FIG. **11** shows elements regarding a scheme of direct communication between terminals (D2D).

[0232] In FIG. **11**, the UE refers to a terminal of a user, and in case where network equipment such as an eNB transmits and receives a signal according to a communication scheme with a UE, the corresponding network equipment may also be regarded as a UE. Hereinafter, UE1 may select a resource unit corresponding to a specific resource within a resource pool indicating a set of resources and operates to transmit a D2D signal using the corresponding resource unit. A UE2, which is a receiving UE thereof, configures a resource pool in which a UE1 may transmit a signal and detects a signal of the UE1 in the corresponding pool. Here, the resource pool may be notified by a BS when the UE1 is within a connection range of the BS, and may be informed by another UE or determined as a predetermined resource when it is outside the connection range of the BS. In general, a resource pool may include a plurality of resource units, and each UE may select one or a plurality of resource units to use the same to transmit a D2D signal thereof.

[0233] FIG. **12** shows an embodiment of configuration of resource units.

[0234] Referring to FIG. **12**, a total of N_F*N_T resource units may be defined by dividing the entire frequency resources into N_F and the entire time resources into N_T. Here, it may be expressed that the corresponding resource pool is repeated at intervals of N_T subframes. Characteristically, one resource unit may appear repeatedly periodically as shown in the drawing. Or, an index of a physical resource unit to which one logical resource unit is mapped may change in a predetermined pattern over time in order to obtain a diversity effect in the time or frequency domain. In this resource unit structure, the resource pool may refer to a set of resource units which may be used by the UE to transmit the D2D signal.

[0235] The resource pools described above may be subdivided into various kinds. First, the resource pools may be divided according to the content of a D2D signal transmitted in each resource pool. For example, the content of the D2D signal may be divided as follows, and a separate resource pool may be configured for each signal.

[0236] Scheduling assignment (SA): A signal including a position of a resource used for transmission of a D2D data channel performed by each transmitting UE, and informa-

tion such as a modulation and coding scheme (MCS) required for demodulating other data channels, a MIMO transmission scheme and/or timing advance, and the like. This signal may also be multiplexed and transmitted along with the D2D data on the same resource unit. In this disclosure, the SA resource pool may refer to a pool of resources in which the SA is multiplexed and transmitted with the D2D data, and may also be referred to as a D2D control channel.

[0237] D2D data channel: A resource pool used by a transmitting UE to transmit user data using a resource designated through an SA. When it is possible to be multiplexed and transmitted together with the D2D data on the same resource unit, only a D2D data channel without the SA information may be transmitted in the resource pool for the D2D data channel. In other words, the resource element, which was used to transmit the SA information on the individual resource unit in the SA resource pool, may be used to transmit D2D data in the D2D data channel resource pool.

[0238] Discovery channel: A resource pool for a message to which a transmitting UE transmits information such as its own ID, or the like, so that a neighboring UE may discover the transmitting UE.

[0239] Contrary to the above case, even when the content of the D2D signal is the same, different resource pools may be used depending on the transmission/reception properties of the D2D signal. For example, even the same D2D data channel or a discovery message may be classified into different resource pools depending on a transmission timing determination scheme of the D2D signal (for example, whether it is transmitted at a time point when a synchronization reference signal is received or whether it is transmitted by applying a certain timing advance at the corresponding time point), a resource allocation scheme (e.g., whether the eNB designates transmission resource of an individual signal to an individual transmitting UE or whether an individual transmitting UE selects an individual signaling transmission resource by itself from the pool), a signal format (e.g., the number of symbols of each D2D signal which occupy one subframe, or the number of subframes used for transmission of one D2D signal), signal strength from the eNB, strength of transmission power of the D2D UE, and the like.

[0240] In this disclosure, for the purposes of description, a method in which the eNB directly indicates a transmission resource of a D2D transmitting UE in D2D communication will be called/defined as Mode 1 and a method in which a transmission resource region is set in advance, the eNB designates a transmission resource region, and a UE directly selects a transmission resource will be called/defined as Mode 2. In the case of D2D discovery, a case in which the eNB directly indicates resource will be called/defined as Type 2 and a case in which the UE directly selects transmission resource in a preset resource region or a resource region indicated by the eNB will be called/defined as Type 1.

[0241] The afore-mentioned D2D may also be called a sidelink, the SA may be called a physical sidelink control channel (PSCCH), a D2D synchronization signal may be called a sidelink synchronization signal (SSS), a control channel for transmitting most basic information prior to D2D communication transmitted together with the SSS may be called a physical sidelink broadcast channel (PSBCH), or a PD2DSCH (Physical D2D synchronization channel) by a different name. A signal indicating that a specific terminal is in its vicinity, which may include an ID of a specific terminal, may be called a physical sidelink discovery channel (PSDCH).

[0242] In D2D of Rel. 12, only a D2D communication UE transmits the PSBCH together with the SSS, and therefore, measurement of the SSS is performed using a DMRS of the PSBCH. An out-coverage UE measures the DMRS of the PSBCH and measures a reference signal received power (RSRP) of the signal to determine whether the UE will become a synchronization source.

[0243] Single-Cell Point-to-Multipoint (PTM) Transmission

[0244] 1. Search Space for Single Cell (SC)-PTM

[0245] The SC-PTM has been introduced primarily to support Mission Critical Push To Talk (MCPTT). TS 22.179 suggests the following guidance regarding expansion of the MCPTT.

[0246] The MCPTT service may support a range of 36 to 150 simultaneous MCPTT Group Calls in every cell of the MCPTT system per regional regulatory requirement.

[0247] If all the MCPTT Group Calls are voice calls (which corresponds the most common traffic type) and a SC-PTM scheduling cycle of a voice call is 40 ms (in the case of 80 ms scheduling cycle, it is not possible to satisfy 1550 ms E2E media transmission delay requirement for MCPTT) is assumed, a system needs to support 9 to 37 PDCCHs scrambled by a Group-RNTI per radio frame.

[0248] Considering the above description, the system needs to support 9 to 37 PDCCHs (which are scrambled by a Group RNTI per radio frame for the purpose of MCPTT), and the SC-PTM scheduling cycle may be assumed to be 40 ms.

[0249] 2. Analysis on Capability of the Existing Common Search Space (CSS)

[0250] In the case of the SC-PTM, transmission is performed toward a group of UEs, so a CSS which carries PDCCHs scrambled by a Group-RNTI may be considered.

[0251] As shown in the following Table 11, the existing CSS may include 16 CCEs. In the case where a system bandwidth is specified, for example, to be less than 10 MHz, 16 valid CCEs for CSS are hardly guaranteed. In this case, even a PDSCH capability may be limited.

TABLE 11

Search space			
Type	Aggregation level (AL)	Size [CCEs]	Number of PDCCH candidates
Common	4	16	4
	8	16	2

[0252] In the following Table 12, a capability of the existing CSS may be expressed as the number of PDCCHs per radio frame. In Table 12, AL may indicate an Aggregation Level. As the number of DL subframes in a TDD system is less than in a FDD system, a capability of the existing CSS in the TDD system may be lower than in the FDD system.

TABLE 12

	FDD	TDD (Config#0)	TDD (Config#1)	TDD (Config#2)
AL 4	40	16	24	32
AL 8	20	8	12	16

[0253] Recently, DCI-format 1A/1C scrambled by a SI-RNTI/P-RNTI/RA-RNTI, DCI-format 3/3A scrambled by a TPC-PUCCH-RNTI/TPC-PUSCH-RNTI, DCI-format 0 scrambled by a temporary C-RNTI may be transmitted in a CSS. 3 or 4 DCIs may be required on average in a CSS for each radio frame. If it is assumed that four PDCCH per radio frame are transmitted, the number of valid PDCCH candidates in the existing CSS for SC-PTM transmission may be derived, as shown in the following Table 13.

TABLE 13

	FDD	TDD (Config#0)	TDD (Config#1)	TDD (Config#2)
All PDCCHs with AL4	36	12	20	28
All PDCCHs with AL8	16	4	8	12
PDCCHs for SC-PTM with AL 4, other PDCCHs with AL 8	32	8	16	24

[0254] In this step, the fact that the existing CSS for SC-PTM transmission is sufficient may be considered. According to system-level evaluation, for 2.5% of UEs and 7% of UEs in a cell, a PDCCH with AL 8 is set in the general 3GPP case 1 scenario and the general 3GPP case 3 scenario. If a range condition 95% for SC-PTM transmission is assumed, using PDSCCHs with AL 4 may be sufficient in the general 3GPP case 1 Scenario. PDCCHS with AL 8 may be needed in the general 3GPP case 3 scenario, but using PDCCHs with AL 4 may be desirable in most cases.

[0255] As shown in Table 13, if AL4 is provided to every PDCCH scrambled by a G-RNTI, the existing CSS may provide a capability sufficient for SC-PTM of the FDD system. In the case of TDD system, the existing CSS may be limited only in specific UL/DL settings, and a PDSCH capability may be limited as well in proportion to a less number of subframes.

[0256] Considering the above description, the existing CSS has a capability sufficient for CS-PMM transmission in most cases. Therefore, the CSS may be used for SC-PTM transmission.

[0257] If the capability of the existing CSS is limited in SC-PTM transmission and needs to be enhanced, potential solutions, such as introduction of an additional search space and use of a SPS for SC-PTM, may be suggested. To select an appropriate solution from those solutions, a UE's complexity regarding PDCCH blind decoding and blocking of a possible PDCCH may be considered as two important factors.

[0258] If an additional search space is supported, a base station may have flexibility to determine whether or not to set the additional search space for SC-PTM. For example, the additional search space may be set only when there is a great number of Group Calls.

[0259] 3. DCI Discussion for SC-PTM Scheduling

[0260] Transmission Mode (TM) 1, 2, and 3 may support SC-PTM transmission. Currently, DCI format 1A/1 is used for TM 1 and TM 2, and DCI format 1A/2A is used for TM3. However, DCI format 1/2A cannot be transmitted in the existing CSS. In the case of SC-PTM transmission, even though DCI format 1 for TM 1 and TM 2 does not exists, a large delay CDD is not supported. To support TM 3 having a large delay CDD in a CSS, the following two methods may be considered.

[0261] 1) Method 1: Transmission of DCI Format 2A in CSS

[0262] If a UE is set to decode a PDCCH having a CRC scrambled by a G-RNTI by an higher layer, the UE may decode the PDCCH and decode a PDSCH corresponding to the PDCCH according to one of combinations defined in the following Table 14.

TABLE 14

DCI format	Search Space	Transmission scheme of PDSCH corresponding to PDCCH
DCI format 1C	Common	If there is one PBCH antenna port, single-antenna port and port 0 is used: otherwise, transmission diversity is used
DCI format 1A	Common	If there is one PBCH antenna port, single-antenna port and port 0 is used: other wise, transmission diversity is used
DCI format 2A	Common	Large delay CDD or transmission diversity

[0263] Initial setting for scrambling PDSCHs corresponding to these PDCCHs may be performed by a G-RNTI. DCI format 1C may be used in TM1 and TM2, and may have a lower overhead than DCI format 1A.

[0264] When Method 1 is applied, change may occur in at least RAN 1. However, because an additional DCI payload size is introduced in the CSS, only additional 6 blind decoding may be performed additionally.

[0265] 2) Method 2: Use of DCI Format 1A for Large Delay CDD

[0266] If a UE is set to decode a PDCCH having a CR scrambled by a G-RNTI by an higher layer, the UE may decode the PDCCH and decode a PDSCH corresponding to the PDCCH according to one of combinations defined in the following Table 15. Initial setting of scrambling PDSCHs corresponding to these PDCCH may be performed by the G-RNTI.

TABLE 15

DCI format	Search Space	Transmission scheme of PDSCH corresponding to PDCCH
DCI format 1C	Common	If there is one PBCH antenna port, single-antenna port and port 0 is used: otherwise, transmission diversity is used
DCI format 1A	COmmon	If there is one PBCH antenna port, single-antenna port and port 0 is used: other wise, transmission diversity is used

[0267] Initial setting of scrambling PDSCHs corresponding to these PDCCH may be performed by the G-RNTI.

[0268] In addition, to support a large delay CDD, the following three types of information needs to be considered.

[0269] Two MCSs in two Transport Blocks (TBs)

[0270] For simplicity, the same MCS may be used for two TBs, and this is equally maintained in DCI format 1A.

[0271] Precoding information

[0272] Recently, a precoding information field does not exists for transmission using two antenna ports, and a two-bit precoding information field may be configured for transmission using four antenna ports. If a large delay CDD is set only when two CRS antenna ports are used, precoding information does not need to be added in DCI format 1A.

[0273] Furthermore, if it is necessary to support a large delay CDD having four antenna ports, the 2-bit precoding information may be needed. Since a HARQ-ACK feedback for SC-PTM transmission is not supported, bits redundant with bits of a TPC command for a PUCCH may be reused to indicate precoding information.

[0274] Transport Block for codeword swap flag

[0275] A transport block for codeword mapping may be defined, and a codeword swap flag needs to be added to DCI format 1A.

[0276] In the case of Method 2, change may occur in at least RAN 1. Furthermore, the number of times to perform PDCCH blind decoding may be maintained to be the same in a CSS.

[0277] Considering the above description, DCI format 1A may be used for scheduling of SC-PTM transmission having a large delay CDD.

[0278] 4. Discussion about Simultaneous Reception of a Plurality of Services in Different Transmission Modes

[0279] Through an additional standardization process and an implementation operation, it is possible to support simultaneous receipt of unicast signals or at least one SC-PTM transmission in one subframe of one carrier by specific UEs. However, simultaneous reception by all UEs are not possible.

[0280] In this case, for SC-PTM enabled UEs, supporting simultaneous reception of a plurality of SC-PTM transmissions in one subframe of one carrier may not be an essential function. For MIMO/CA enabled UEs, supporting simultaneous reception of a plurality of SC-PTM transmissions in one subframe of one carrier may be a choice of selection.

[0281] As only TM 1 and TM 2 are set for non-MINO enabled UEs, a non-MIMI UE having a parallel reception capability is able to support simultaneous reception of a plurality of services having TM 1 and TM2. As TM 3 may be additionally set for the MIMO enabled UEs, a MIMO enabled UE having a parallel reception capability is able to support simultaneous reception of a plurality of services having TM 1, TM 2, and TM 3.

[0282] The recent load of the conventional CSS may be found by analyzing the number of DCIs requested by a radio frame in Table 16. If all available DCI formats are transmitted in one radio frame, 6 or 7 DCIs may be transmitted at the maximum, and this may result in increasing the load of the CSS.

TABLE 16

DCI formats	Purpose	Number of required DCIs in a radio frame
Format 0	Trigger random access procedure for each packet arrival	0.03 Assuming medium arriving rate (uplink and downlink lambda = 1.5)
Format 3/3A	Group UL PC (TPC-RNTI)	1 Supporting group UL PC for over 10/20 users' periodical UL transmissions (UL SPS, SRS etc)
Format 1C/1A	SIB 1 schedule (SI-RNTI)	0.5 (Occurs in every even radio frame)
	SIB i (i >= 2) (SI-RNTI)	1~2 Assuming SI window num = 4; Num of SI scheduling within window = 4; SI period = 8~16 radio frames
	Paging schedule(P-RNTI)	1/32 Assuming minimum default paging period
	Random access response (RA-RNTI)	0.03 Assuming medium arriving rate (uplink and downlink lambda = 1.5)

[0283] The base station may distribute such transmissions to different radio frames, and, as a result, three or four DCIs may be required on average in a CSS for one radio frame.

[0284] Considering the above description, SC-PTM transmission aims to support broadcast/multicast transmission so as to allow a plurality of UEs to receive data, transmitted from a base station, simultaneously/together. To this end, a SC-PTM scheduling message of DCI format 2A may be typically transmitted through a CSS, and a plurality of UEs may detect the corresponding scheduling message. The SC-PTM scheduling message may indicate a message including scheduling information for SC-PTM transmission and reception. Using/based on the detected scheduling message, the UEs may receive broadcast/multicast data.

[0285] However, DCI format 2A cannot be transmitted in a CSS according to the current standard, so, as one of ways to solve this problem, there has been proposed a method of enabling the DCI format 2A to be transmitted in a CSS (however, the number of times for a UE to perform BD increases). In this case, the DCI format 2A is a transmission method by use of a large CDD of TM3, and, as described above, supporting TM 1 to TM 3 may be considered in the current SC-PTM operation.

[0286] However, a (DMRS-based) broadcast/multicast transmission-related method proposed in this specification is not limited to TM 1 to MT3, and may be applied/supported even in an advanced TM. For example, when a next-generation DMRS-based TM is supported for broadcast/multicast transmission, the technology proposed in this specification may be applied to V2X (vehicle-to-vehicle/infrastructure/pedestrian) communications more particularly, a V21 (vehicle-to-infrastructure) communications) which considers the following types. However, it is merely exemplary, and the technology proposed in this specification may be applied to various scenarios of various wireless communication systems. Hereinafter, for convenience of

explanation, the present invention is described mainly about the case where the present invention is applied to V2X communications.

[0287] The aforementioned typical three V2X services are as follows.

[0288] V2V (vehicle-to-Vehicle): Communications between vehicles.

[0289] V21 (Vehicle-to-Infrastructure): Communications between a vehicle and a roadside unit (RSU) which is implemented in an eNB or a stationary UE.

[0290] V2P (Vehicle-to-Pedestrian): Communications between a vehicle and a device carried by an individual (a pedestrian, a cyclist, a driver, or a passenger)

[0291] FIG. **13** is a diagram illustrating an example of V2X communications according to an embodiment of the present invention.

[0292] FIG. **13** shows an example I which communication is performed as vehicles (or called UEs) transmit and receive a Cooperative Awareness Message (CAM)/a Decentralized Environmental Notification Message (DENM) or communication is performed via an infrastructure network of an RSU or the like.

[0293] As such, a specific network node, such as an LTE RSU, may wishes to transmit specific message (for example, a message about traffic information, driving related information, accident information, collision warning information, or the like) in the form of PTM to a plurality of UEs (for example, vehicles). In this case to enhance a transmission throughput and transmission efficiency, a DMRS-based enhanced transmission mode (for example, TM 9 and 10) may be applied for PTM transmission.

[0294] At this point, in the case where TM 3-based DCI format 2A is allowed in a CSS, as described above, if transmission is performed by setting a length of a DCI format, which is to be transmitted based on the DMRS-based enhanced transmission mode, to the same length of the DCI format 21, a UE may have the advantage that the number of times to perform BD on another DCI format is not increased.

[0295] More specifically, for example, applying TM 9 and TM 10 as enhanced transmission modes for PTM transmission may be assumed. In this case, a network mode may perform transmission by setting the payload size of the DCI format 2C based on TM 9 to be the same as the payload size of the DCI format 2D based on TM 10. In this case, the UE may present increase of the number of times to perform BD on the DCI format 2C and the DCI format 2D, except for the DCI format 2A transmitted in the CSS. That is, as the DCI format 2C/2D are transmitted in the same payload size of the DCI format 2A, a UE is able to perform BD on the DCI format 2C/2D in the same manner as when performing BD on the DCI format 2A, and therefore, it is not necessary to perform additional BD to detect the DCI format 2C/2D.

[0296] Considering the above description, to minimize the number of time that a UE performs BD, this specification proposes a method in which a target DCI format is set as a reference and the payload size of other DCI formats is set to the same as the payload size of the target DCI format to be (PTM) transmitted. Hereinafter, for convenience of explanation, this specification will be described mainly about the case of performing PTM transmission by setting the payload size of the DCI format 2C/2D to be the same as the payload size of the DCI format 2A. However, the present invention is not limited thereto, and various DCI formats may be set as a target DCI format in PTM transmission, and a DCI format to be adjusted to have the same payload size of the target format may be set variously.

[0297] FIG. **14** shows DCI formats (21, 2C, and 2D) in FDD. FIG. **15** shows DCI formats (2A, 2C, and 2D) in TDD. Hereinafter, embodiments of adjusting of a payload size will be described with reference to the drawings.

[0298] 1. Embodiment in which TM 9 Having DCI Format 2C is Supported for TDD-Type PTM Transmission.

[0299] Referring to FIGS. **14**(*a*) and **14**(*b*), the payload size of the DCI format 2A and the payload size of the DCI format 2C are set equally (especially when the Rank field in the DCI format 2A is processed into 2 bits). Thus, the DCI format 2C in FDD may be defined/set to be transmitted in a CSS without the need of additionally changing the payload size.

[0300] In this case, the DCI format 2C may not be masked by the conventional C-RNTI (or not be CRC-scrambled) but may be masked by a new RNTI (which is hereinafter referred to as a PTM-RNTI) to be PTM-transmitted in a CSS. By performing BD on the DCI format scrambled by the PTM-RNTI in a CSS, a UE may receive PTM transmission data. When PTM transmission and reception is set in the UE or when the UE descrambles the DCI format 2C using a pre-defined PTM-RNTI, the UE may recognize the received DCI of format 2C as a DCI related to broadcast/multicast transmission.

[0301] There may be some cases where the payload size of a target DCI format is reduced, for example, when Rank field (0 or 2 bits) of DCI 2A is processed into 0 bits. In this case, the payload size of the DCI format 2C needs to be reduced in accordance with the reduced payload size of the DCI format 2A.

[0302] To this end, according to one embodiment, the DCI format 2C may be transmitted with a New Data Indicator (MDI) (2 bits in total) field removed. Due to characteristics of PTM transmission (or multicast/broadcast transmission, in order to reduce system complexity, a plurality of UEs may not additionally transmit ACK/NACK responsive to received PTM-transmitted data, and, in this case, the NDI field may not be necessarily required. Thus, by removing unnecessary NDI fields, it is possible to adjust the payload size of the DCI format 2C to be the same payload size as the DCI format 2A (not including the Rank field).

[0303] According to another embodiment, at least one field from among a Modulation and Coding Scheme (MCS) 2 field, a Redundancy Version (RV) 2 field, a HARQ field, a Transmit Power Control (TPC) field, and a Carrier Indicator Field (CIF) field in the DCI format 2C may be deleted or the bit size thereof may be reduced so as to adjust the payload size of the DCI format 2C to be the same payload size of the DCI format 2A. For example, after a MCS 2 field (5 bits) is removed from the DCI format 2C, a zero padding bit in the size of 3 bits may be inserted or the bit size of the MCS 2 field may be reduced from 5 bits to 3 bits.

[0304] 2. Embodiment in which TM 9 Having the DCI Format 2C is Supported for TDD-Type PTM Transmission.

[0305] Referring to FIGS. **15**(*a*) and **15**(*b*), except for a Sound Reference Signal (SRS) field (1 bit), the payload size of the DCI format 2C is the same as a payload size of the DCI format 2A. Thus, this embodiment proposes transmitting the DCI format 2C, from which the SRS field is removed, in a CSS.

[0306] In the case of PTM transmission, a SRS may be triggered via a DCI format other than the DCI format 2C (or

a SRS field may be transmitted via a different DCI), and thus, an SRS field may not be necessarily required for the DCI format 2C.

[0307] In this case, the DCI format 2C may not be masked by the conventional C-RNTI (or not CRC-scrambled) and may be masked by a PTM-RNTI (or CRC scrambled) to be PTM-transmitted in a CSS. By performing BD in a CSS on the DCI format 2C scrambled by the PTM-RNTI, a UE may receive PTM transmission data. When PTM transmission or reception is set in the UE or when the UE descrambles the DCI format 2C using a pre-defined PTM-RMTI, the UE may recognize the received DCI of format 2C as broadcast/multicast transmission-related DCI.

[0308] The payload size of a target DCI format may be reduced, for example, when the Rank field (0 or 2 bits) of the DCI format 2A is processed into 0 bit. In this case, the payload size of the DCI format 2C needs to be reduced in accordance with the reduced payload size of the DCI format 2A.

[0309] To this end, similarly to the above embodiment regarding FDD, at least one field selected from among a NDI field, a MCS 2 field, a RV2 field, a HARQ field, a TPC field, a Downlink Assignment Index (DAI) field, or a CIF field in the DCI format 2C may be deleted or the bit size of the at least one field may be reduced to adjust the payload size of the DCI format 2C to be the same payload size of the DCI format 2A.

[0310] 3. Embodiment in which TM 10 Having the DCI Format 2D is Supported for FDD-Type PTM Transmission

[0311] Referring to FIGS. **14**(*a*) and **14**(*c*), except for a PDSCH RE Mapping and Quasi-co-location Indicator (PQI) field (2 bits), the payload size of the DCI format 2D is the same as the payload size of the DCI format 2A. Thus, this embodiment proposes transmitting DCI format 2D in a CSS with the PQI field removed

[0312] However, the PQI field corresponds to a Dynamic Indication Field necessarily required for TM 10-based CoMP operation, and thus, if transmission is performed with the PQI field removed, an error may occur in the CoMP operation. Thus, how to additionally transmit, to a UE, the PQI field removed from the DCI format 2D will be described in detail.

[0313] In this case, the DCI format 2D may not be masked by the conventional C-RNTI (or not be CRC-scrambled) but may be masked by a PTM-RNTI (or be CRC-scrambled) to be PTM transmitted in a CSS. By performing BD on the DCI format 2D scrambled by the PTM-RNTI in the CSS, a UE may receive PTM transmission data. When PTM transmission and reception is set in the UE or when the UE descrambles the DCI format 2D using a pre-defined PTM-RNTI, the UE may recognize the received DCI of format 2D as broadcast/multicast transmission-related DCI.

[0314] The payload size of a target DCI format may be reduced, for example, when the Rank field (0 or 2 bits) of the DCI 2A is processed into 0 bit. In this case, the payload size of the DCI format 2D needs to be reduced in accordance with the reduced payload size of the DCI format 2A.

[0315] To this end, at least one field selected from among the NID field, the MCS 2 field, the RV2 field, the HARQ field, the TPC field, and the CIF field in the DCI format 2D may be deleted or the bit size thereof may be reduced so as to adjust the payload size of the DCI format 2D to be the same as the payload size of the DCI format 2A.

[0316] 4. Embodiment in which TM 10 Having the DCI Format 2D is Supported for TDD-Type PTM Transmission

[0317] Referring to FIGS. **15**(*a*) and **15**(*c*), except for a SRS field (1 bit) and a PQI field (2 bits), the payload size of the DCI format 2D is the same as the payload size of the DCI format 2A. Thus, this embodiment proposes transmitting the DCI format 2D, from which the SRS field and the PQI field are removed, in a CSS.

[0318] In the case of PTM transmission, a SRS may be triggered via a DCI format other than the DCI format 2D (or the SRS field may be transmitted via a different DCI), and thus, the SRS field may not be necessarily required for the DCI format 2D. However, the PQI field corresponds to a Dynamic Indication Field necessarily required for TM 10-based CoMP operation, and thus, if transmission is performed with the PQI field removed, an error may occur in the CoMP operation. Thus, how to additionally transmit, to a UE, the DCI format 2D from which the PQI field is removed will be described in detail.

[0319] In this case, the DCI format 2D may not be masked by the conventional C-RNTI (or not be CRC-scrambled) but may be masked by a PTM-RNTI (or be CRC-scrambled) to be PTM transmitted in a CSS. By performing BD on the DCI format 2D scrambled by the PTM-RNTI BD in the CSS, a UE may receive PTM transmission data. When PTM transmission and reception is set in the UE or when the UE descrambles the DCI format 2D using a pre-defined PTM-RNTI, the UE may recognize the received DCI of format 2D as broadcast/multicast transmission-related DCI.

[0320] The payload size of a target DCI format may be reduced, for example, when the Rank field (0 or 2 bits) of the DCI 2A is processed into 0 bit. In this case, the payload size of the DCI format 2D needs to be reduced in accordance with the reduced payload size of the DCI format 2A.

[0321] To this end, at least one field selected from among the NID field, the MCS 2 field, the RV2 field, the HARQ field, the TPC field, the DAI field, and the CIF field in the DCI format 2D may be deleted or the bit size thereof may be reduced so as to adjust the payload size of the DCI format 2D to be the same payload size of the DCI format 2A.

[0322] The method of removing a PQI field from the DCI format 2D in the embodiments shown in FIGS. **14**(*c*) and **15**(*c*) has the advantage that the payload size is adjusted to be the same payload size of a target DCI format so as to efficiently perform PTM scheduling in a CSS. However, as described above, the PQI field corresponds to a field necessarily required for TM 10-based CoMP operation. Thus, a new method of transmitting the PQI field without passing through the DCI format 2D will be proposed in the following.

[0323] In one embodiment, a method of generating a new additional RNTI capable of replacing a function of a PQI field removed from the DCI format 2D and for providing PQI information to a UE using the generated RNTI may be proposed.

[0324] For example, a 2 bit PQI field may be a PQI information indicating a total four number of PQI states, so four additional RNTIs (e.g., PTM-RNTI 1-4) corresponding to the respective PQI states may be generated. The four RNTIs (e.g., PTM-RNTI 1-4) may be applied as PTM-RNTIs which are used for CRC-scrambling in the above embodiments.

[0325] That is, a UE may perform BD in a CSS with respect to the DCI format 2D with a PQI field removed, and

descramble a CRC of the DCI format 2D. When a detected RNTI value coincides with any one of the four PTM-RNTIs (PTM-RNTI 1-4) during descrambling of the CRC, the UE may determine detection success, and acquire/receive PQI information by recognizing a PQI state corresponding to the coincided PTM-RNTI. For example, if the coincided PTM-RNTI is PTM-RNTI 3, the UE may decode a PTM-PDSCH by applying setting information of RRC parameter set 3 corresponding to/associated with the conventional PQI state 3.

[0326] For such an operation, a base station may transmit PQI parameter sets (e.g., four PQI parameter sets) used in TM 10 to a UE through higher layer signaling (by RRC), and these parameter sets may be defined/set to correspond to specific PTM-RNTIs (e.g., PTM-RNTI-n, n is a natural number), respectively.

[0327] As such, an embodiment/exemplary method for reducing the number of times for a UE to performs BD by transmitting PTM via a CSS with a payload size as the same as the payload size of a target DCI format has been described. However, apart from this, to minimize the number of times for the UE to perform BD, a method of defining/setting TDM transmission of each DCI format in each specific subframe set may be also possible. That is, in other words, it is possible to minimize the number of times for the UE to perform BD by pre-defining/pre-setting a DCI format capable of being transmitted in a specific subframe set.

[0328] For example, it is possible to set/limit a format capable of being transmitted (for PTM) in a CSS in subframe set #1 to the DCI format 2A, and to set/restrict a format capable of being transmitted (for PTM to target DMRS-based TM (e.g., TM 9 and TM 10) in a CSS in subframe set #2 to the DCI format 2C and/or 2D. In this case, there will be no case of performing BD on the DCI format 2A and the DCI format 2C/2D in at least the same subframe set (that is, it is not necessary to perform BD on both DCI formats having different payload sizes in the same subframe set), and therefore, the number of times for a UE to perform BD with respect to each separate subframe set may be minimized.

[0329] To support such an operation, a base station needs to provide information about a subframe set to be mapped to a specific DCI format (the information which is hereinafter referred to as "mapping subframe information") to a UE in advance through an higher layer signal (e.g., an RRC signaling). In this case, various examples of the mapping subframe information may be provided to the UE.

[0330] In one example, the mapping subframe information in a bit map form may be provided to a UE. For instance, the base station may provide mapping subframe information, which is mapped to each specific DCI format, in the form of a bit map of each subframe set to a UE, and, a corresponding bit map may indicate that a subframe corresponding to the value "1" is mapped to a specific DCI format (that is, in a subframe corresponding to the value "1" in the bit map, a specific DCI format needs to be detected/BD).

[0331] Alternatively, in another example, the base station may provide the mapping subframe information in the form of a single bitmap for a preset number of subframes, not for each subframe set unit to be mapped to a specific DCI format. In this case, the corresponding bitmap may indicate that a subframe corresponding to the value "1" is mapped to a first DCI format (e.g., DCI format 2A), and that a subframe corresponding to the value "0" is mapped to a second DCI format (e.g. DCI format 2C and/or 2D) (which means that the fist DCI format needs to be detected/BD in the subframe corresponding to the value "1", and the second DCI format needs to be detected/BD in the subframe corresponding to the value "0").

[0332] In the above example, a unit of a subframe provided in the form of a single bitmap, may be N-SF (N=1, 2, 3, . . .). If N>1, a subframe from which a UE needs to detect the DCI format 2A or 2C/2D is not every subframe, but N number of periodically conventional subframes. That is, subframe restriction may be set or applied in a manner in which the UE does not need to perform BD in every subframe, and thus, there is an advantage that a network is able to adjust control signaling overhead of PTM transmission scheduling to occur at a rate which is appropriate compared with conventional control signal transmission.

[0333] Apart from this, the above-described examples proposed to minimize the number of times for a UE to perform BD may be applied in combination. For example, PQI information indicated by a PQI field is information necessarily required for CoMP operation of the UE, and thus, transmitting TM 10-based DCI format 2D with the PQI field excluded may be a huge burden for the base station. Thus, the base station may transmit the DCI format 2C with at least one field excluded, as described above with reference to FIGS. **14** and **15**, and may transmit the DCI format 2D with the PQI field included. Instead, in the latter example, by setting a specific subframe set through which the DCI format 2D is transmitted, the base station may prevent the number of times for the UE to perform BD from increasing.

[0334] FIG. **16** is a flowchart illustrating an example of a method of transmitting a DCI by a base station according to an embodiment of the present invention. The above description provided with reference to FIGS. **14** and **15** may be applied identically/similarly as detailed description of this flowchart, and any redundant description will be omitted.

[0335] First, the base station may allocate a resource for data transmission in S**1610**. In this case, the base station may allocate a resource for multicast/broadcast transmission or a resource for unicast transmission.

[0336] Next, the base station may transmit scheduling information about the resource allocated for data transmission in a first DCI format in S**1620**. The first DCI format may correspond to the DCI format 2C or 2D in FIGS. **14** and **15**. However, aspects of the present invention are not limited thereto, and the fist DCI format may correspond to any of various DCI formats, as described above.

[0337] Next, the base station may transmit data on the scheduling information in S**1630**.

[0338] If a DCI includes scheduling information on multicast/broadcast data (that is, data to be transmitted corresponds to multicast/broadcast data), the payload size of the first DCI format may be adjusted to be the same as the payload size of a preset DCI format and transmitted via a CSS. The second DCI format may correspond to the aforementioned target DCI format, and the second DCI format may, for example, correspond to the DCI format 2A.

[0339] In contrast, if a DCI includes scheduling information on unicast data (that is, data to be transmitted corresponds to unicast data), the payload size of the first DCI format may not be adjusted and the first DCI format may be transmitted via a UE-specific Search Space (USS).

[0340] Examples about the case where the first DCI format is the DCI format 2C or 2D and the second DCI format

corresponds to the DCI format 2A is the same as the above-described examples of FIGS. **14** and **15**.

[0341] General Device to which Present Invention May be Applied

[0342] FIG. **17** is a block diagram of a wireless communication device according to an embodiment of the present invention.

[0343] Referring to FIG. **17**, a wireless communication system includes a base station (BS) (or eNB) **1710** and a plurality of terminals (or UEs) **1720** located within coverage of the BS **1710**.

[0344] The eNB **1710** includes a processor **1711**, a memory **1712**, and a radio frequency (RF) unit **1713**. The processor **1711** implements functions, processes and/or methods proposed in FIGS. **1** through **16**. Layers of radio interface protocols may be implemented by the processor **1711**. The memory **1712** may be connected to the processor **1711** to store various types of information for driving the processor **1711**. The RF unit **1713** may be connected to the processor **1711** to transmit and/or receive a wireless signal.

[0345] The UE **1720** includes a processor **1721**, a memory **1722**, and a radio frequency (RF) unit **1723**. The processor **1721** implements functions, processes and/or methods proposed in above-described embodiments. Layers of radio interface protocols may be implemented by the processor **1721**. The memory **1722** may be connected to the processor **1721** to store various types of information for driving the processor **1721**. The RF unit **1723** may be connected to the processor **1721** to transmit and/or receive a wireless signal.

[0346] The memory **1712** or **1722** may be present within or outside of the processor **1711** or **1721** and may be connected to the processor **1711** or **1721** through various well known units. Also, the eNB **1710** and/or the UE **1720** may have a single antenna or multiple antennas.

[0347] Performance Enhancement of Multicast/Broadcast Transmission Multiple Cells

[0348] RAN 1 has investigated performance advantages as well as the following performance enhancement of downlink multicast/broadcast.

[0349] Dynamic scheduling for multicast/broadcast transmission (e.g., PDCCH-based scheduling by TBs associated with TMGI)

[0350] Semi-static scheduling for multicast/broadcast

[0351] Use of a DM-RS based transmission scheme by a plurality of transmission points (TPs), the scheme which uses reception for idle UEs (this does not imply introduction of any new TM)

[0352] DMRS-based Single-Cell multicast

[0353] PDSCHs transmitted from multiple TPs

[0354] TP(s), which transmits system information, and a PDSCH/PDCCH-based CRS transmitted from different TP(s)

[0355] DMRS based on PDSCH/EPDCCH transmitted from different TB(s)

[0356] Use of normal CP

[0357] HARQ feedback

[0358] CSI feedback

[0359] Note 1: enhancement of each performance is expected to bring about different result in terms of advantage, complexity, and damage to LTE standard technology specification

[0360] Note 2: specific performance enhancement does not cause damage to the LTE standardization technology specification.

[0361] Note 3: Network/UE complexity is not addressed by RAN 1.

[0362] Note 4: the above performance enhancement case(s) may be assumed with a specific level of inter-TP corporation which does not cause damage to the standard technology specification.

[0363] Note 5: the above performance enhancement case(s) may be based on contribution made by a limited number of company(ies)

[0364] A UE is able to identify which broadcast transmission (e.g., TMGI) is related to the above-described performance enhancement (e.g, based on a location of the UE).

[0365] Based on the above description, it may be concluded that expansion of the use of a PDSCH for multi-cell broadcast is useful because a PDSCH is based on a DMRS to make cooperated transmission of multiple cells to be performed similarly to MBMS transmission. More specifically, the PDSCH may be transmitted from a serving cell or a neighboring cell or may be transmitted from multiple cells due to TM 10 operation already being supported. However, transmission from the multi-cells are not allowed based on SC-PTM. It is because SC-PTM is solely based on a CRS in TM 1/TM 2. Hereinafter, a technology relating to multi-cell transmission in light of a physical layer will be described in more detail.

[0366] 1. Suggestion of Re-Use of TM 10 for Downlink Multicast/Broadcast Enhancement to Support a PDSCH—V2V Service Transmitted from Different TP Sets

[0367] As described above, the advantage of MBMS multi-cell transmission needs to be facilitated to achieve robustness in terms of performance. Regarding this, it is desirable to re-use a physical format of a PDSCH, and, as a result, overall performance enhancement may be expected. In order to achieve substantially significant effects/advantages and enable efficient implementation on the conventional cellular network, it is desirable that a PDSCH format-based TM 10 is re-used in DL multicast/broadcast. In addition, identified performance enhancement principles are properly activated by TM 10 compared with CRS-based TMs, which are expected to cause a lot of changes and damages to the conventional technology specification to achieve identified effects/advantages. And thus, it is desirable to re-use the PDSCH format-based TM 10 in DL multicast/broadcast.

[0368] TM 10 already supports transmission of PDSCHs from different TP sets. For example, in a V2V service, a UE may receive a PDSCH for broadcast from a set of TPs in one resource and from a set of different TPs in a different resource. For respective PDSCH transmission, each TP set may be composed of at least one TP. Multiple TPs may belong to the same cell or different cells.

[0369] FIG. **18** shows an example of one TP set in which multiple TPs transmitting PDSCHs is included.

[0370] If TPs belong to different cells, the TPs may belong to the same base station or different base stations, as shown in FIG. **18**. From the perspective of a UE, a TP participating in PDSCH transmission for broadcast may or may not belong to a serving cell.

[0371] If the multiple TPs belongs to different base stations, PDSCH broadcast may be scheduled by an MCE, similarly in the case of MBSFN transmission. That is, the MCE may periodically select a MCS level for transmission

of a time/frequency resource and transmission of PDSCHs by the different base stations.

[0372] If the multiple TPs belongs to the same base station, the PDSCH broadcast may be scheduled by the base station, similarly to the case of SC-PTM. That is, the base station may select a time/frequency resource and an MCS level for PDSCH broadcast transmission (e.g., the case where scheduling information is not provided by the MCE).

[0373] Dynamic scheduling of downlink broadcast is very useful for supporting a V2V service. Thus, a PDCCH may be used to inform UE of a scheduled PDSCH, regardless of whether the TPs belong to the same base station. From the perspective of a UE, PDSCH broadcast from the multiple TPs may be scheduled similarly to the case of SC-PTM. From the perspective of a network, an MBSFN region concept may be used when PDSCHs are broadcasted from multiple cells.

[0374] The MCE may employ M2 signaling to adjust which subframe participates in multi-cell PDSCH broadcast. This is very similar to configuration/setting of MBSFN subframes.

[0375] PDSCH broadcast from the multiple TPs may be transmitted to any subframe (that is, it is not limited to an MBSFN subframe). Hereinafter, TM 10-based operation for V2X will be described in more detail.

[0376] 2. Quasi Co-Location

[0377] Legacy QCL signaling and its relevant operations are optimized for single-cell transmission.

[0378] Suggestion of appropriate performance enhancement of QCL and RM operations to support DMRS-based PDSCH broadcast on the basis of multiple-cell/TP joint transmission

[0379] In the case where downlink multicast/broadcast is a multi-TP joint transmission type, it is necessary to further consider the conventional UE's operation regarding QCL which is assumed in TM 10. For a UE in which TM 10 is set, QCL type A or QCL type B may be set through RRC signaling. Type A basically implies that QCL is set between all RS ports set in a UE. Type B indicates QCL of one CSI-RS resource about a PDSCH DMRS in a given subframe so that a UE is able perform Dynamic Point Selection (DPB) to receive a PDSCH.

[0380] The legacy operation about such QCL assumption may be considered not to be optimized multi-cell/TP joint transmission, but to be optimized for a target single cell/TP transmission. As such, QCL CSI-RS dynamically indicated by DCI signaling may be generally transmitted from a single cell/TP. Thus, it is necessary to consider in detail a method for providing appropriate QCL signaling as well as PDSCH Rate Matching (RM) which is to support DMRS-based PDSCH broadcast from sets of TPs.

[0381] Regarding CoMP, joint transmission having necessary QCL signaling has been partially discussed. However, this targets "coherent JT (Joint Transmission)" based on a CSI feedback from a UE. On contrary, due to high mobility of a UE (in addition, in order to use "non-coherent JT" for PDSCH broadcast), PDSCH broadcast for a V2X service may be performed substantially based on open-loop transmission. If TM 10 is set in a UE, Inter-TP cooperation for JT, point selection, and muting cannot be recognized by the UE that is not capable of performing QCL and RM.

[0382] Hereinafter, candidate open-loop schemes for supporting PDSCH broadcast from the perspective of an higher layer will be described in more detail.

[0383] 3. Open-Loop Precoding—

[0384] To achieve robust performance of PDSCH broadcast, it is necessary to further consider schemes for performing Open-Loop (OL)-MIMO precoding in one cell and obtaining macro diversities from multiple cells/TPs.

[0385] As described above, open-loop precoding schemes based on appropriate DMRS for PDSCH broadcast needs to be studied more by classifying the schemes into categories as below.

[0386] (1) Schemes for Obtaining Macro Diversity from Multiple Cells

[0387] Multiple cells participating in PDSCH broadcast transmission may transmit the same V2X messages through SFN transmission. The same V2X messages may be combined in the air. The SFN transmission's difference from MBMS transmission maybe a smaller size of a cluster composed of some cells/TPs, and a significantly reduced RS compared with DMRS-based PDSCHs and MSFN RSs.

[0388] In the case where cell-TP CSI-RS resources shared for the SFN transmission are used, there may be as many cell/TP combinations respectively corresponding to the CSI-RS resources as many, and the combinations may be transmitted at least for the purpose of QCL (however, this causes expanded CSI-RS overhead). To avoid such CSI-RS overhead, it is necessary to further study combinations on the side of UE when it comes to QCL tracking per TP and SFN transmission in a given cluster.

[0389] (2) Schemes for OL-MINO Precoding in One Cell

[0390] Along with the macro diversity schemes described above with respect to multiple of cells/TPs, it may be desirable that a PDSCH transmitted to each call is generated by specific OL-MIMO or semi-OL MIMO precoding. More specifically, to achieve even a frequency diversity, an RB level and/or an RE level's precoder cycling may be considered additionally. The semi-OL MIMO discussed regarding eFD-MIMO may be applied for PDSCH. For example, not just for PDSCH broadcast, but also for unicast, the semi-OL MIMO may be applied by re-using a semi-OL MIMO in which a CSI feedback is set or by independent/dedicated CSI feedback (for example, R1 and W1 feedback, and additionally CQI feedback (together with an associated/dedicated CSI procedure setting)) (for example, when semi-OL MIMO dedicated for PDSCH broadcast is set).

[0391] 4. PDCCH-Based Dynamic Scheduling

[0392] For supporting V2V, dynamic scheduling of downlink broadcast is very useful. To enable the dynamic scheduling this, it is necessary to discuss/determine an issue regarding a search space/DCI format for PDSCH broadcast scheduling. PDSCH broadcast may be dynamically scheduled by a L1 scheduling grant. In this case, a relevant DCI may be transmitted through a CSS, as described above with reference to FIGS. **14** and **15**.

[0393] Since DCI format 2D and 1A are used in TM 10, these are allowed to be reused for downlink broadcast scheduling. In this case, however, to avoid additional BD complexity, it is desirable that the corresponding formats are transmitted to have the same payload size as that of a legacy DCI format transmitted in the CSS, as described above.

[0394] To make the corresponding DCI formats have the same payload size, an conventional field of the corresponding DCI formats may be deleted, the size of the conventional field may be deleted, or the conventional field may be replaced with a new field necessary for PDSCH broadcast scheduling. Detailed examples regarding this are the same as

the above examples described with reference with FIGS. **14** to **16**, and additional examples not described above will be provided later.

[0395] Although a target DCI format is described as DCI format 2A in FIGS. **14** to **16**, the target DCI format will be described as DCI format 1A in the following. That is, FIGS. **14** to **16** show examples in which the payload size of the DCI format 2C/2D is adjusted to have the same size as that of the DCI format 2A, but the following examples show the case where the payload size of the DCI format 2C/2D is adjusted to be the same as that of the DCI format 1A. However, aspects of the present invention is not limited thereto, as described above, and a payload size of a specific DCI format may be adjusted to have the same payload size of a target DCI format in order to minimize the number of times to perform BD.

[0396] In one example, a conventional resource allocation field may be replaced with a field of a more compact format (that is, a field having a smaller payload size). For example, a RA field of the DCI format 2D it may be replaced with a RA field of a more compact format (e.g., a RA field of the DCI format 1A).

[0397] And/or, in another embodiment, a conventional field about DMRS settings may be deleted, or the field may be replaced with a field of a more compact format (that is, a field having a smaller payload size). In the case where DCI to be transmitted by a base station is not DCI for MU-MIMO, information about DMRS settings may be fixed in the form of single DMRS sequence setting/VCID information, port/layer indicator information, and/or OCC information, or the information may be in the form of an higher layer signal, such as RRC signaling, to be transmitted/set to a UE.

[0398] If the base station wishes to dynamically indicate a plurality of DMRS settings, a conventional field (3 bits) for DMRS setting may be adjusted to 1-bit or 2-bit independently of and differently from the conventional DCI format 2C/2D. Thus, only some of information included in the conventional DMRS field of the DCI format DC/2D may be transmitted to a UE through a DMRS field that is adjusted according to this embodiment.

[0399] And/or, in yet another embodiment, the size of an MCS indication field may be reduced. More specifically, the MCS 1 field/RV 1 field and the MCS 2 field/RV 2 field included both in the DCI format 2C and the DCI format 2D in order to leave only the MCS 1 field and the RV 1 field in a payload (that is, only the MCS 2 field/RV 2 field are deleted).

[0400] In other words, it may be understood that it is restricted to use only a single TB/codeword for the purpose of PDSCH broadcast. That is, the PDSCH broadcast may be defined/set in a form of transmission only to rank 1(layer1). Alternatively, even though transmission to a plurality of ranks/layers is allowed for PDSCH broadcast, it may be understood that the DCI format is restricted to be transmitted to the plurality of ranks/layers by CW(codeword)-to-layer mapping that is derived from a single codeword/TB, as the conventional retransmission method does.

[0401] And/or, in yet another embodiment, a HARQ field (3 bits or 4 bits) may be deleted. That is, in PDSCH broadcast transmission, it may be limited to applying a single HARQ process It is because a HARQ ID indication field is not necessary when a single HARQ process is applied.

[0402] And/or, a few number of HARQ IDs (that is, the number of HARQ IDs less than the conventional number of HARQ IDs) may be supported, and, in this case, a 1-bit or 2-bit HARQ field which is in size more compact than the size of the conventional HARQ field may be newly defined/set for PDSCH broadcast. For example, a HARQ field may be re-designed in the size of 2 bits so as to indicate four HARQ IDs at maximum, and, in this case, even a timeline may be defined/set independently of and differently from the conventional timeline.

[0403] And/or, in yet another embodiment, a SRS request field may be deleted when PDSCH broadcast is limited to be scheduled by a CSS.

[0404] And/or, a TPC field may be deleted. A conventional TPC field is used to indicate power control of a UE's transmission of an ACK/NACK feedback (on PUCCH) regarding PDSCH unicast. However, in the case of PDSCH broadcast, a plurality of UE shares a specific resource to transmit ACK/NACK, so PDSCH broadcast is carried out with operations different from what is required for unicast PDSCH, and thus, a TPC field may be unnecessary for PDSCH broadcast. Thus, the payload size may be adjusted by deleting the TPC field. However, in this case, a UE may be defined/set to always perform ACK/NACK at a specific pre-defined/pre-configured power level. The power level may be set by the UE through RRC signaling (RRC-configurable).

[0405] Or, the size of the TPC field may be adjusted to 1-bit. In this case, the TPC field may be defined/set to indicate adjusting power levels of ACK/NACK transmitted together by a plurality of UEs having received PDSCH broadcast. The TPC field may be distinguished/separated not to be mixed/accumulated with other TPC fields existing in a DL grant for scheduling of other PDSCH unicast. In other words, even though DL grants are received, a UE may be restricted to share (or accumulate) information between TPC fields existing in a DL for scheduling of PDSCH unicast. In doing so, the UE may distinguish a TPC field for scheduling of PDSCH unicast and a TPC field for scheduling of PDSCH broadcast (or special PDSCH transmission in a specially indicated form), and the UE may follow indication in an additionally distinguished/separated TPC field according to a situation.

[0406] And/or, in yet another embodiment, when a TDD scheme is applied for PDSCH broadcast, "DAI field" may remain intact or may be simplified. In this case, the DAI field may be used to indicate which number (subframe) transmission the corresponding broadcast is. Alternatively, the DAI field may be deleted for PDSCH broadcast, and, in this case, the DAI field may be deleted to be re-interpreted as a form which indicates scheduling of PDSCH broadcast corresponding to the corresponding scheduling subframe.

[0407] As such, an additional embodiment in which conventional fields in a specific DCI format is simplified or removed has been described. In this case, instead of the deleted/removed field, at least one filed including the following information necessarily required for scheduling of PDSCH broadcast may be added. However, replacement of a field should satisfy a condition that a corresponding DCI format needs to have a payload size as the same as that of a target DCI format.

[0408] As described above, PQI information included in a PQI field may be information necessarily required for scheduling of PDSCH broadcast. Thus, the PQI field may be

inserted into DCI, instead of fields, for example, the HARQ field, the DMRS setting field, and/or the TPC field, which can be deleted in the above-described examples.

[0409] And/or, the PQI field may be modified such that some information of a parameter set is deleted or added. As a typical example, QCL and RM-related information in the PQI field may be updated/changed so as to indicate multiple cells/TPs (for example, when scheduling SPN transmission, the base station indicates, through the PQI field, which cells/TPs the QCL/RM operation need to be performed. In this case, each cell/TP may be indicated in a form corresponding to a specific RS (e.g., CSI-RS ID)).

[0410] And/or, the TMGI indicator-related information/field may be inserted into DCI, instead of the above-suggested fields which can be deleted, and the corresponding TMGI indicator-related information/field may be defined/set to indicate a TMGI ID, a MBSFN region ID, and/or a specific packet ID.

[0411] Thus, if a DCI format for scheduling of PDSCH broadcast is designed as above, the payload size of the DCI format 2C/2D may become identical or similar to the payload size of the DCI format 1A (as a result, the number of times for a UE to perform BD may be minimized). Furthermore, as described above, when the DCI format 2C/2D uses the same RA field as that of the DCI format 1A, the DCI format 2C/2D, except for the PQI field and/or the TMGI indication field may be considered to have been designed based on the DCI format 1A.

[0412] As such, DCI for PDSCH broadcast, which is designed based on the principle proposed in this specification, may be indicated as a new name "DCI format 1F", and, as TM for receiving PDSCH broadcast, a newly defined TM may be given or may be applied to a conventionally defined TM, such as TM 10.

[0413] If the above examples are applied to a conventional TM, such as TM 10, there are three types of DCI formats that a UE needs to perform BD, as below:

[0414] DCI format 2D (or 2C): (unicast) TM-dependent DCI

[0415] DCI format 1A: (unicast) fallback purpose

[0416] DCI format 1F: (multicast/broadcast) DCI

[0417] Meanwhile, a DCI format, such as the DCI format 2D and the like, to be used for PDSCH broadcast, is not changed by adjusting a payload size thereof to be the same as a payload size of a target DCI format, such as the conventional DCI format 1A, and the DCI format may be defined/set as a form such that a UE perform BD in a CSS independently (that is, a form which triggers increase of the number of times to perform BD). Instead, to reduce the increase in the number of times to perform BD, a subframe set restriction may be defined/set as described above to as to transmit/perform BD on the specific DCI format (e.g., DCI format 2D) for PDSCH broadcast only with respect to a specific (pre-defined/pre-configured) subframe set

[0418] The aforementioned embodiments are achieved by combination of structural elements and features of the present invention in a predetermined manner. Each of the structural elements or features should be considered selectively unless specified separately. Each of the structural elements or features may be carried out without being combined with other structural elements or features. Also, some structural elements and/or features may be combined with one another to constitute the embodiments of the present invention. The order of operations described in the embodiments of the present invention may be changed. Some structural elements or features of one embodiment may be included in another embodiment, or may be replaced with corresponding structural elements or features of another embodiment. Moreover, it will be apparent that some claims referring to specific claims may be combined with another claims referring to the other claims other than the specific claims to constitute the embodiment or add new claims by means of amendment after the application is filed.

[0419] An embodiment of the present invention may be implemented by various means, for example, hardware, firmware, software or a combination of them. In the case of implementations by hardware, an embodiment of the present invention may be implemented using one or more Application-Specific Integrated Circuits (ASICs), Digital Signal Processors (DSPs), Digital Signal Processing Devices (DSPDs), Programmable Logic Devices (PLDs), Field Programmable Gate Arrays (FPGAs), processors, controllers, microcontrollers and/or microprocessors.

[0420] In the case of implementations by firmware or software, an embodiment of the present invention may be implemented in the form of a module, procedure, or function for performing the aforementioned functions or operations. Software code may be stored in the memory and driven by the processor. The memory may be placed inside or outside the processor, and may exchange data with the processor through a variety of known means.

[0421] It is evident to those skilled in the art that the present invention may be materialized in other specific forms without departing from the essential characteristics of the present invention. Accordingly, the detailed description should not be construed as being limitative from all aspects, but should be construed as being illustrative. The scope of the present invention should be determined by reasonable analysis of the attached claims, and all changes within the equivalent range of the present invention are included in the scope of the present invention.

MODE FOR INVENTION

[0422] Various modes for carrying out the invention have been described in the mode for invention.

INDUSTRIAL APPLICABILITY

[0423] The method for assisting communication between UEs in a wireless communication system of the present invention has been described on the basis of the example applied to the 3GPP LTE/LTE-A system, but the present invention may also be applied to various wireless communication systems other than the 3GPP/LTE/LTE-A system.

1. A method for transmitting Downlink Control Information (DCI) by a base station in a wireless communication system, the method comprising:

allocating a resource for data transmission;

transmitting, in a first DCI format, DCI including scheduling information about the allocated resource; and

transmitting data according to the scheduling information,

wherein, when the DCI includes scheduling information about multicast/broadcast data, the first DCI format is transmitted in a payload size, which is adjusted to be identical to a payload size of a pre-configured second DCI format, through a Common Search Space (CSS), and

wherein, when the DCI includes scheduling information about unicast data, the first DCI format is transmitted in a payload size, which is not adjusted, through a UE-specific Search Space (USS).

2. The method of claim **1**, wherein the payload size of the first DCI format is adjusted to be identical to the payload size of the second DCI format by deleting at least one field of fields included in the payload of the first DCI format or by reducing a bit size of the at least one field.

3. The method of claim **2**, wherein the second DCI format is DCI format 2A and the first DCI format is DCI format 2C.

4. The method of claim **3**, wherein the first DCI format is scrambled by a Point to Multipoint-Radio Network Temporary Identifier (PTM-RNTI), which is newly defined for multicast/broadcast transmission, and the scrambled first DCI format is transmitted.

5. The method of claim **3**, wherein, when the first and second DCI formats are transmitted in a Frequency Division Duplex (FDD) scheme and a bit size of a Rank field included in a payload of the second DCI format is set to 0 bit, at least one field of a New Data Indicator (NDI) field, a Modulation and Coding Scheme (MCS) 2 field, a Redundancy Version (RV) 2 field, a Hybrid Automatic Repeat Request (HARQ) field, a Transmit Power Control (TPC) field, and a Carrier Indicator Field (CIF) included in the payload of the first DCI format is deleted or a bit size of the at least one field is reduced.

6. The method of claim **3**, wherein, when the first and second DCI formats are transmitted in a Time Division Duplex (TDD) scheme and a bit size of a rank field included in the second DCI format is set to 2 bits, a Sound Reference Signal (SRS) field is deleted from the payload of the first DCI format and the payload of the first DCI format is transmitted.

7. The method of claim **3**, wherein, when the first and second DCI formats are transmitted in a TDD method and a bit size of a Rank field included in the payload of the second DCI format is set to 0 bit, an SRS field is deleted from the payload of the first DCI format, the payload of the first DCI format is transmitted and, additionally, at least one field of an NDI field, an MCS 2 field, an RV 2 field, an HARQ field, a TPC field, a Downlink Assignment Index (DAI) field, and a CIF is deleted or a bit size of the at least one field is reduced.

8. The method of claim **2**, wherein the second DCI format is DCI format 2A and the first DCI format is DCI format 2D.

9. The method of claim **8**, wherein, when the first and second DCI formats are transmitted in an FDD scheme and a bit size of a Rank field included in the payload of the second DCI format is set to 2 bits, a PDSCH RE Mapping and Quasi-co-location Indicator (PQI) field is deleted from the payload of the first DCI format and the payload of the first DCI format is transmitted.

10. The method of claim **9**, wherein, when a PTM-RNTI for indicating PQI information included in the deleted PQI field is separately defined, the first DCI format is scrambled by the PTM-RNTI and transmitted.

11. The method of claim **10**, wherein information about a PTM-RNTI corresponding to the PQI information is transmitted via higher layer signaling.

12. The method of claim **8**, wherein, when the first and second DCI formats are transmitted in a TDD scheme and a bit size of a Rank field included in the payload of the second DCI format is set to 2 bits, a PQI field and a SRS field are deleted from the payload of the first DCI format and the payload of the first DCI format is transmitted.

13. The method of claim **8**, wherein, when the first and second DCI formats are transmitted in a TDD scheme and a bit size of a Rank field included in the payload of the second DCI format is set to 0 bit, a PQI field and a SRS field are deleted from the payload of the first DCI format, the payload of the first DCI format is transmitted, and, additionally, at least one field of an NDI field, an MCS 2 field, an RV 2 field, an HARQ field, a TPC field, a DAI field, and a CIF is deleted or a bit size of the at least one field is reduced.

14. The method of claim **13**, wherein, when a PTM-TNTI is separately defined to indicate PQI information included in the deleted PQI field, the first DCI format is scrambled by the PTM-RNTI and transmitted.

15. The method of claim **14**, wherein information about the PTM-RNTI corresponding to the PQI information is transmitted via higher layer signaling.

16. A method for transmitting Downlink Control Information (DCI) by a base station in a wireless communication system, the method comprising:

a Radio Frequency (RF) unit configured to transmit and receive a radio signal; and

a processor configured to control the RF unit,

wherein the base station is configured to:

allocate a resource for data transmission;

transmit, in a first DCI format, DCI including scheduling information about the allocated resource; and

transmit data according to the scheduling information,

wherein, when the DCI includes scheduling information about multicast/broadcast data, the DCI is transmitted in a payload size, which is adjusted to be identical to a payload size of a preset second DCI format, through a Common Search Space (CSS), and

wherein, when the DCI includes scheduling information about unicast data, the first DCI format is transmitted in a payload size, which is not adjusted, through a UE-specific Search Space (USS).

* * * * *

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(43) Pub. Date: Apr. 21, 2016

LEE et al.

(54) **REFERENCE SIGNALS EXTENSION FOR MASSIVE MIMO SYSTEM**

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(21) Appl. No.: **14/891,921**

(22) PCT Filed: **Feb. 21, 2014**

(86) PCT No.: **PCT/KR2014/001427**

§ 371 (c)(1),
(2) Date: **Nov. 17, 2015**

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H04L 25/02	(2006.01)
H04L 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***H04B 7/0413*** (2013.01); ***H04L 5/0048*** (2013.01); ***H04L 25/0202*** (2013.01)

(57) **ABSTRACT**

Reference signals (RSs) transmission scheme for massive MIMO system is disclosed. For this, 'M' resource blocks (RBs) are grouped into a resource block group (M>1). One or more antenna ports are grouped into one antenna group, wherein each of the antenna ports corresponds to each of the multiple antennas. The reference signals of the one antenna group are mapped into only one RB within one resource block group.

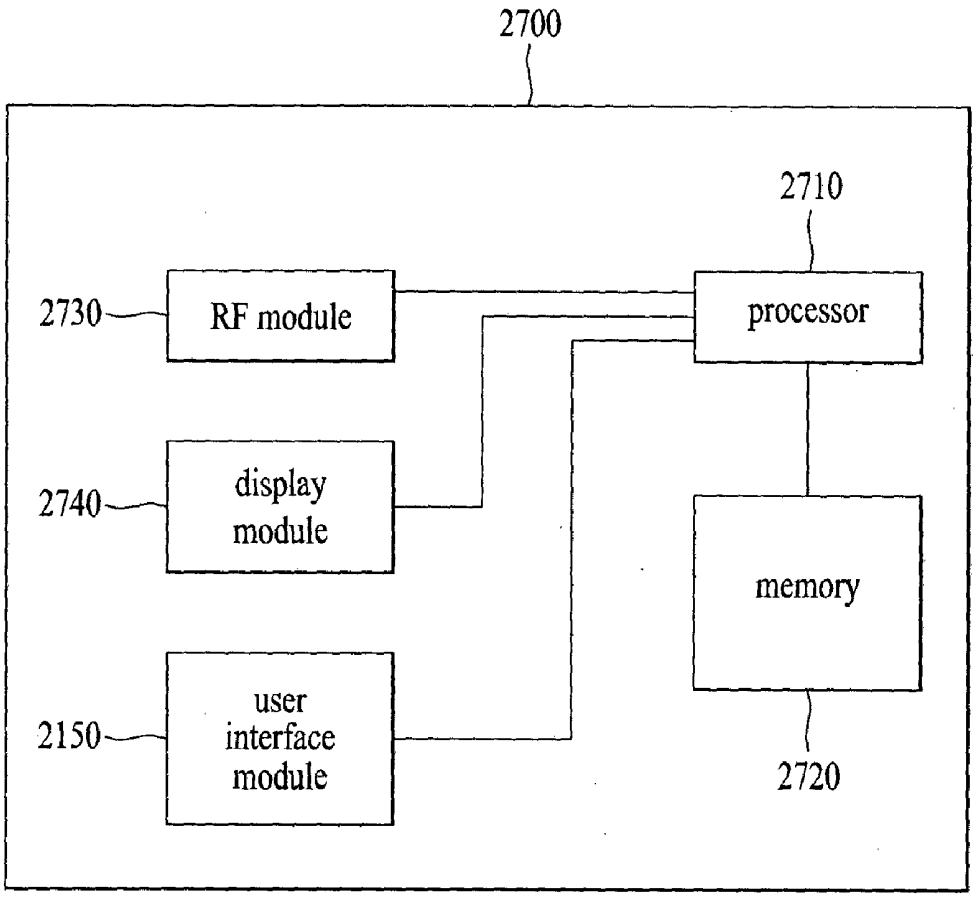


FIG. 1

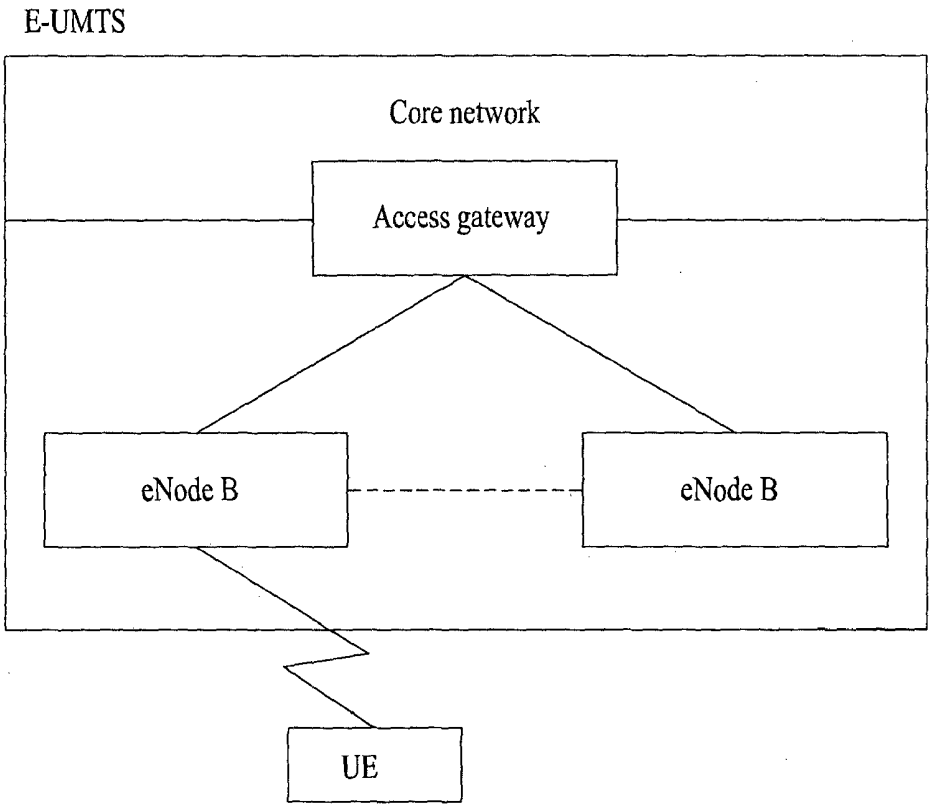
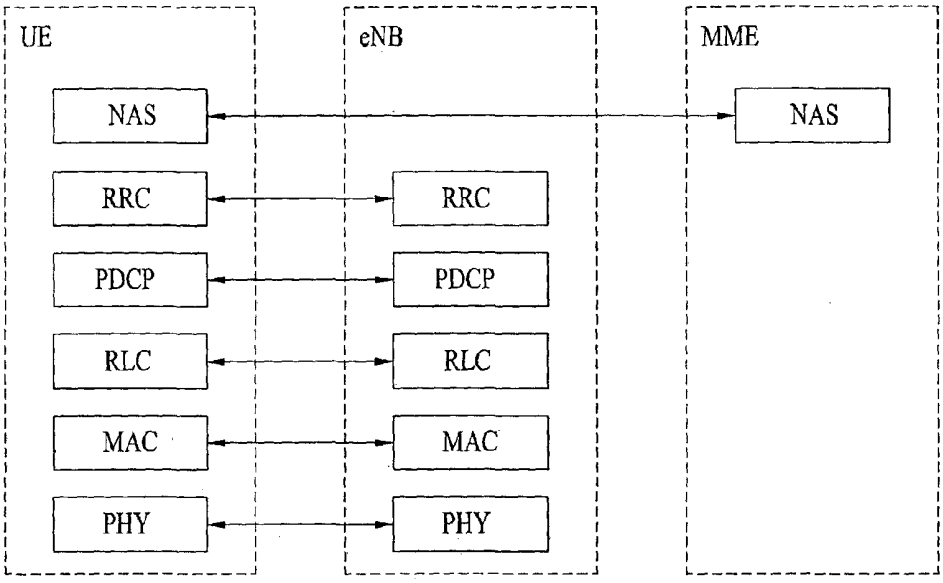
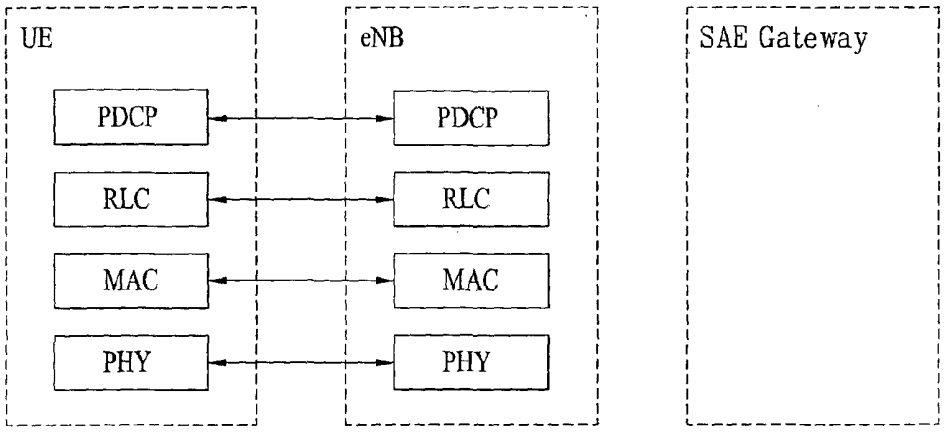


FIG. 2



(a) Control-plane protocol stack



(b) User-plane protocol stack

FIG. 3

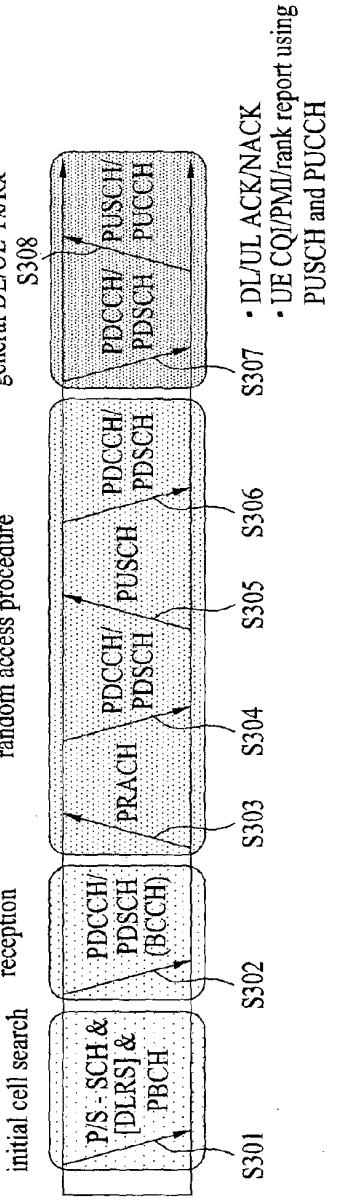
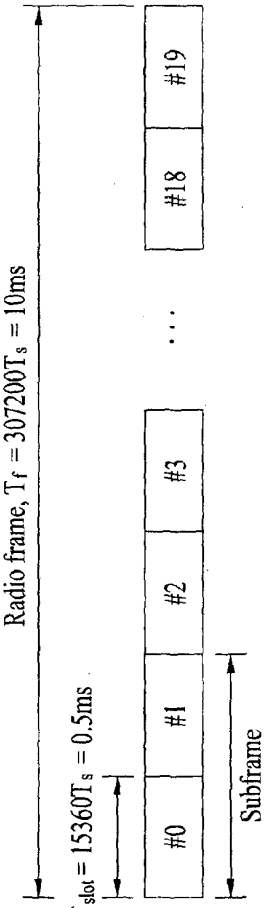


FIG. 4



789

FIG. 5

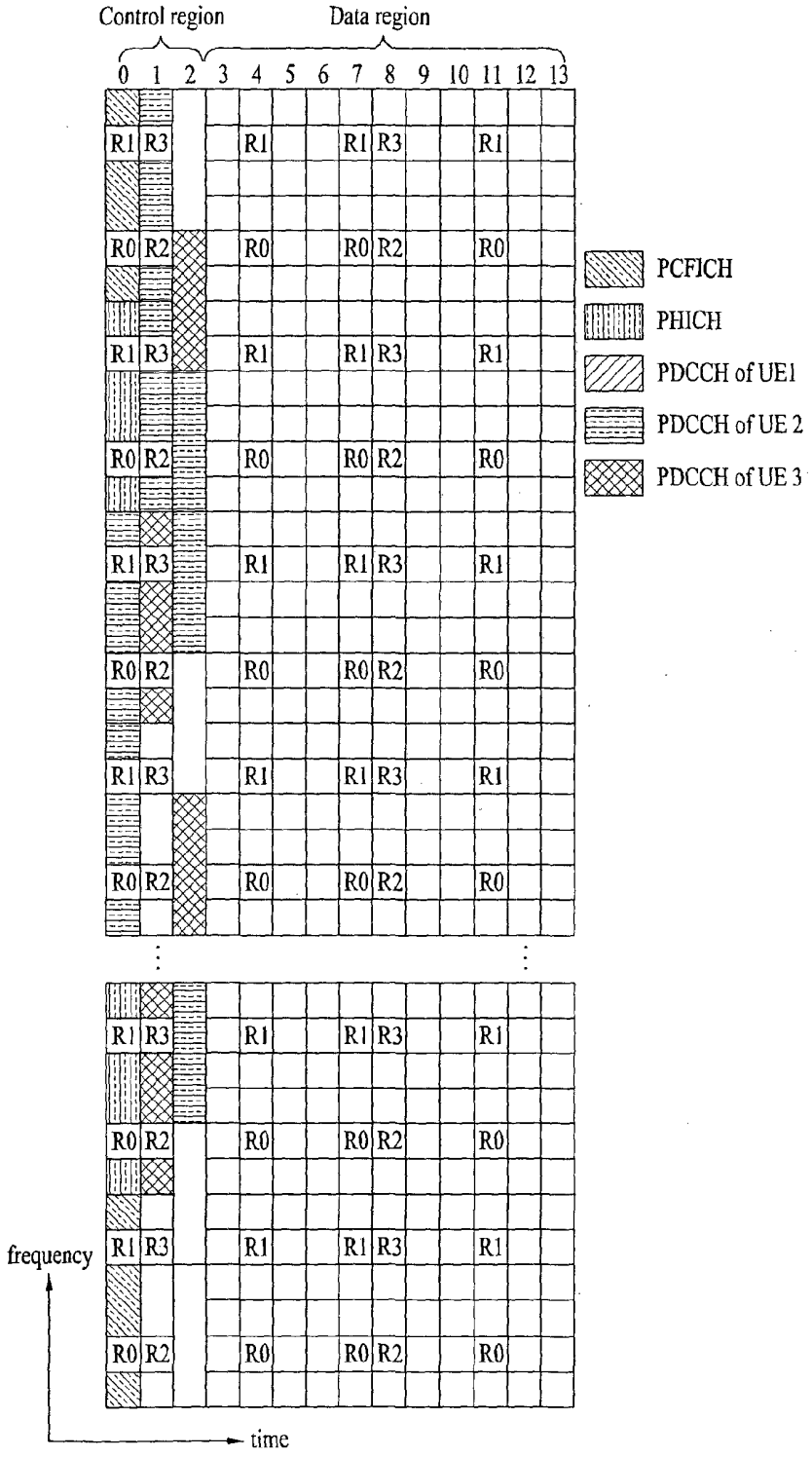

Control region
Data region
0 1 2 3 4 5 6 7 8 9 10 11 12 13
R1 R3
R0 R2
PCFICH
PHICH
PDCCH of UE1
PDCCH of UE 2
PDCCH of UE 3
frequency
time

FIG. 6

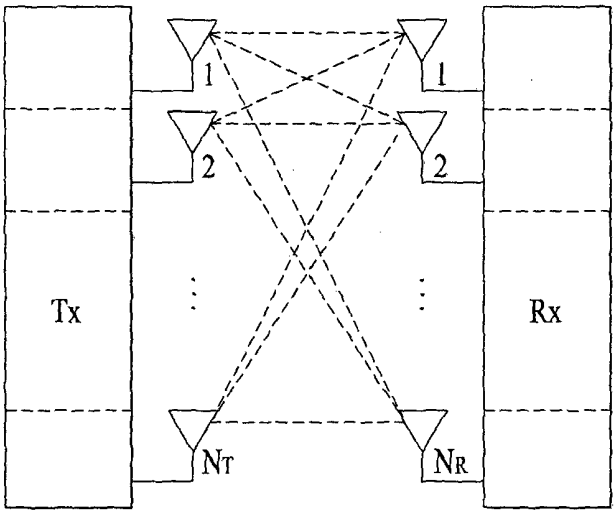


FIG. 7

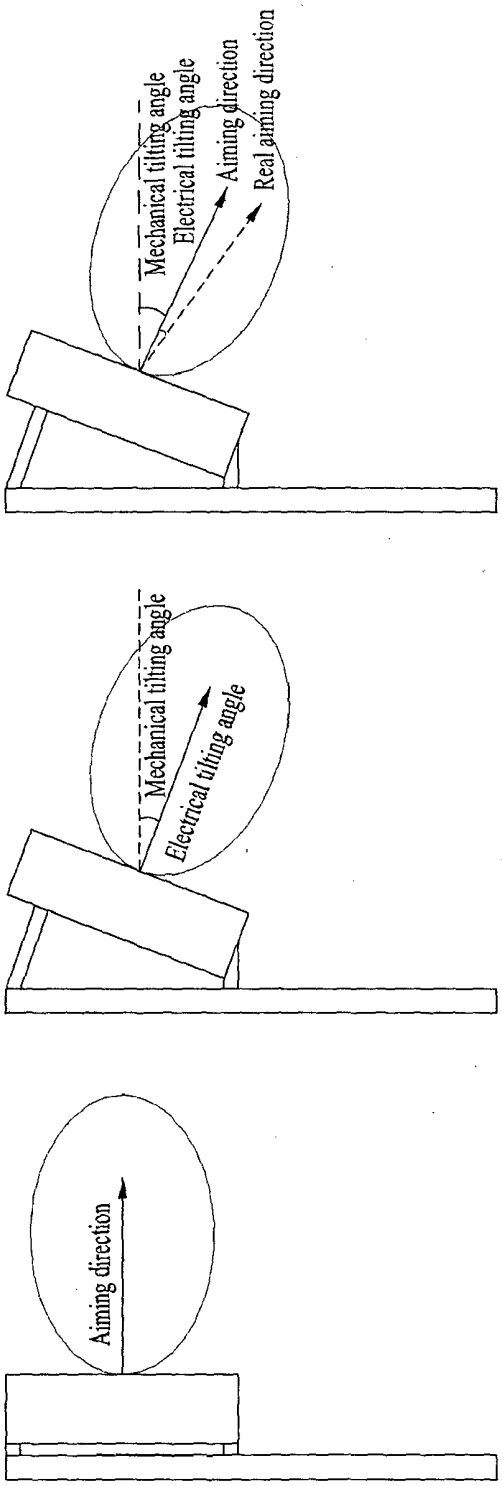
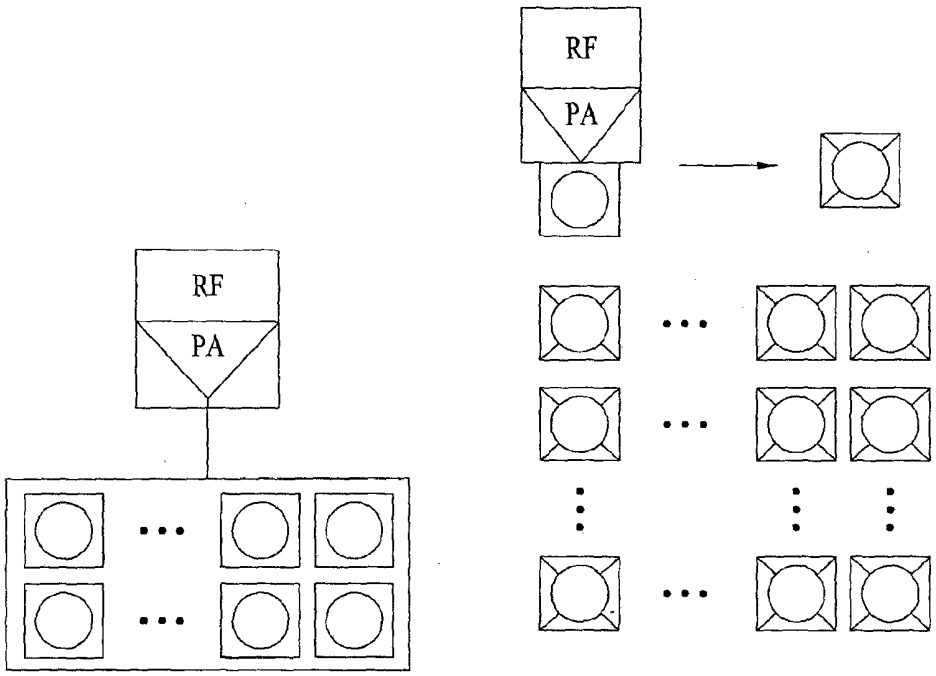

Mechanical tilting angle
Electrical tilting angle
Aiming direction
Real aiming direction
(c)
Mechanical tilting angle
Electrical tilting angle
(b)
Aiming direction
(a)

FIG. 8



(a) Existing antenna system (b) Active antenna system

FIG. 9

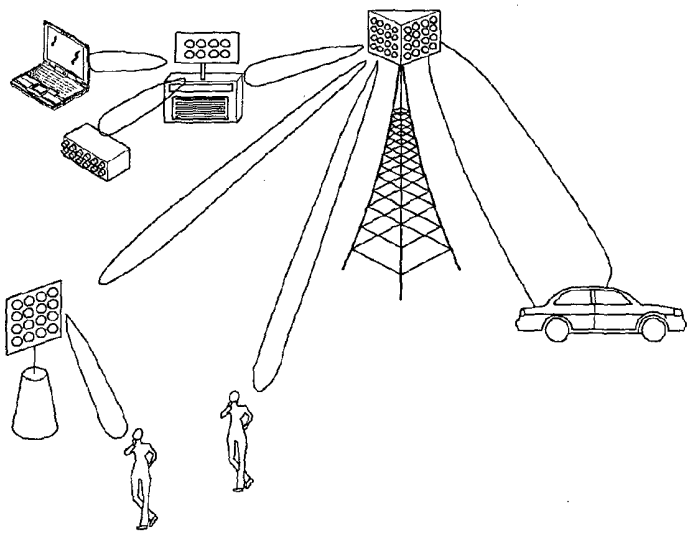


FIG. 10

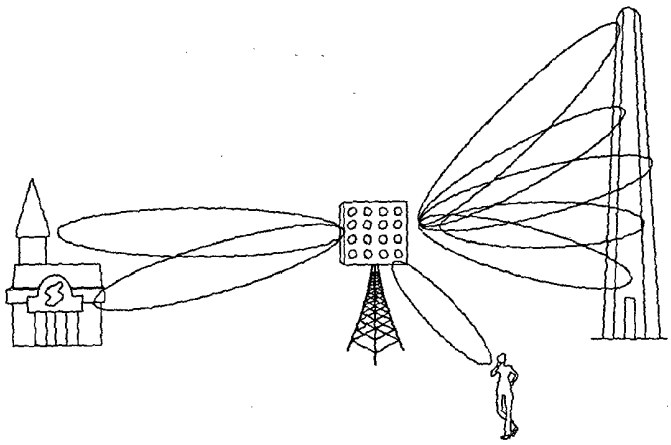


FIG. 11

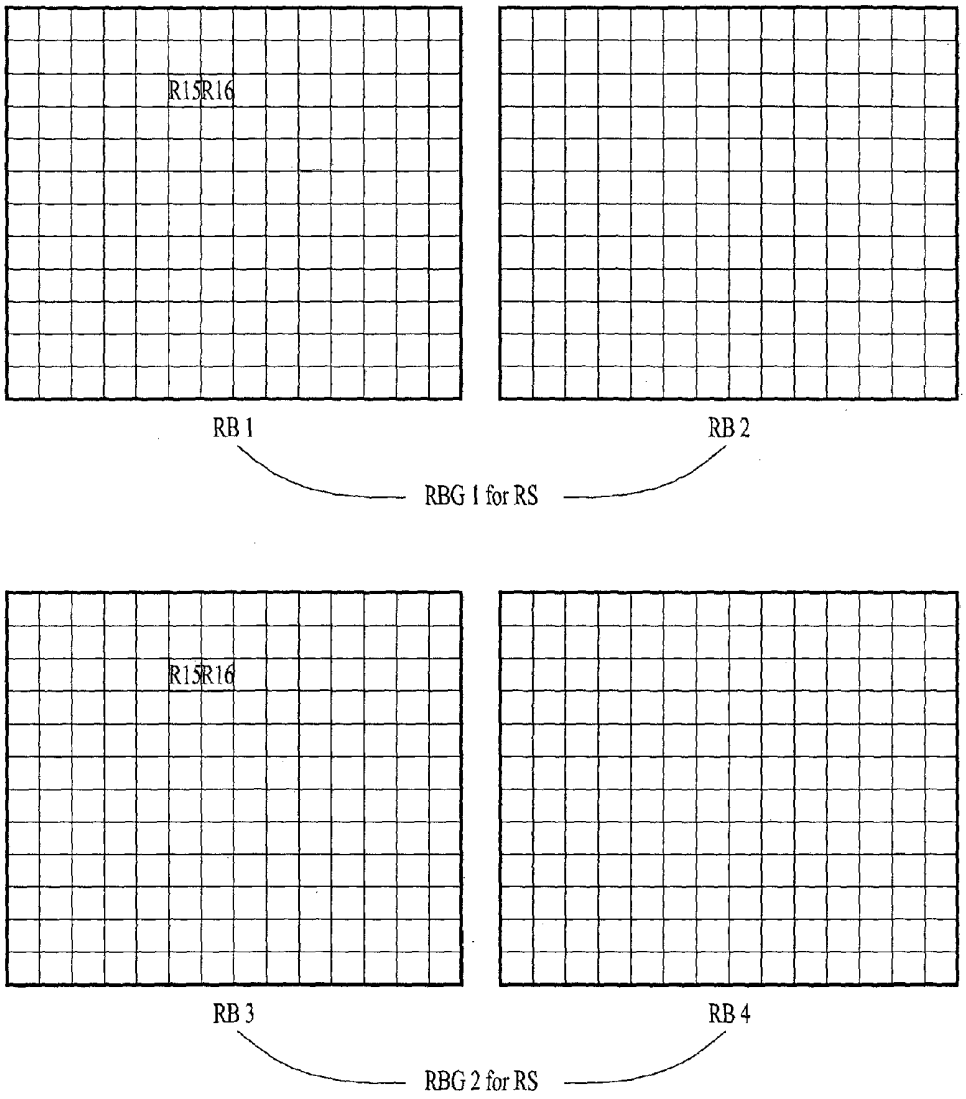


FIG. 12

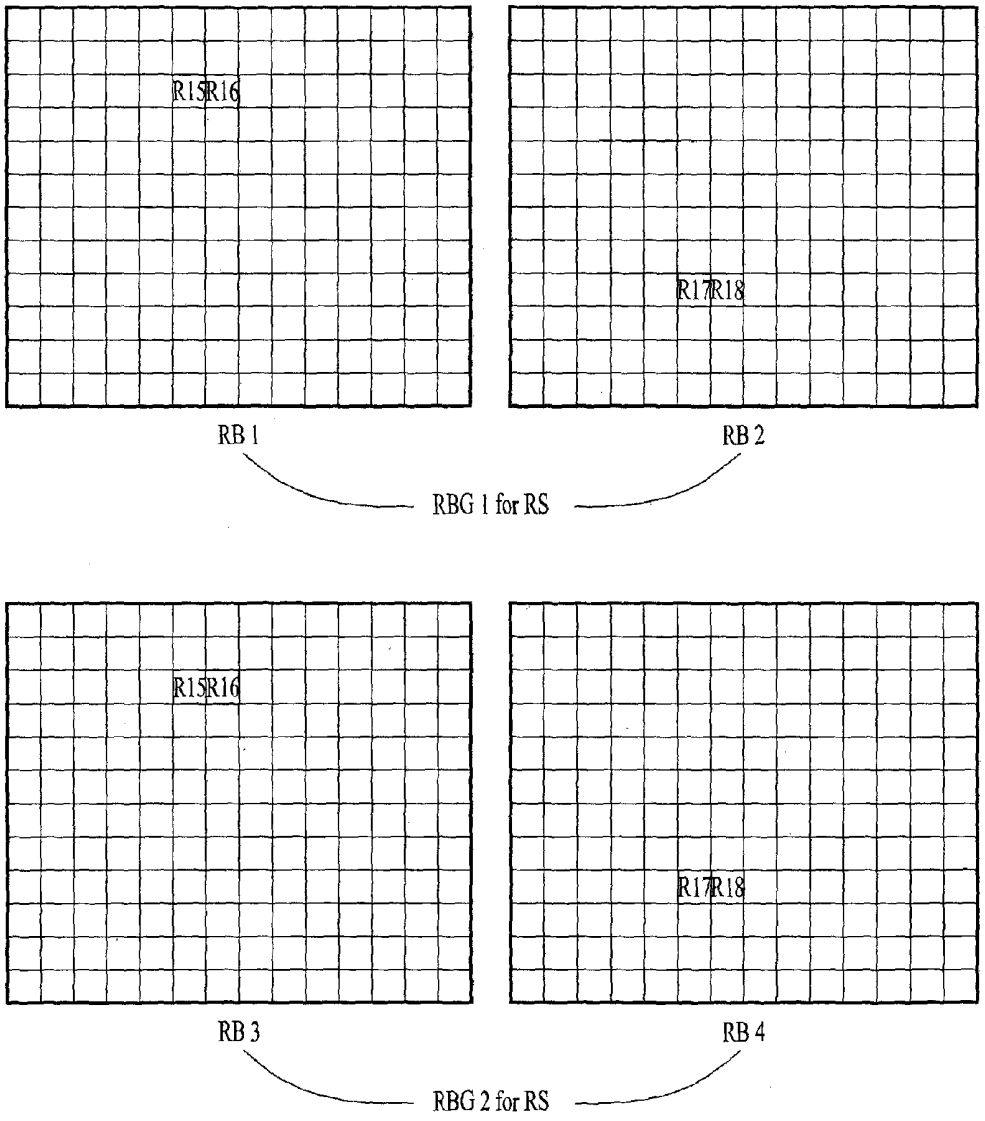

R15R16
R17R18
RB 1
RB 2
RBG 1 for RS
R15R16
R17R18
RB 3
RB 4
RBG 2 for RS
Ports 15 and 16 = Antenna group 1
Ports 17 and 18 = Antenna group 2

FIG. 13

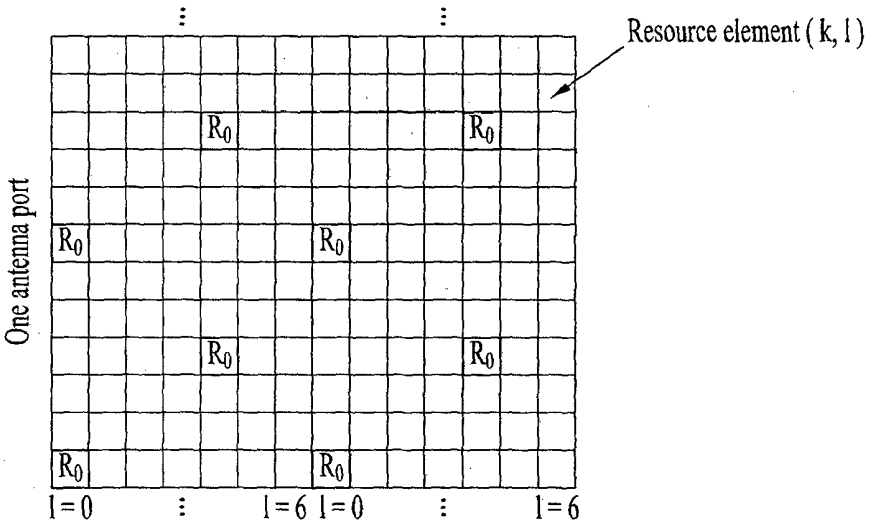


FIG. 14

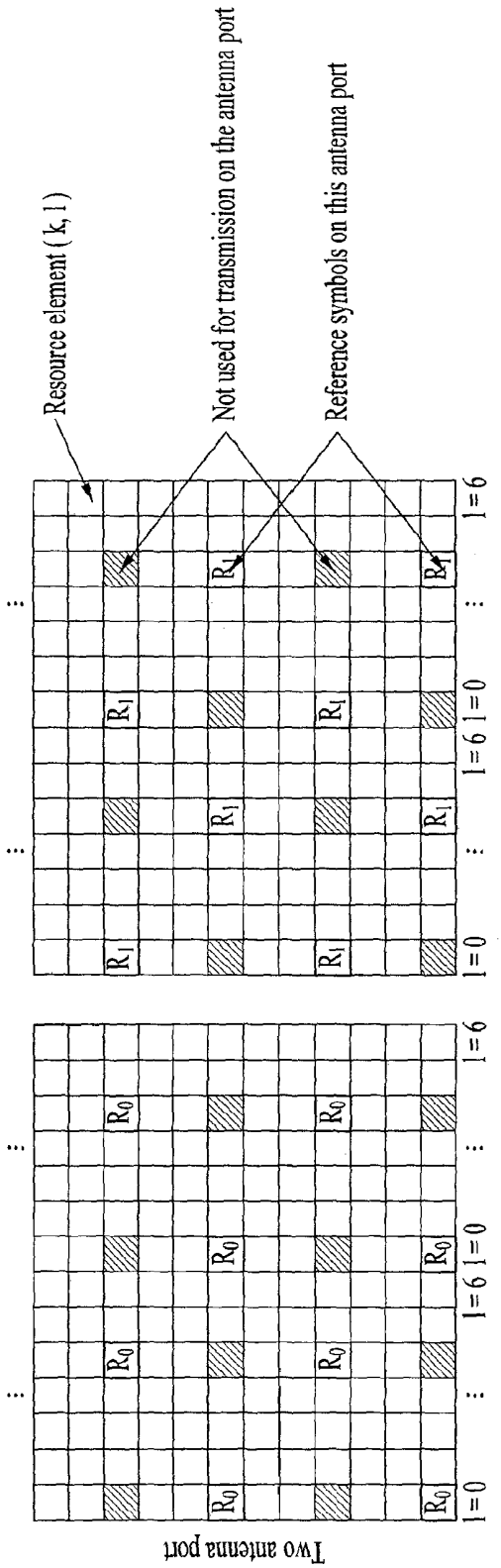

Resource element (k, l)
Not used for transmission on the antenna port
Reference symbols on this antenna port
Two antenna port
l=6
l=0
R_0
R_1

FIG. 15

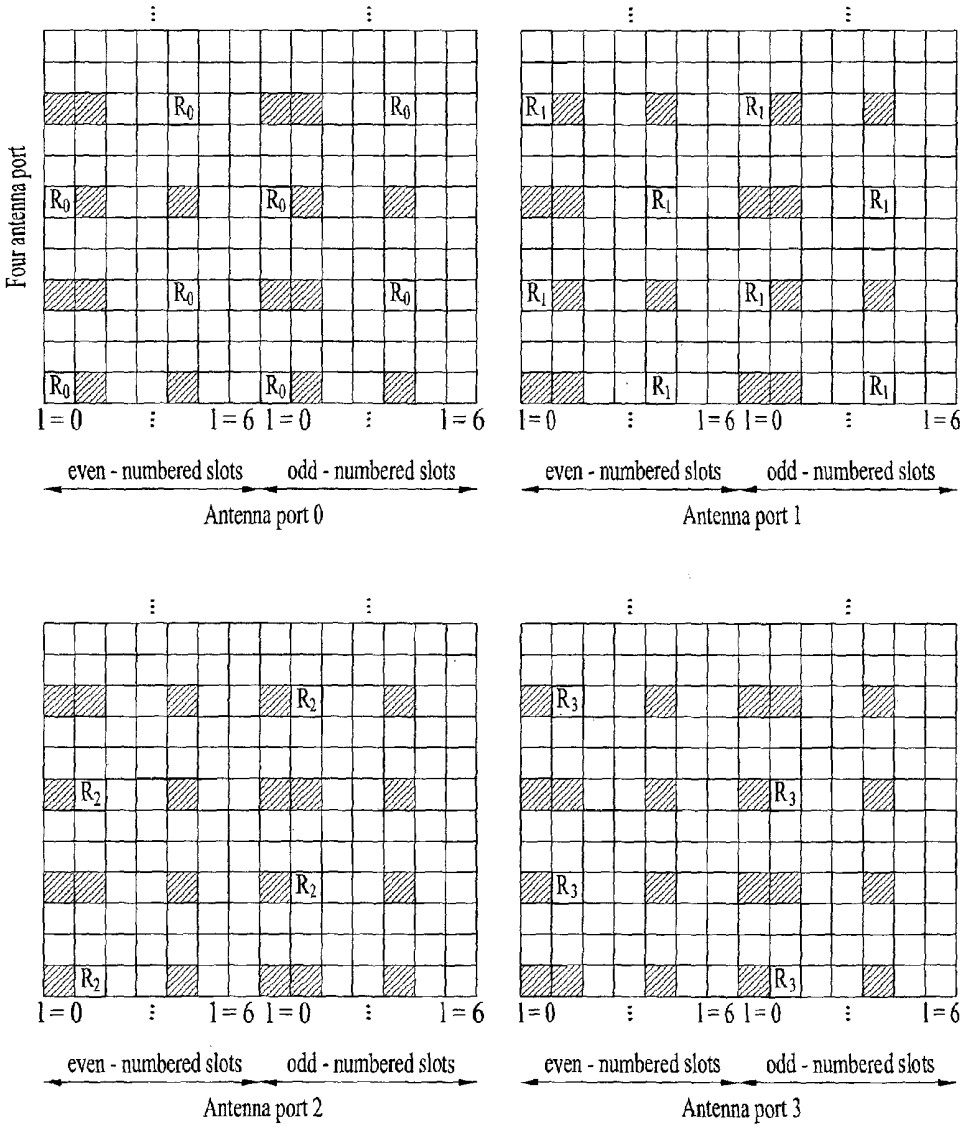

Four antenna port
R0
R1
R2
R3
l = 0
l = 6
even - numbered slots
odd - numbered slots
Antenna port 0
Antenna port 1
Antenna port 2
Antenna port 3

FIG. 16A

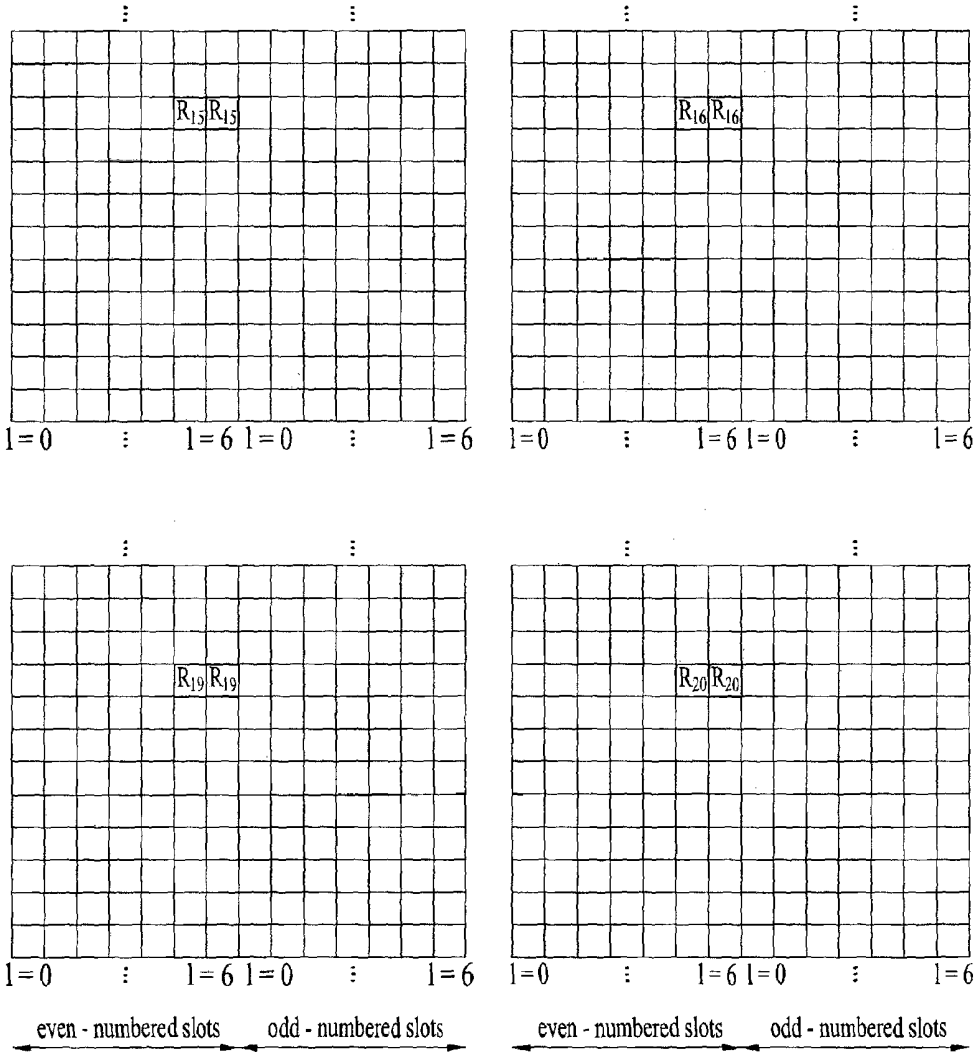

R15 R15
R16 R16
R19 R19
R20 R20
l=0
l=6
even - numbered slots
odd - numbered slots

FIG. 16B

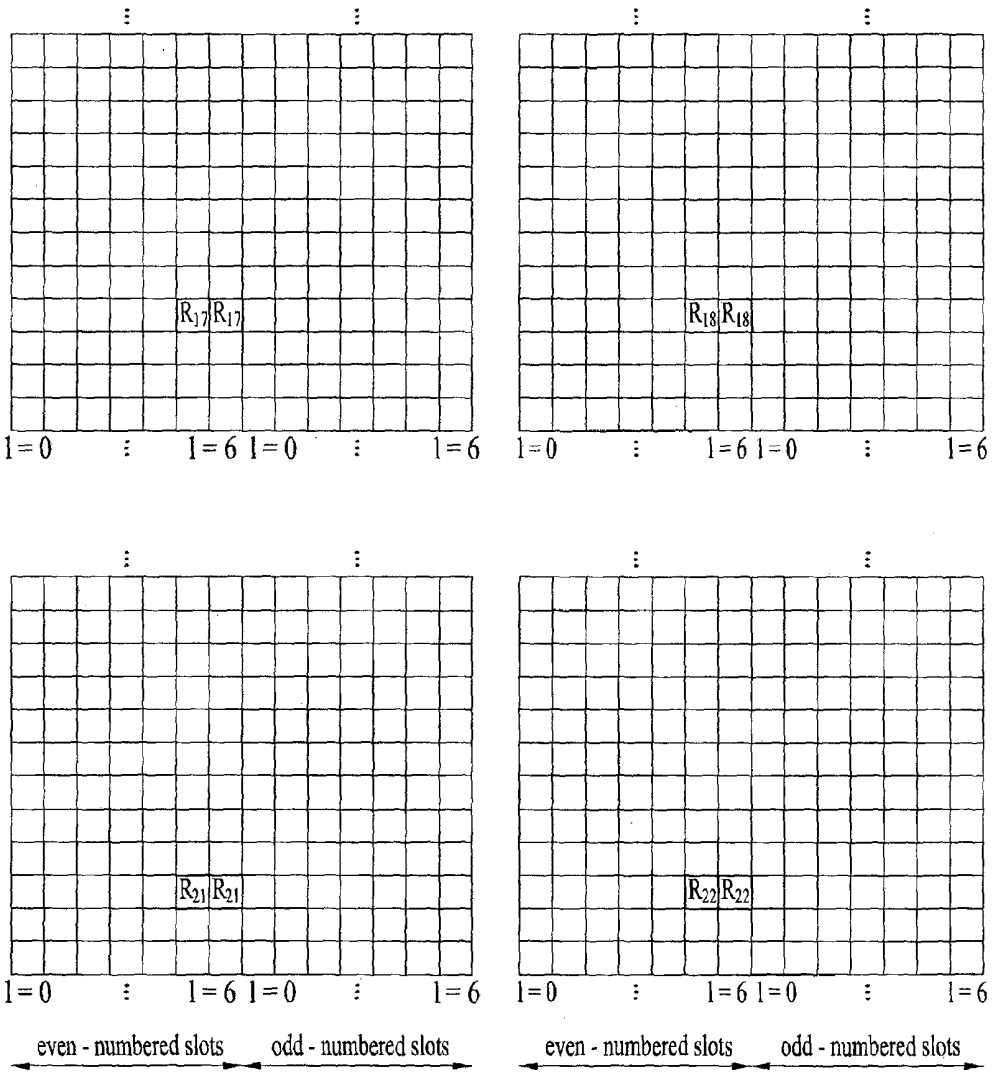

R_{17} R_{17}
R_{18} R_{18}
R_{21} R_{21}
R_{22} R_{22}
l=0
l=6
even - numbered slots
odd - numbered slots

FIG. 17

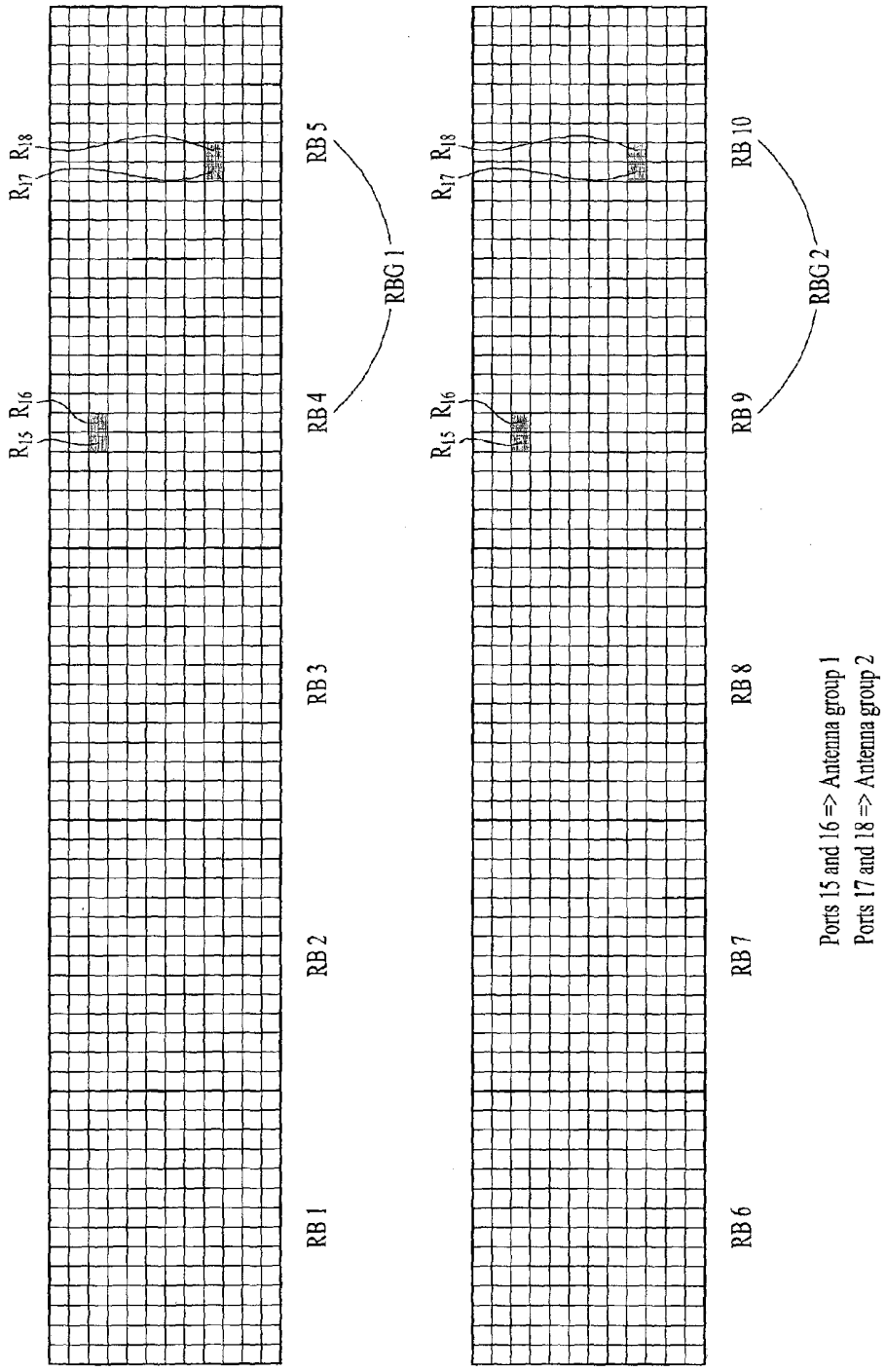

R17 R18
R15 R16
RB 1
RB 2
RB 3
RB 4
RB 5
RBG 1
RB 6
RB 7
RB 8
RB 9
RB 10
RBG 2
Ports 15 and 16 => Antenna group 1
Ports 17 and 18 => Antenna group 2

FIG. 18

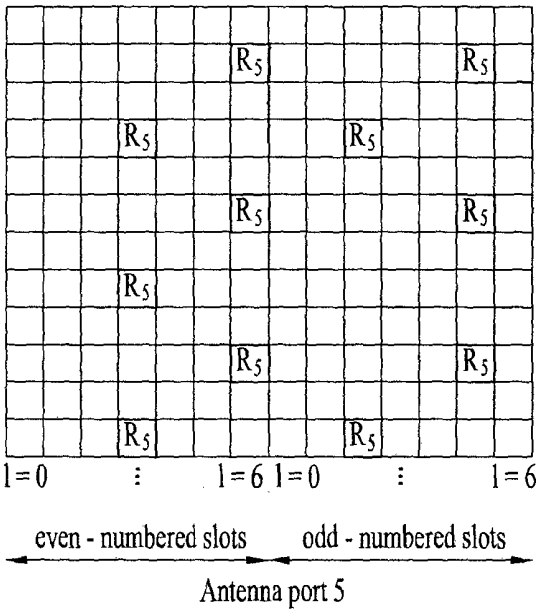

R5
l=0
l=6
l=0
l=6
even - numbered slots
odd - numbered slots
Antenna port 5

FIG. 19

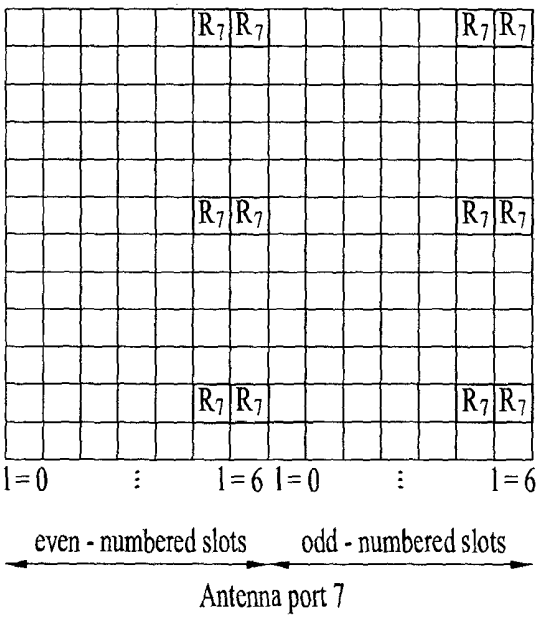

R7
l=0
l=6
l=0
l=6
even - numbered slots
odd - numbered slots
Antenna port 7

FIG. 20

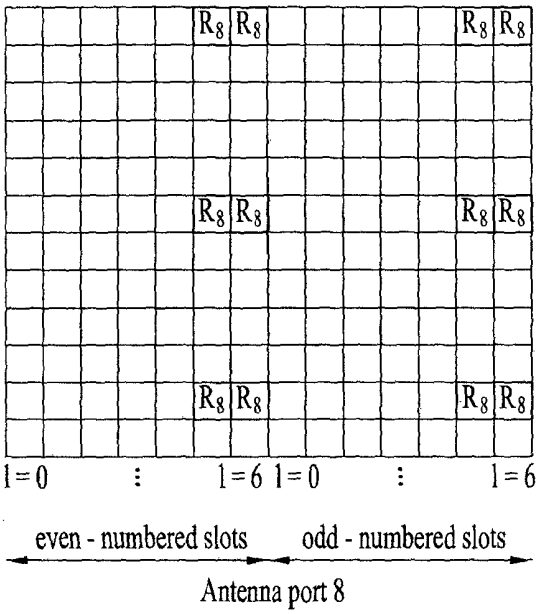

R8 R8
R8 R8
R8 R8
R8 R8
R8 R8
R8 R8
l=0
l=6
l=0
l=6
even - numbered slots
odd - numbered slots
Antenna port 8

FIG. 21

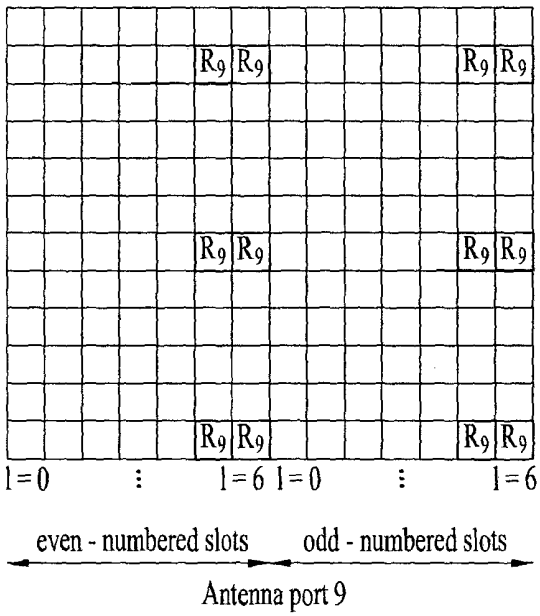

R9 R9
R9 R9
R9 R9
R9 R9
R9 R9
R9 R9
l=0
l=6
l=0
l=6
even - numbered slots
odd - numbered slots
Antenna port 9

FIG. 22

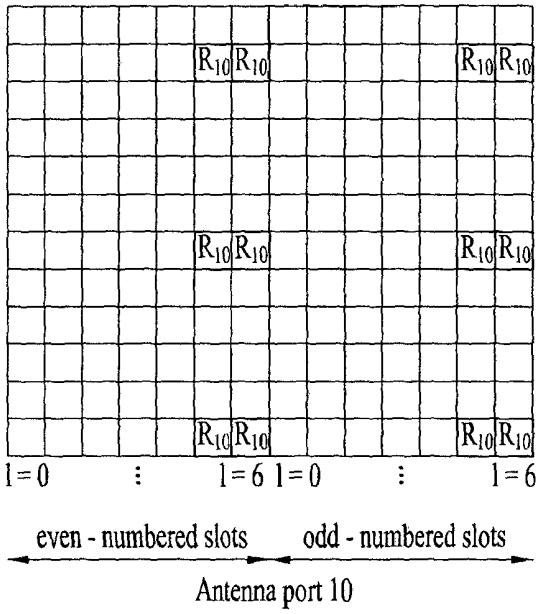
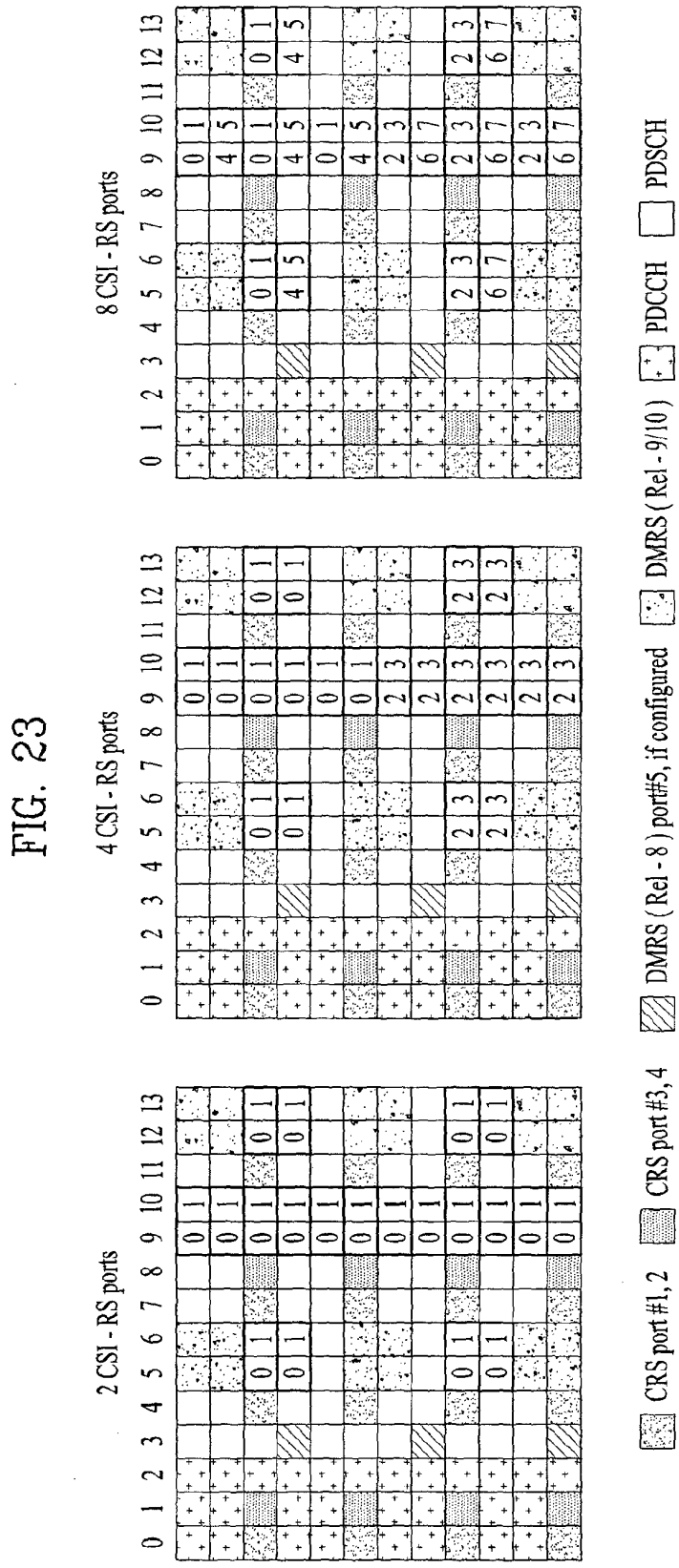

R10 R10 R10 R10
R10 R10 R10 R10
R10 R10 R10 R10
l = 0 ⋮ l = 6 l = 0 ⋮ l = 6
even - numbered slots
odd - numbered slots
Antenna port 10

FIG. 23


2 CSI - RS ports
4 CSI - RS ports
8 CSI - RS ports
0 1 2 3 4 5 6 7 8 9 10 11 12 13
CRS port #1, 2
CRS port #3, 4
DMRS (Rel - 8) port#5, if configured
DMRS (Rel - 9/10)
PDCCH
PDSCH

806

FIG. 24

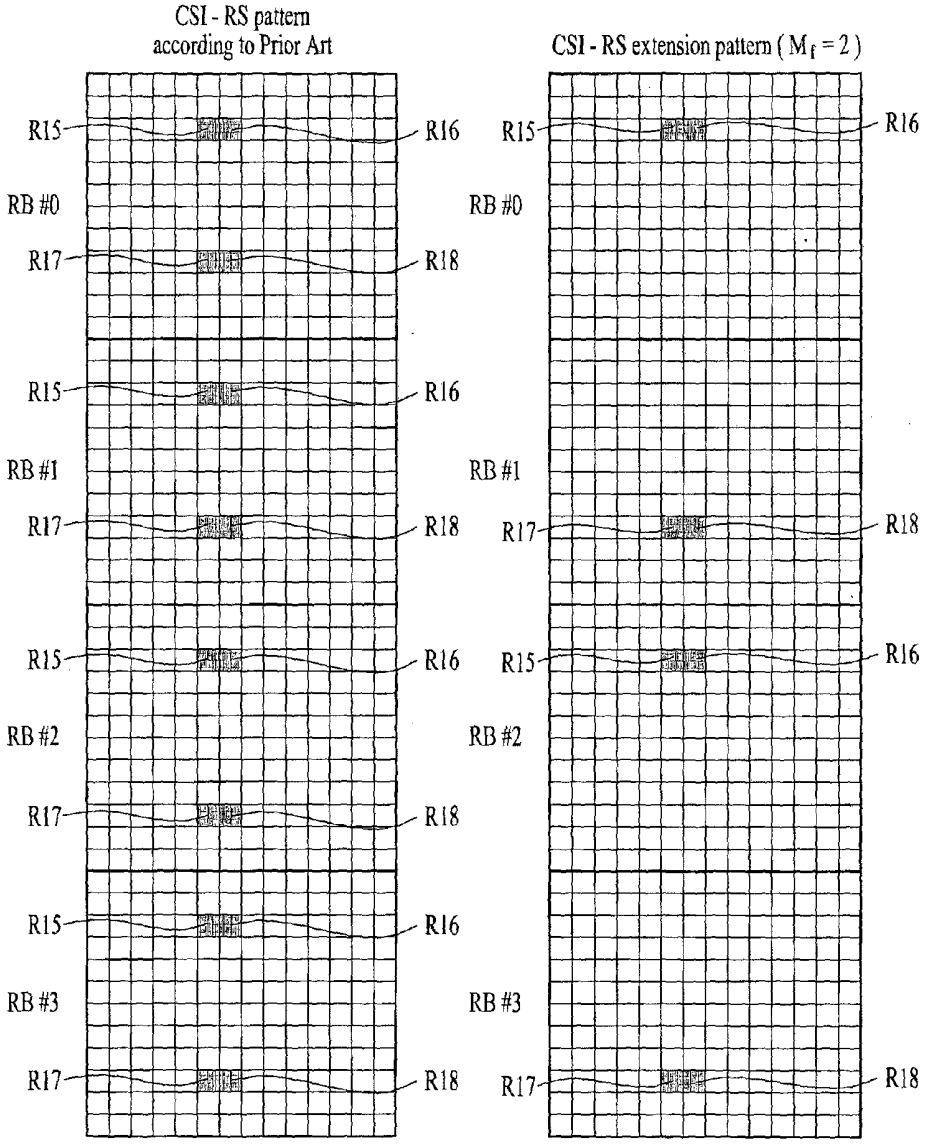

CSI - RS pattern according to Prior Art
CSI - RS extension pattern ($M_f = 2$)
R15
R16
R17
R18
RB #0
RB #1
RB #2
RB #3

FIG. 25

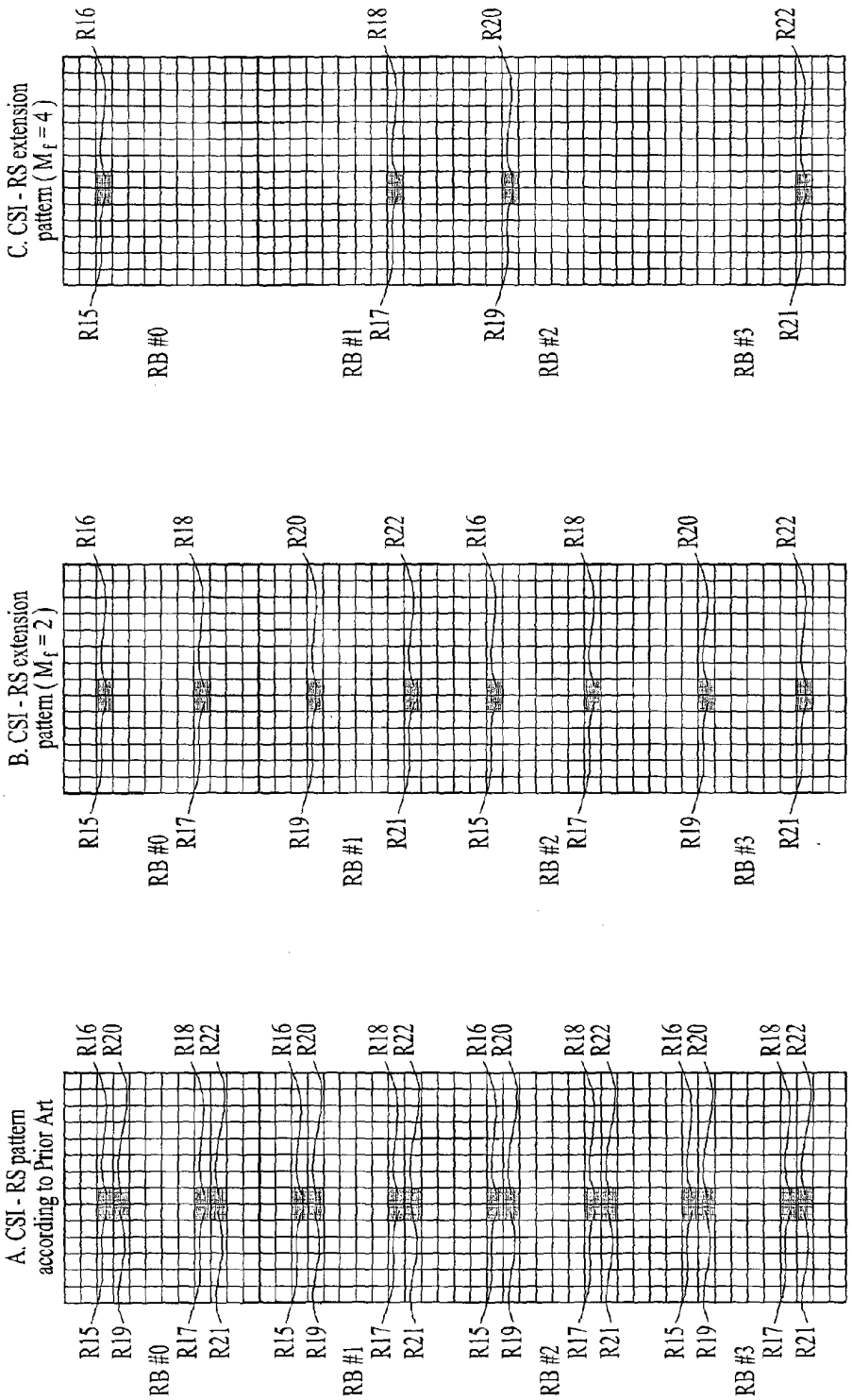
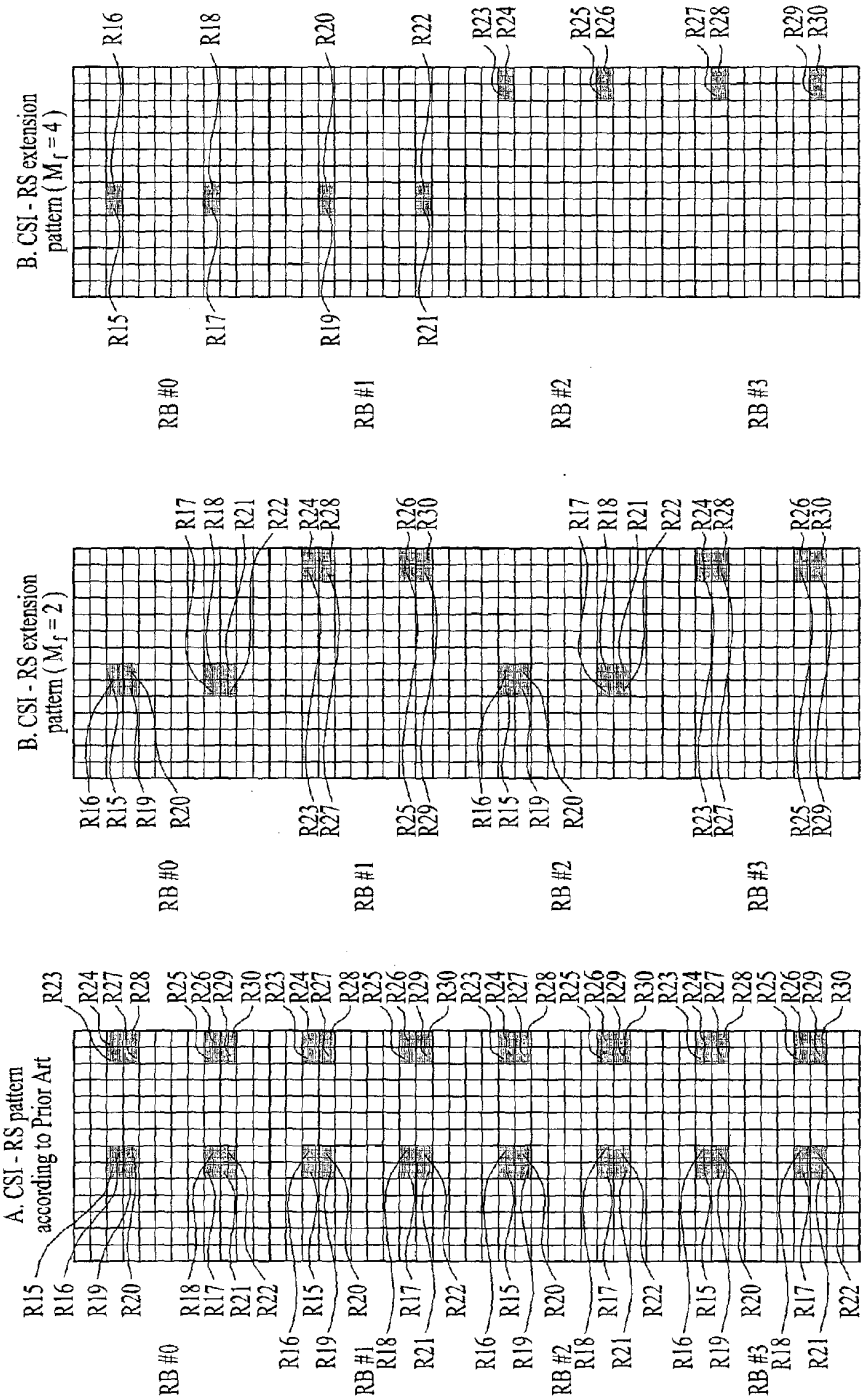
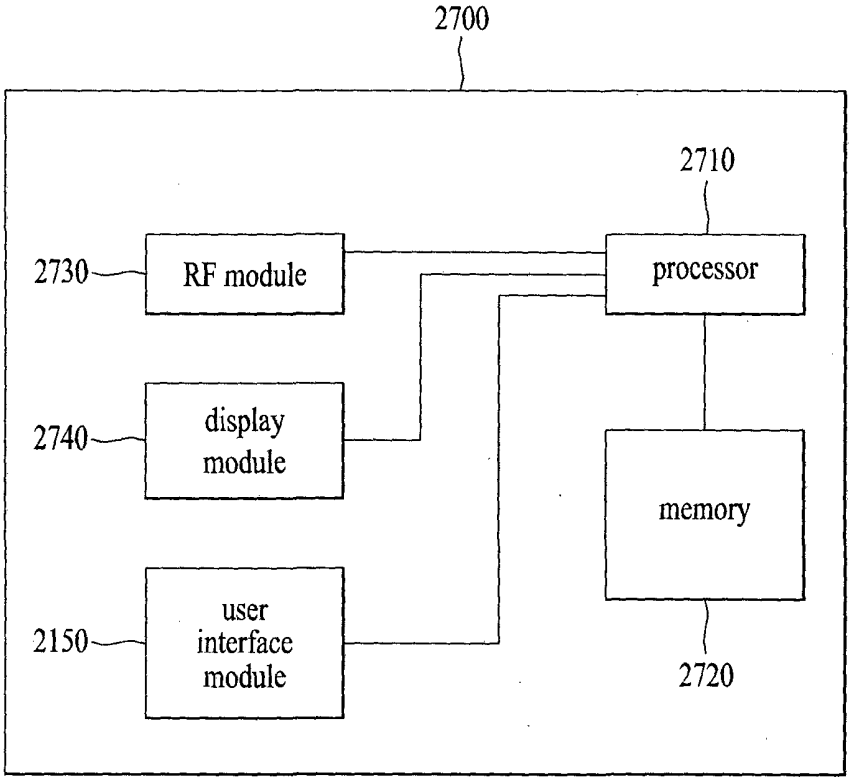

A. CSI - RS pattern according to Prior Art
B. CSI - RS extension pattern ($M_f = 2$)
C. CSI - RS extension pattern ($M_f = 4$)
R15
R16
R17
R18
R19
R20
R21
R22
RB #0
RB #1
RB #2
RB #3
808

FIG. 26


B. CSI - RS extension pattern ($M_T = 4$)
B. CSI - RS extension pattern ($M_T = 2$)
A. CSI - RS pattern according to Prior Art
RB #0
RB #1
RB #2
RB #3

809

FIG. 27


2700
2710
2730
RF module
processor
2740
display module
memory
2150
user interface module
2720

REFERENCE SIGNALS EXTENSION FOR MASSIVE MIMO SYSTEM

TECHNICAL FIELD

[0001] The present invention relates to a wireless communication system, and more particularly, to methods of transmitting reference signals for a massive MIMO system and apparatuses therefor.

BACKGROUND ART

[0002] 3GPP LTE (3rd generation partnership projecting long term evolution) communication system is schematically described for one example of a wireless communication system to which the present invention is applicable.

[0003] FIG. **1** is a schematic diagram of E-UMTS network structure as an example of a wireless communication system.

[0004] E-UMTS (evolved universal mobile telecommunications system) is the system evolved from a conventional UMTS (universal mobile telecommunications system) and its basic standardization is progressing by 3GPP. Generally, E-UMTS can be called LTE (long term evolution) system. For the details of the technical specifications of UMTS and E-UMTS, Release 7 and Release 8 of '3rd Generation Partnership Project: Technical Specification Group Radio Access Network' can be referred to.

[0005] Referring to FIG. **1**, E-UMTS consists of a user equipment (UE) **120**, base stations (eNode B: eNB) **110***a* and **110***b* and an access gateway (AG) provided to an end terminal of a network (E-UTRAN) to be connected to an external network. The base station is able to simultaneously transmit multi-data stream for a broadcast service, a multicast service and/or a unicast service.

[0006] At least one or more cells exist in one base station. The cell is set to one of bandwidths including 1.25 MHz, 2.5 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz and the like and then provides an uplink or downlink transmission service to a plurality of user equipments. Different cells can be set to provide different bandwidths, respectively. A base station controls data transmissions and receptions for a plurality of user equipments. A base station sends downlink scheduling information on downlink (DL) data to inform a corresponding user equipment of time/frequency region for transmitting data to the corresponding user equipment, coding, data size, HARQ (hybrid automatic repeat and request) relevant information and the like. And, the base station sends uplink scheduling information on uplink (UL) data to a corresponding user equipment to inform the corresponding user equipment of time/frequency region available for the corresponding user equipment, coding, data size, HARQ relevant information and the like. An interface for a user traffic transmission or a control traffic transmission is usable between base stations. A core network (CN) can consist of an AG, a network node for user registration of a user equipment and the like. The AG manages mobility of the user equipment by a unit of TA (tracking area) including a plurality of cells.

[0007] The wireless communication technology has been developed up to LTE based on WCDMA but the demands and expectations of users and service providers are continuously rising. Since other radio access technologies keep being developed, new technological evolution is requested to become competitive in the future. For this, reduction of cost per bit, service availability increase, flexible frequency band use, simple-structure and open interface, reasonable power consumption of user equipment and the like are required.

Technical Problem

[0008] Based on the above-mentioned discussion, methods of transmitting reference signals for a massive MIMO system and apparatuses therefor shall be proposed in the following description.

[0009] Technical tasks obtainable from the present invention are non-limited by the above-mentioned technical task. And, other unmentioned technical tasks can be clearly understood from the following description by those having ordinary skill in the technical field to which the present invention pertains.

Technical Solution

[0010] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, a method for a base station having multiple antennas to transmit reference signals to user equipments (UEs), the method comprising: grouping 'M' resource blocks (RBs) into a resource block group, wherein the 'M' is greater than 1, wherein a number of the multiple antennas is greater than 8; grouping one or more antenna ports into one antenna group, wherein each of the antenna ports corresponds to each of the multiple antennas; mapping the reference signals of the one antenna group into only one RB within one resource block group; and transmitting the reference signals to the UEs, is provided.

[0011] In another aspect of the present invention, a method for a user equipment (UE) to receive reference signals from one or more base stations, the method comprising: receiving the reference signals from the base stations, wherein 'M' resource blocks (RBs) are grouped into a resource block group, wherein the is greater than 1, wherein the reference signals are transmitted by 8 or more antennas, wherein one or more antenna ports are grouped into one antenna group, wherein each of the antenna ports corresponds to each of the multiple antennas, wherein the reference signals of the one antenna group are received via only one RB within one resource block group; and estimating channel based on the received reference signals, is provided.

[0012] In another aspect of the present invention, a base station device comprising: multiple antennas to transmit reference signals to user equipments (UEs), wherein a number of the multiple antennas is greater than 8; and a processor connected to the multiple antennas, and adapted to: group 'M' resource blocks (RBs) into a resource block group, wherein the 'M' is greater than 1, group one or more antenna ports into one antenna group, wherein each of the antenna ports corresponds to each of the multiple antennas; map the reference signals of the one antenna group into only one RB within one resource block group, is provided.

[0013] In still another aspect of the present invention, a method for a user equipment (UE) to receive reference signals from one or more base stations, the method comprising: receiving the reference signals from the base stations, wherein 'M' resource blocks (RBs) are grouped into a resource block group, wherein the 'M' is greater than 1, wherein the reference signals are transmitted by 8 or more antennas, wherein one or more antenna ports are grouped into one antenna group, wherein each of the antenna ports corresponds to each of the multiple antennas, wherein the refer-

ence signals of the one antenna group are received via only one RB within one resource block group; and estimating channel based on the received reference signals, is provided.

[0014] The reference signals of different antenna groups may be mapped to different RBs of a same resource block group.

[0015] The 'M' can be based on system information. Or, the 'M' can be determined based on a number of co-located Reference Signal ports.

[0016] Preferably, the reference signals can be CSI-RS reference signals.

[0017] Preferably, a reference signal of an antenna port 'p' among the antenna ports can be mapped to resource block 'r' based on an equation of:

$$r=P \bmod M+nM+o$$

[0018] wherein the 'P' corresponds to a sequence of the antenna port 'p' among the antenna ports transmitting the reference signals, the 'n' corresponds to the number of resource block groups, and the 'o' corresponds to an offset value.

[0019] Here, the offset value can be determined based on a physical cell ID, a CSI-RS ID, a subframe number or an antenna port index.

[0020] Preferably, the base station may transmit signals based on a 3D beam forming scheme using the multiple antennas.

[0021] The above-mentioned general description of the present invention and the following details of the present invention are exemplary and may be provided for the additional description of the invention disclosed in claims.

Advantageous Effects

[0022] Accordingly, the present invention can efficiently reduce RS overhead problem for massive MIMO operation.

[0023] It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

DESCRIPTION OF DRAWINGS

[0024] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

[0025] FIG. **1** is a schematic diagram of E-UMTS network structure as an example of a mobile communication system.

[0026] FIG. **2** is a diagram of structures of control and user planes of a radio interface protocol between a user equipment and E-UTRAN based on 3GPP radio access network specification.

[0027] FIG. **3** is a diagram for explaining physical channels used by 3GPP system and a general signal transmitting method using the same.

[0028] FIG. **4** is a diagram for an example of a structure of a radio frame used by LTE system.

[0029] FIG. **5** is a diagram for one example of a control channel included in a control region of one subframe in a downlink (DL) radio subframe.

[0030] FIG. **6** is a diagram for a configuration of a general multi-antenna (MIMO) communication system.

[0031] FIG. **7** is a diagram to describe an antenna tilting system.

[0032] FIG. **8** is a diagram for one example of comparing an existing antenna system and an active antenna system to each other.

[0033] FIG. **9** is a diagram for one example of forming a UE-specific beam based on an active antenna system.

[0034] FIG. **10** is a diagram of a 2-dimensional (2D) beam transmission scenario based on an active antenna system.

[0035] FIG. **11** shows an alternating RB scheme for RS transmission in a system employing massive MIMO.

[0036] FIG. **12** shows another example of one embodiment of the present invention.

[0037] FIG. **13** is for CRS pattern for one antenna port.

[0038] FIG. **14** is for CRS pattern for two antenna ports.

[0039] FIG. **15** is for CRS pattern for four antenna ports.

[0040] FIG. **16** shows RS pattern for CSI-RS to be used for one embodiment of the present invention.

[0041] FIG. **17** shows an example according to one embodiment of the present invention for alternating RBs for transmitting CSI-RS with subframe configuration.

[0042] FIGS. **18-22** show RS pattern for DM-RS.

[0043] FIG. **23** shows 2 Tx, 4 Tx, 8 Tx CSI-RS pattern for normal CP structure.

[0044] FIG. **24** shows the CSI-RS patterns of one embodiment of the present invention and the prior art where M_f is 2 and the number of antenna is 4.

[0045] FIG. **25** shows the CSI-RS patterns of one embodiment of the present invention and the prior art where M_f is 2 or 4 and the number of antenna is 8.

[0046] FIG. **26** shows the CSI-RS patterns of one embodiment of the present invention and the prior art where M_f is 2 or 4 and the number of antenna is 16.

[0047] FIG. **27** is a block diagram for one example of a communication device according to one embodiment of the present invention.

MODE FOR INVENTION

[0048] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. The embodiments described in the following description include the examples showing that the technical features of the present invention are applied to 3GPP system.

[0049] Although an embodiment of the present invention is exemplarily described in the present specification using the LTE system and the LTE-A system, the embodiment of the present invention is also applicable to any kinds of communication systems corresponding to the above definitions. Although an embodiment of the present invention is exemplarily described with reference to FDD scheme in the present specification, the embodiment of the present invention is easily modifiable and applicable to H-FDD or TDD scheme.

[0050] In the present specification, a name of a base station can be used as an inclusive terminology for RRH (remote control head), eNB, TP (transmission point), RP (repetition point), RN (relay node) or the like.

[0051] FIG. **2** is a diagram of structures of control and user planes of a radio interface protocol between a user equipment and E-UTRAN based on 3GPP radio access network specification. First of all, a control plane means a passage for transmitting control messages used by a user equipment and a network to manage a call. A user plane means a passage for

transmitting such data generated from an application layer as voice data, internet packet data and the like.

[0052] A physical layer, i.e., a first layer, provides an information transfer service to an upper layer using a physical channel. The physical layer is connected to a medium access control layer located above via a transport channel. Data are transferred between the medium access control layer and the physical layer via the transport channel. Data are transferred between a physical layer of a transmitting side and a physical layer of a receiving side via a physical channel. The physical channel uses time and frequency as radio resources. In particular, a physical layer is modulated in downlink by OFDMA (orthogonal frequency division multiple access) scheme and is modulated in uplink by SC-FDMA (single carrier frequency division multiple access) scheme.

[0053] A medium access control (hereinafter abbreviated MAC) layer of a second layer provides a service to a radio link control (hereinafter abbreviated RLC) layer of an upper layer via a logical channel. The RLC layer of the second layer supports reliable data transfer. A function of the RLC layer can be implemented using a function block within the MAC. A packet data convergence protocol (hereinafter abbreviated PDCP) layer of the second layer performs a header compression function for reducing unnecessary control information to transmit such an IP packet as IPv4 and IPv6 in a radio interface having a narrow bandwidth.

[0054] A radio resource control (hereinafter abbreviated RRC) layer located on a lowest level of a third layer is defined in a control plane only. The RRC layer is responsible for controlling logical channel, transport channel and physical channels in association with configuration, reconfiguration and release of radio bearers (RBs). In this case, the RB means a service provided by the second layer for a data transfer between a user equipment and a network. For this, the RRC layer of the user equipment exchanges RRC messages with the RRC layer of the network. In case that an RRC connection is established between an RRC layer of a user equipment and an RRC layer of a network, the user equipment is in a connected mode. Otherwise, the user equipment is in an idle mode. NAS (non-access stratum) layer above an RRC layer performs a function of session management, a function of mobility management and the like.

[0055] A downlink transport channel for transporting data to a user equipment from a network includes a broadcast channel (BCH) for transporting system information, a paging channel (PCH) for transmitting a paging message, a downlink shared channel (SCH) for transmitting a user traffic or a control message or the like. A traffic or control message of a downlink multicast or broadcast service can be transmitted via a downlink SCH or a separate downlink multicast channel (MCH). Meanwhile, an uplink transport channel for transmitting data from a user equipment to a network includes a random access channel for transmitting an initial control message, an uplink shared channel (SCH) for transmitting a user traffic or a control message or the like. A logical channel located above a transport channel to be mapped by a transport channel includes BCCH (Broadcast Control Channel), PCCH (Paging Control Channel), CCCH (Common Control Channel), MCCH (Multicast Control Channel), MTCH (Multicast Traffic Channel) or the like.

[0056] FIG. **3** is a diagram for explaining physical channels used by 3GPP system and a general signal transmitting method using the same.

[0057] Referring to FIG. **3**, if a power of a user equipment is turned on or the user equipment enters a new cell, the user equipment performs an initial cell search for matching synchronization with a base station and the like [S**301**]. For this, the user equipment receives a primary synchronization channel (P-SCH) and a secondary synchronization channel (S-SCH) from the base station, matches synchronization with the base station and then obtains information such as a cell ID and the like. Subsequently, the user equipment receives a physical broadcast channel from the base station and is then able to obtain intra-cell broadcast information. Meanwhile, the user equipment receives a downlink reference signal (DL RS) in the initial cell searching step and is then able to check a downlink channel status.

[0058] Having completed the initial cell search, the user equipment receives a physical downlink control channel (PDCCH) and a physical downlink shared control channel (PDSCH) according to information carried on the physical downlink control channel (PDCCH) and is then able to obtain system information in further detail [S**302**].

[0059] Meanwhile, if the user equipment initially accesses the base station or fails to have a radio resource for signal transmission, the user equipment is able to perform a random access procedure (RACH) on the base station [S**303** to S**306**]. For this, the user equipment transmits a specific sequence as a preamble via a physical random access channel (PRACH) [S**303**, **5305**] and is then able to receive a response message via PDCCH and a corresponding PDSCH in response to the preamble [S**304**, S**306**]. In case of contention based RACH, it is able to perform a contention resolution procedure in addition.

[0060] Having performed the above mentioned procedures, the user equipment is able to perform PDCCH/PDSCH reception [S**307**] and PUSCH/PUCCH (physical uplink shared channel/physical uplink control channel) transmission [S**308**] as a general uplink/downlink signal transmission procedure. In particular, the user equipment receives a downlink control information (DCI) via PDCCH. In this case, the DCI includes such control information as resource allocation information on a user equipment and can differ in format in accordance with the purpose of its use.

[0061] Meanwhile, control information transmitted/received in uplink/downlink to/from the base station by the user equipment includes ACK/NACK signal, CQI (channel quality indicator), PMI (precoding matrix index), RI (rank indicator) and the like. In case of the 3GPP LTE system, the user equipment is able to transmit the above mentioned control information such as CQI, PMI, RI and the like via PUSCH and/or PUCCH.

[0062] FIG. **4** is a diagram for an example of a structure of a radio frame used by LTE system.

[0063] Referring to FIG. **4**, a radio frame has a length of 10 ms (327200×Ts) and is constructed with 10 subframes in equal size. Each of the subframes has a length of 1 ms and is constructed with two slots. Each of the slots has a length of 0.5 ms (15360×Ts). In this case, Ts indicates a sampling time and is expressed as Ts=1/(15 kHz×2048)=3.2552×10−8 (about 33 ns). The slot includes a plurality of OFDM symbols in a time domain and includes a plurality of resource blocks (RB) in a frequency domain. In the LTE system, one resource block includes '12 subcarriers×7 or 6 OFDM symbols'. A transmission time interval (TTI), which is a unit time for transmitting data, can be determined by at least one subframe unit. The above described structure of the radio frame is just

exemplary. And, the number of subframes included in a radio frame, the number of slots included in a subframe and/or the number of OFDM symbols included in a slot can be modified in various ways.

[0064] FIG. **5** is a diagram for one example of a control channel included in a control region of one subframe in a downlink (DL) radio subframe.

[0065] Referring to FIG. **5**, a subframe may include 14 OFDM symbols. First 1 to 3 OFDM symbols may be used as a control region and the rest of 13 to 11 OFDM symbols may be used as a data region, in accordance with subframe configurations. In the drawing, R**1** to R**4** indicate reference signals (RS) for antennas 0 to 3, respectively. The RS may be fixed to a predetermined pattern in a subframe irrespective of the control region or the data region. The control region may be assigned to a resource, to which the RS is not assigned, in the control region. And, a traffic channel may be assigned to a resource, to which the RS is not assigned, in the data region. Control channels assigned to the control region may include PCFICH (Physical Control Format Indicator CHannel), PHICH (Physical Hybrid-ARQ Indicator CHannel), PDCCH (Physical Downlink Control CHannel) and the like.

[0066] The PCFICH is a physical control format indicator channel and informs a user equipment of the number of OFDM symbols used for PDCCH in each subframe. The PCFICH is situated at a first OFDM symbol and is set prior to the PHICH and the PDCCH. The PCFICH is constructed with four resource element groups (REGs). Each of the REGs is distributed within the control region based on a cell ID. One REG is constructed with four Res, not assigned to RS. In this case, the RE indicates a minimum physical resource defined as '1 subcarrier×1 OFDM symbol'. A value of the PCFICH indicates a value of '1~3' or '2~4' and is modulated by QPSK (quadrature phase shift keying).

[0067] The PHICH is a physical HARQ (hybrid-automatic repeat and request) indicator channel and is used in carrying HARQ ACK/NACK for uplink transmission. In particular, the PHICH indicates a channel for carrying DL ACK/NACK information for UL HARQ. The PHICH is constructed with 1 REG and is cell-specifically scrambled. The ACK/NACK is indicated by 1 bit and then modulated by BPSK (binary phase shift keying). The modulated ACK/NACK is spread by 'SF (spreading factor)=2 or 4'. A plurality of PHICHs mapped to the same resource configure a PHICH group. The number of the PHICHs multiplexed into the PHICH group is determined depending on the number of spreading codes. And, the PHICH (group) is repeated three times to obtain a diversity gain in frequency domain and/or time domain.

[0068] The PDCCH is a physical downlink control channel and is assigned to first n OFDM symbols of a subframe. In this case, 'n' is an integer equal to or greater than 1 and is indicated by the PCFICH. The PDCCH informs each user equipment or UE group of resource allocation information on transport channels PCH (paging channel) and DL-SCH (downlink-shared channel), uplink scheduling grant, HARQ information and the like. The PCH (paging channel) and the DL-SCH (downlink-shared channel) are carried on the PDSCH. Therefore, a base station or a user equipment normally transmits or receives data via the PDSCH except specific control information or specific service data.

[0069] Information indicating that data of the PDSCH is transmitted to a prescribed user equipment (or a plurality of user equipments), information indicating how the user equipments receive and decode PDSCH data, and the like are transmitted by being included in the PDCCH. For instance, assume that a specific PDCCH is CRC masked with RNTI (radio network temporary identity) 'A' and that information on data transmitted using a radio resource 'B' (e.g., frequency position) and transmission format information 'C' (e.g., transport block size, modulation scheme, coding information, etc.) is transmitted via a specific subframe. If so, at least one user equipment located in a corresponding cell monitors PDCCH using RNTI information of its own. If there is at least one user equipment having the RNTI 'A', the user equipments receive the PDCCH and then receive PDSCH indicated by 'B' and 'C' through the information of the received PDCCH.

[0070] As explained above, the REs for transmitting RS cannot be used for transmitting control information or data. FIG. **5** is for an example of 4 transmission antenna system. If the number of transmission antennas increase, the RS overhead shall increase. So, one embodiment of the present invention proposes alternating RBs for transmitting RS instead of transmitting RS per every RB. This scheme can efficiently reduce the RS overhead especially in a system employing massive MIMO system. Hereinafter, the massive MIMO system in accordance with one embodiment of the present invention will be explained.

[0071] First of all, MIMO (multi-input multi-output) is a method that uses a plurality of transmitting antennas and a plurality of receiving antennas. And, this method may be able to improve efficiency in transceiving data. In particular, a transmitting or receiving stage of a wireless communication system uses a plurality of antennas to increase capacity or enhance performance. In the following description, the MIMO may be called 'multiple antennas (multi-antenna)'.

[0072] The MIMO technology does not depend on a single antenna path to receive one whole message. Instead, the MIMO technique completes data by putting fragments received via several antennas together. If the MIMO technique is adopted, a data transmission rate within a cell area having a specific size may be improved or a system coverage may be increased by securing a specific data transmission rate. Moreover, this technique may be widely applicable to a mobile communication terminal, a relay and the like. According to the MIMO technique, it may be able to overcome the transmission size limit of the related art mobile communication which used to use a single data.

[0073] FIG. **6** is a diagram for a configuration of a general multi-antenna (MIMO) communication system.

[0074] N_T transmitting antennas are provided to a transmitting stage, while N_R receiving antennas are provided to a receiving stage. In case that each of the transmitting and receiving stages uses a plurality of antennas, theoretical channel transmission capacity is increased more than that of a case that either the transmitting stage or the receiving stage uses a plurality of antennas. The increase of the channel transmission capacity is in proportion to the number of antennas. Hence, a transmission rate is enhanced and frequency efficiency can be raised. Assuming that a maximum transmission rate in case of using a single antenna is set to R_0, the transmission rate in case of using multiple antennas may be theoretically raised by a result from multiplying the maximum transmission rate R_0 by a rate increasing rate R_i, as shown in Equation 1. In this case, R_i is a smaller one of N_T and N_R.

$$R_i=\min(N_T,N_R) \quad \text{[Equation 1]}$$

[0075] For instance, in an MIMO communication system, which uses 4 transmitting antennas and 4 receiving antennas,

it may be able to obtain a transmission rate 4 times higher than that of a single antenna system. After this theoretical capacity increase of the MIMO system has been proved in the middle of 90's, many ongoing efforts are made to various techniques to substantially improve a data transmission rate. And, these techniques are already adopted in part as standards for the 3G mobile communications and various wireless communications such as a next generation wireless LAN and the like.

[0076] The trends for the MIMO relevant studies are explained as follows. First of all, many ongoing efforts are made in various aspects to develop and research information theory study relevant to MIMO communication capacity calculations and the like in various channel configurations and multiple access environments, radio channel measurement and model derivation study for MIMO systems, spatiotemporal signal processing technique study for transmission reliability enhancement and transmission rate improvement and the like.

[0077] In order to explain a communicating method in an MIMO system in detail, mathematical modeling can be represented as follows. Referring to FIG. **6**, assume that N_T transmitting antennas and N_R receiving antennas exist. First of all, regarding a transmission signal, if there are N_T transmitting antennas, N_T maximum transmittable informations exist. Hence, the transmission information may be represented by the vector shown in Equation 2.

$$s=[s_1,s_2,\ldots,s_{N_T}]^T \quad \text{[Equation 2]}$$

[0078] Meanwhile, transmission powers can be set different from each other for transmission informations $s^1, s^2, \ldots, s_{N_T}$, respectively. If the transmission powers are set to $P^1, P^2, \ldots, P_{N_T}$, respectively, the transmission power adjusted transmission information can be represented as Equation 3.

$$\hat{s}=[\hat{s}_1,\hat{s}_2,\ldots,\hat{s}_{N_T}]^T=[P_1s_1,P_2s_2,\ldots,P_{N_T}s_{N_T}]^T \quad \text{[Equation 3]}$$

[0079] And, $\hat{S}$ may be represented as Equation 4 using a diagonal matrix P of the transmission power.

$$\hat{s}=\begin{bmatrix} P_1 & & 0 \\ & P_2 & \\ & \ddots & \\ 0 & & P_{N_T} \end{bmatrix}\begin{bmatrix} s_2 \\ s_2 \\ \vdots \\ s_{N_T} \end{bmatrix}=Ps \quad \text{[Equation 4]}$$

[0080] Let us consider a case of configuring NT transmitted signals $x_1, x_2, \ldots, x_{N_T}$, which are actually transmitted, by applying a weight matrix W to a transmission power adjusted information vector $\hat{S}$. In this case, the weight matrix plays a role in properly distributing each transmission information to each antenna according to a transmission channel status and the like. The transmitted signals are set to $x_1, x_2, \ldots, X_{N_T}$ may be represented as Equation 5 using a vector X. In this case, W_{ij} means a weight between an ith transmitting antenna and a jth information. And, the W may be called a weight matrix or a precoding matrix.

$$x= \quad \text{[Equation 5]}$$

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_i \\ \vdots \\ x_{N_T} \end{bmatrix}=\begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1N_T} \\ w_{21} & w_{22} & \cdots & w_{2N_T} \\ \vdots & & \ddots & \\ w_{i1} & w_{i2} & \cdots & w_{iN_T} \\ \vdots & & \ddots & \\ w_{N_T1} & w_{N_T2} & \cdots & w_{N_TN_T} \end{bmatrix}\begin{bmatrix} \hat{s}_1 \\ \hat{s}_2 \\ \vdots \\ \hat{s}_j \\ \vdots \\ \hat{s}_{N_T} \end{bmatrix}=W\hat{s}=WPs$$

[0081] Generally, a physical meaning of a rank of a channel matrix may indicate a maximum number for carrying different informations on a granted channel. Since a rank of a channel matrix is defined as a minimum number of the numbers of independent rows or columns, a rank of a channel is not greater than the number of rows or columns. For example by equation, a rank of a channel H (i.e., rank (H)) is limited by Equation 6.

$$\text{rank}(H)\leq\min(N_T,N_R) \quad \text{[Equation 6]}$$

[0082] Meanwhile, each different information sent by MIMO technology may be defined as 'transport stream' or 'stream' simply. This 'stream' may be called a layer. If so, the number of transport streams is unable to be greater than a channel rank, which is the maximum number for sending different informations. Hence, the channel matrix H may be represented as Equation 7.

$$\#\text{ of streams}\leq\text{rank}(H)\leq\min(N_T,N_R) \quad \text{[Equation 7]}$$

[0083] In this case, of streams' may indicate the number of streams. Meanwhile, it should be noted that one stream is transmittable via at least one antenna.

[0084] Various methods for making at least one stream correspond to several antennas may exist. These methods may be described in accordance with a type of MIMO technique as follows. First of all, if one stream is transmitted via several antennas, it may be regarded as spatial diversity. If several streams are transmitted via several antennas, it may be regarded as spatial multiplexing. Of course, such an intermediate type between spatial diversity and spatial multiplexing as a hybrid type of spatial diversity and spatial multiplexing may be possible.

[0085] In the following description, an active antenna system (AAS) and a 3-dimensional (3D) beamforming of one embodiment of the present invention are explained.

[0086] First of all, in an existing cellular system, a base station reduces inter-cell interference and enhances throughput (e.g., SINR (signal to interference plus noise ratio)) of user equipments in a cell, using a mechanical tilting or an electrical tilting. This is described in detail with reference to the accompanying drawings as follows.

[0087] FIG. **7** is a diagram to describe an antenna tilting system.

[0088] Particularly, FIG. **7** (*a*) shows an antenna structure to which an antenna tilting is not applied. FIG. **7** (*b*) shows an antenna structure to which a mechanical tilting is applied. And, FIG. **7** (*c*) shows an antenna structure to which both a mechanical tilting and an electrical tilting are applied.

[0089] Comparing FIG. **7** (*a*) and FIG. **7** (*b*) to each other, regarding a mechanical tilting, as shown in FIG. **7** (*b*), it is disadvantageous in that a beam direction is fixed in case of an initial installation. Moreover, regarding an electrical tilting, as shown in FIG. **7** (*c*), despite that a tilting angle is change-

able using an internal phase shift module, it is disadvantageous in that a very restrictive vertical beamforming is available only due to a substantially cell-fixed tilting.

[0090] FIG. **8** is a diagram for one example of comparing an existing antenna system and an active antenna system to each other.

[0091] Particularly, FIG. **8** (*a*) shows an existing antenna system, while FIG. **8** (*b*) shows an active antenna system.

[0092] Referring to FIG. **8**, in an active antenna system, unlike an existing antenna system, each of a plurality of antenna modules includes active devices such as a power amplifier, an RF module and the like. Hence, the active antenna system is capable of controlling/adjusting a power and phase for each of the antenna modules.

[0093] In a generally considered MIMO antenna structure, a linear antenna (i.e., 1-dimensional array antenna) like a ULA (uniform linear array) antenna is taken into consideration. In this 1-dimensional array structure, a beam generable by beamforming exists in a 2-dimensonal plane. This applies to a PAS (passive antenna system) based MIMO structure of an existing base station. Although vertical antennas and horizontal antennas exist in the PAS based base station, since the vertical antennas are combined into one RF module, beamforming in vertical direction is impossible but the above-mentioned mechanical tilting is applicable only.

[0094] Yet, as an antenna structure of a base station evolves into AAS, an independent RF module is implemented for each antenna in a vertical direction, whereby a beamforming in a vertical direction is possible as well as in a horizontal direction. Such a beamforming is called an elevation beamforming.

[0095] According to the elevation beamforming, generable beams can be represented in a 3-dimensional space in vertical and horizontal directions. Hence, such a beamforming can be named a 3-dimensional (3D) beamforming. In particular, the 3D beamforming is possible because the 1D array antenna structure is evolved into a 2D array antenna structure in a plane shape. In this case, the 3D beamforming is possible in a 3D array structure of a ring shape as well as in a planar-shaped antenna array structure. The 3D beamforming is characterized in that an MIMO process is performed in a 3D space owing to antenna deployments of various types instead of an existing 1D array antenna structure.

[0096] FIG. **9** is a diagram for one example of forming a UE-specific beam based on an active antenna system.

[0097] Referring to FIG. **9**, owing to the 3D beamforming, a beamforming is possible in case that a user equipment moves back and forth as well as in case that the user equipment moves right and left to the base station. Hence, it can be observed that a higher degree of freedom is provided to a UE-specific beamforming.

[0098] Moreover, as a transmission environment using an active antenna based 2D array antenna structure, an environment (**021**: outdoor to indoor) of a transmission from an outdoor base station to an indoor user equipment, an environment (indoor hotspot) of a transmission from an indoor base station to an indoor user equipment or the like can be considered as well as an environment of a transmission from an outdoor base station to an outdoor user equipment.

[0099] FIG. **10** is a diagram of a 2-dimensional (2D) beam transmission scenario based on an active antenna system.

[0100] Referring to FIG. **10**, assuming a real cell environment in which a plurality of various buildings exist within a cell, a base station needs to consider a vertical beam steering capability in consideration of various user equipment heights in accordance with a building height as well as a UE-specific horizontal beam steering capability. Considering such a cell environment, it is necessary to reflect channel characteristics (e.g., radio shadow/path loss variation due to a height difference, fading characteristic change, etc.) considerably different from an existing radio channel environment.

[0101] So to speak, a 3D beamforming, which is evolved from a horizontal beamforming performed in a horizontal direction only based on an antenna structure of an existing linear 1D array, indicates an MIMO processing scheme performed in a manner of being extended to and combined with an elevation beamforming or a vertical beamforming based on an antenna structure of multi-dimensional arrays including a planar array and the like.

[0102] In addition to or instead of the above mentioned Adaptive antenna system and 3D beam forming scheme, one embodiment of the present invention proposes using massive MIMO system.

[0103] In the LTE system, the maximum number of antennas for downlink transmission is 4. In the LTE-Advanced system, the maximum number of antennas for downlink transmission is 8 and the maximum number of antennas for uplink transmission is 4. But, demand for high speed transmission leads to the concept of massive MIMO system.

[0104] Based on this, the concept of massive MIMO system of the present application will be explained.

[0105] Recently, the massive MIMO scheme got lots of attention as a candidate constituent technology for 5G mobile communication system. This massive MIMO scheme can be employed to the system including a base station having multiple antennas and UEs having one antenna. Even though each UE has only one antenna, the entire system can be viewed as MIMO system when multiple UEs served by the base station having multiple antennas. If we assume that the number of UEs is K, the gradation of capacity in high SNR may be expressed as $\min(N_t, K)$.

[0106] The number of antennas for the base station can be unlimited. But, practically, we can suppose that the number of antennas of a base station exceed a certain threshold number, in order to distinguish the massive MIMO scheme from the conventional MIMO scheme. This threshold value can be 4 or 8, for example, but we suppose the case when the number of antenna for one base station is much more than this exemplary threshold number.

[0107] Theoretically, when the number of antennas for one base station goes to infinite, the optimal transmission algorism of the base station may be MRT (maximal ration transmission), and optimal reception algorithm may be MRC (maximal ration combining). These MRT and MRC are simple, but the performance of these schemes is limited when the conventional MIMO scheme is used, because these schemes do not consider the interference. However, when the number of antennas for one base station goes to infinite, the above drawback is addressed. Also, if the number of antennas increases, the beam from one antenna can be sharp, so the signal from that antenna can be carried to the received without giving interference to other receivers.

[0108] When the above explained massive MIMO scheme is used, the number of antennas dramatically increases, so RS overhead shall be serious problem. And, when 3D beamforming or massive MIMO is employed, the RRH may use tens or hundreds of antennas for transmission. CSI-RS ports for sup-

porting these shall be increased. To address this issue, the following solutions can be used.

1. Multiple CSI-RS Resources

[0109] The base station may group the multiple antenna into sub-array, and allocate one CSI-RS for one sub array

2. Increase Maximum Number of CSI-RS Ports within a CSI-RS Resource

[0110] Increasing the maximum number of CSI-RS ports in a single CSI-RS pattern CSI-RS ports can be newly defined from port #23

3. Defining New RS

[0111] New channel estimation RS can be newly defined

[0112] The above solutions can be employed together. The present invention proposes alternating RB scheme to efficiently reduce RS overhead and reuse the RS pattern of conventional technology.

[0113] FIG. **11** shows an alternating RB scheme for RS transmission in a system employing massive MIMO.

[0114] According to the one embodiment of the present invention, when the base station uses the above explained massive MIMO system, 'M' RBs are grouped into a RB group (M>1). 'M' can be determined based on system information. In the example of FIG. **11**, 'M' corresponds to 2. So, RB 1 and RB 2 are grouped into RBG 1, and RB 3 and RB 4 are grouped into RGB 2, and so on.

[0115] To distinguish the massive MIMO system over the conventional MIMO system, we may suppose the number of antennas is greater than 8, but practically, the number of antennas shall be much more than 8. Further, one or more antenna ports are grouped into an antenna group. In FIG. **11**, antenna ports 15 and 16 are grouped into one antenna group. Different antenna ports may be grouped into different antenna group.

[0116] According to this embodiment, the base station may map the reference signals of the one antenna group into only one RB within one resource block group. Conventionally, RSs of each antenna are mapped to every RB based on the predetermined RS pattern. But, in order to reduce the RS overhead, the present embodiment proposes to map the RSs of one antenna group into only one RB within one RBG. In FIG. **11**, the RBs of antenna ports 15 and 16 are mapped only to RB 1 within RBG 1 and RB 3 within RBG 2, and so on.

[0117] FIG. **12** shows another example of one embodiment of the present invention.

[0118] As stated above, according to the one embodiment of the present invention, when the base station uses the above explained massive MIMO system, 'M' RBs are grouped into a RB group (M>1). And, one or more antenna ports are grouped into an antenna group. In FIG. **12**, antenna ports 15 and 16 are grouped into one antenna group (antenna group 1). And, antenna ports 17 and 18 are grouped into another antenna group (antenna group 2). Different antenna ports may be grouped into different antenna group.

[0119] According to the present embodiment, the base station may map the RSs of different antenna groups to different RBs of the same RBG. For each antenna group, the base station maps the reference signals of the one antenna group into only one RB within one resource block group. In FIG. **12**, RSs of antenna group 1 are mapped only to RB 1 and RB 3, and RSs of antenna group 2 are mapped only to RB 2 and RB 4.

[0120] Based on these schemes, the RS overhead can be efficiently reduced.

[0121] As stated above, when the number of antennas increase, the RS overhead problem become more serious. Furthermore, there are various kinds of RSs in addition to the RS explained in FIG. **5**. Hereinafter, downlink reference signals in the LTE system will be explained.

[0122] First of all, a reference signal already known to both a transmitting side and a receiving side is generally transmitted for channel measurement to the receiving side from the transmitting side together with data. This reference signal is provided for the channel measurement and also indicates a modulation scheme to play a role in enabling a demodulation process. Reference signals can be categorized into a dedicated reference signal (DRS) for a specific user equipment (UE) and a dedicated reference signal for a base station, i.e., a UE-specific reference signal and a common reference signal (common RS or CRS (cell-specific RS) that is a cell-specific reference signal for all user equipments within a cell. Moreover, the cell-specific reference signal includes a reference signal for measuring and reporting CQI/PMI/RI to a base station from a user equipment. And, such a reference signal is called CSI-RS (channel state information-RS).

[0123] To sum, in the LTE system, the following downlink RSs are used.

(1) Cell Specific RS: RSs for Channel Estimation

[0124] Cell specific RS (CRS) may be used for CSI measurement/reporting purpose. As the short term measurement, these RSs are used for link adaptation, rank adaptation, closed loop MIMO precoding. As long term measurement, these RSs are used for handover, cell selection/reselection etc.

(2) Demodulation RS: RSs for Receiving Downlink Physical Channel.

(3) Positioning RS: RSs for Estimating the Location of the UE.

(4) MBSFN RS: RSs for Multicase/Broadcast Service.

[0125] In the LTE system, the RSs for channel measurement is CRS. But, in LTE-A system, to reduce RS overhead, a separate CSI-RS is defined for CSI measurement purpose, and UE-specific RS is used for PDSCH reception. CSI-RS may be characterized for CSI measurement and feedback. It is transmitted with lower density comparing to the CRS. CRS can supports upto 4 antennas, but CSI-RS supports upto 8 antennas,

[0126] UE-specific RS is designed for demodulating data channel and it is transmitted after MIMO precoding is performed as data. So, UE-specific RS needs not to be transmitted via every antenna contrary to CRS, but it is enough to be transmitted via antennas transmitting data. It may correspond to the number of layers simultaneously transmitted.

[0127] Hereinafter, each of the downlink RSs is explained in detail.

[0128] FIGS. **13** to **15** are RS pattern for transmitting CRS. Specifically, FIG. **13** is for CRS pattern for one antenna port, FIG. **14** is for CRS pattern for two antenna ports, and FIG. **15** is for CRS pattern for four antenna ports.

[0129] CRSs are transmitted in very subframe where PDSCH is transmitted. And, CRSs are transmitted via antenna ports 0~3, and they supports only Δf=15 kHz. Pseudo-random sequence $r_{l,n_s}(m)$ with seed value based on

cell ID is modulated to produce complex-symbols of $a_{k,l}^{(p)}$, and they are used for these RSs. Here, 'p' represent antenna port, n_s represents slot number, 'l' represents OFDM symbol index, and 'k' represents subframe index.

[0130] The position of each complex symbol is determined based on the following equations.

$$l = \begin{cases} 0, N_{symb}^{DL} - 3 & \text{if } p \in \{0, 1\} \\ 1 & \text{if } p \in \{2, 3\} \end{cases} \quad \text{[Equation 8]}$$

$$k = 6m + (v + v_{shift}) \bmod 6,\ v_{shift} = N_{ID}^{cell} \bmod 6 \quad \text{[Equation 9]}$$

[0131] That is, 'l' is determined based on an antenna port and 'k' is differently determined based on the cell ID. FIGS. **13-15** shows the RS pattern according to the above equations.

[0132] As shown in FIGS. **14** and **15** if a specific RE is taken by one antenna port, it cannot be used by another antenna port. Also, within a MBSFN subframe, CRSs are mapped only to the non-MBSFN region.

[0133] The above explained embodiment of the present invention can be applied to extend the above CRSs over 8 Tx system. However, the preferred embodiment of the present invention proposes to apply the above mentioned embodiment to CSI-RS to effectively reduce the RS overhead in the massive MIMO system.

[0134] CSI-RS supports 1, 2, 4 and 8 antenna ports using p=15~22. In the LTE-A system, it only supports Δf=15 kHz, but the present invention may not be limited to such.

[0135] FIG. **16** shows RS pattern for CSI-RS to be used for one embodiment of the present invention.

[0136] Pseudo-random sequence $r_{l,n_s}(m)$ with seed value of Cell ID N_{ID}^{cell} or CSI-RS ID N_{ID}^{CSI} can be modulated into complex value symbols of $a_{k,l}^{(p)}$. Here, 'p' represent antenna port, n_s represents slot number, 'l' represents OFDM symbol index, and 'k' represents subframe index. The positions of CSI-RSs can be determined based on the following equations.

$$k = k' + 12m + \begin{cases} -0 & \text{for } p \in \{15, 16\}, \text{ normal cyclic prefix} \\ -6 & \text{for } p \in \{17, 18\}, \text{ normal cyclic prefix} \\ -1 & \text{for } p \in \{19, 20\}, \text{ normal cyclic prefix} \\ -7 & \text{for } p \in \{21, 22\}, \text{ normal cyclic prefix} \end{cases} \quad \text{[Equation 10]}$$

$$l = l' + \begin{cases} l'' & \text{CSI reference signal configurations 0-19, normal cyclic prefix} \\ 2l'' & \text{CSI reference signal configurations 20-31, normal cyclic prefix} \end{cases} \quad \text{[Equation 11]}$$

[0137] That is, 'k' can be determined based on antenna ports, and 'l' can be determined based on the configuration as shown in the following table.

TABLE 1

		Number of CSI reference signals configured					
	CSI reference signal	1 or 2		4		8	
	configuration	(k', l')	n_s mod 2	(k', l')	n_s mod 2	(k', l')	n_s mod 2
Frame structure type 1 and 2	0	(9, 5)	0	(9, 5)	0	(9, 5)	0
	1	(11, 2)	1	(11, 2)	1	(11, 2)	1
	2	(9, 2)	1	(9, 2)	1	(9, 2)	1
	3	(7, 2)	1	(7, 2)	1	(7, 2)	1
	4	(9, 5)	1	(9, 5)	1	(9, 5)	1
	5	(8, 5)	0	(8, 5)	0		
	6	(10, 2)	1	(10, 2)	1		
	7	(8, 2)	1	(8, 2)	1		
	8	(6, 2)	1	(6, 2)	1		
	9	(8, 5)	1	(8, 5)	1		
	10	(3, 5)	0				
	11	(2, 5)	0				
	12	(5, 2)	1				
	13	(4, 2)	1				
	14	(3, 2)	1				
	15	(2, 2)	1				
	16	(1, 2)	1				
	17	(0, 2)	1				
	18	(3, 5)	1				
	19	(2, 5)	1				
Frame structure type 2 only	20	(11, 1)	1	(11, 1)	1	(11, 1)	1
	21	(9, 1)	1	(9, 1)	1	(9, 1)	1
	22	(7, 1)	1	(7, 1)	1	(7, 1)	1
	23	(10, 1)	1	(10, 1)	1		
	24	(8, 1)	1	(8, 1)	1		
	25	(6, 1)	1	(6, 1)	1		
	26	(5, 1)	1				
	27	(4, 1)	1				
	28	(3, 1)	1				
	29	(2, 1)	1				
	30	(1, 1)	1				
	31	(0, 1)	1				

[0138] FIG. **16** shows a resultant CSI-RS pattern. As shown in FIG. **16**, CSI-RS has low density comparing to the above explained CRS.

[0139] Within one cell, various CSI-RS configurations can be used. NZP (non-zero power) CSI-RS can use 0 or 1 configuration, and ZP (zero-power) CSI-RS can use 0 or multiple configurations. Various configuration can be set by setting 1 to each bit of 16 bit map representing 16 configurations for 4 ports for ZP CSI-RS in table 1. This bitmap can be indicated by the supper layer signal, ZeroPowerCSI-RS. But, Res set as Non-zero power CSI-RS shall be excluded from the above. In this signaling, MSB (most significant bit) corresponds to the lowest CSI-RS configuration index, and the correspondence increase according to the configuration index.

[0140] In this embodiment, CSI-RS is not transmitted on the following subframes.

[0141] In the special subframe in Frame Structure type 2.

[0142] In the subframe where CSI-RS collides with synchronization signals, PBCH, SystemInformationBlockType1 messages.

[0143] In the subframe where paging message is transmitted.

[0144] In the set S where S={15}, S={15,16}, S={17,18}, S={19,20} or s={21,22}, the RE transmitting CSI-RS of one antenna port cannot be used for transmitting PDSCH or CSI-RS of another antenna port.

[0145] CSI-RS can be transmitted with periodicity. The subframe configuration of the CSI-RS, $I_{CSI\text{-}RS}$, can be set by upper layer signaling as shown in the following table 2.

TABLE 2

CSI-RS-SubframeConfig $I_{CSI\text{-}RS}$	CSI-RS periodicity $T_{CSI\text{-}RS}$ (subframes)	CSI-RS subframe offset $\Delta_{CSI\text{-}RS}$ (subframes)
0-4	5	$I_{CSI\text{-}RS}$
5-14	10	$I_{CSI\text{-}RS} - 5$
15-34	20	$I_{CSI\text{-}RS} - 15$
35-74	40	$I_{CSI\text{-}RS} - 35$
75-154	80	$I_{CSI\text{-}RS} - 75$

[0146] The above explained alternating RB scheme for massive MIMO system can be implemented together with the above subframe configuration of CSI-RS.

[0147] FIG. **17** shows an example according to one embodiment of the present invention for alternating RBs for transmitting CSI-RS with subframe configuration.

[0148] In this example, suppose that the number of RB groups (M) corresponds to 2. And, antenna ports 15 and 16 are grouped into antenna group 1 and antenna ports 17 and 18 are grouped into antenna group 2. Further, suppose that the above explained subframe configuration, $I_{CSI\text{-}RS}$, for CSI-RS corresponds to 3.

[0149] According to the table 2, CSI-RS periodicity shall be 5 and CSI-RS offset shall be 3. So, based on this configuration the base station may start to transmit CSI-RSs at subframes 4, 9, 13, ... But, according to the above explained alternating RB scheme, the base station may map the CSI-RSs of antenna ports 15 and 16 only to RB 4, 9, 13, . . . and CSI-RSs of antenna ports 17 and 18 only to RB 5, 10, 15, ...

[0150] Hereinafter, CSI-RS configuration IE according to one embodiment of the present invention will be explained.

[0151] The upper layer signaling for CSI-RS configuration shall be expressed as following table.

TABLE 3

CSI-RS-Config information elements

```
-- ASN1START
CSI-RS-Config-r10 ::=              SEQUENCE {
        csi-RS-r10                     CHOICE {
            release                            NULL,
            setup                          SEQUENCE {
                antennaPortsCount-r10          ENUMERATED {an1, an2, an4, an8},
                resourceConfig-r10             INTEGER (0..31),
                subframeConfig-r10             INTEGER (0..154),
                p-C-r10                        INTEGER (-8..15)
            }
    }                                                  OPTIONAL,          -- Need ON
    zeroTxPowerCSI-RS-r10          CHOICE {
            release                            NULL,
            setup                          SEQUENCE {
                zeroTxPowerResourceConfigList-r10 BIT STRING (SIZE (16)),
                zeroTxPowerSubframeConfig-r10     INTEGER (0..154)
            }
    }                                                  OPTIONAL           -- Need ON
}
-- ASN1STOP
```

TABLE 3-continued

CSI-RS-Config information elements
CSI-RS-Config field descriptions
antennaPortsCount
Parameter represents the number of antenna ports used for transmission of CSI reference signals where an1 corresponds to 1, an 2 to 2 antenna ports etc. p-C
Parameter: P_c. resourceConfig
Parameter: CSI reference signal configuration. subframeConfig
Parameter: $I_{CSI\text{-}RS}$. zeroTxPowerResourceConfigList
Parameter: ZeroPowerCSI-RS. zeroTxPowerSubframeConfig
Parameter: $I_{CSI\text{-}RS}$.

[0152] The CSI-RS-Config information elements according to one embodiment of the present invention may further comprises information on 'M' and/or antenna grouping information.

[0153] Hereinafter, DM-RS (UE-specific RS) will be explained in detail.

[0154] For antenna port 5, the UE-specific reference-signal sequence $r_{n_s}(m)$ is defined by:

$$r_{n_s}(m) = \frac{1}{\sqrt{2}}(1-2\cdot c(2m)) + j\frac{1}{\sqrt{2}}(1-2\cdot c(2m+1)), \quad m = 0, 1, \ldots, 12N_{RB}^{PDSCH}-1 \qquad \text{[Equation 12]}$$

[0155] where N_{RB}^{PDSCH} denotes the bandwidth in resource blocks of the corresponding PDSCH transmission. The pseudo-random sequence c(i) shall be initialised with $c_{init}=(\lfloor n_s/2\rfloor+1)\cdot(2N_{ID}^{cell}+1)\cdot 2^{16}+n_{RNTI}$ at the start of each subframe where n_{RNTI} is the value of RNTI.

[0156] For any of the antenna ports $p\in\{7, 8, \ldots, \upsilon+6\}$, the reference-signal sequence r(m) is defined by:

$$r(m) = \frac{1}{\sqrt{2}}(1-2\cdot c(2m)) + j\frac{1}{\sqrt{2}}(1-2\cdot c(2m+1)), \quad m = \begin{cases} 0, 1, \ldots, 12N_{RB}^{max,DL}-1 & \text{normal cyclic prefix} \\ 0, 1, \ldots, 16N_{RB}^{max,DL}-1 & \text{extended cyclic prefix} \end{cases} \qquad \text{[Equation 13]}$$

[0157] The pseudo-random sequence c(i) shall be initialised with $c_{init}=(\lfloor n_s/2\rfloor)\cdot(2N_{ID}^{cell}+1)\cdot 2^{16}+n_{SCID}$ at the start of each subframe, where for antenna ports 7 and 8 n_{SCID} is given by the scrambling identity field according to the following table 4 in the most recent DCI format 2B or 2C associated with the PDSCH transmission. If there is no DCI format 2B or 2C associated with the PDSCH transmission on antenna ports 7 or 8, the UE shall assume that n_{SCID} is zero. For antenna ports 9 to 14, the UE shall assume that n_{SCID} is zero.

TABLE 4

Scrambling identity field in DCI format 2B or 2C [3]	n_{SCID}
0	0
1	1

[0158] UE-specific reference signals are supported for transmission of PDSCH and are transmitted on antenna port (s) p=5, p=7, p=8 or p=7, 8, . . . , υ+6, where υ is the number of layers used for transmission of the PDSCH. UE-specific reference signals are transmitted to one UE on any of the antenna ports in the set S, where S={7,8,11,13} or S={9,10, 12,14}.

[0159] FIGS. **18-22** show RS pattern for DM-RS.

[0160] For antenna ports p=7, p=8 or p=7, 8, . . . , v+6, in a physical resource block with frequency-domain index n_{PRB} assigned for the corresponding PDSCH transmission, a part of the reference signal sequence r (m) shall be mapped to complex-valued modulation symbols $a_{k,l}^{(p)}$ in a subframe according to:

For Normal cyclic prefix [Equation 14]

$$a_{k,l}^{(p)} = w_p(l')\cdot r(3\cdot l'\cdot N_{RB}^{max,DL}+3\cdot n_{PRB}+m')$$

where

$$w_p(i) = \begin{cases} \overline{w}_p(i) & (m'+n_{PRB})\bmod 2 = 0 \\ \overline{w}_p(3-i) & (m'+n_{PRB})\bmod 2 = 1 \end{cases}$$

$$k = 5m' + N_{sc}^{RB}n_{PRB} + k'$$

$$k' = \begin{cases} 1 & p\in\{7, 8, 11, 13\} \\ 0 & p\in\{9, 10, 12, 14\} \end{cases}$$

-continued

$$l = \begin{cases} l' \bmod 2 + 2 & \text{if in a } \textit{specialsubframe} \text{ with configuration 3, 4, or 8} \\ l' \bmod 2 + 2 + 3\lfloor l'/2 \rfloor & \text{if in a } \textit{specialsubframe} \text{ with configuration 1, 2, 6, or 7} \\ l' \bmod 2 + 5 & \text{if not in a } \textit{specialsubframe} \end{cases}$$

$$l' = \begin{cases} 0, 1, 2, 3 & \text{if } n_s \bmod 2 = 0 \text{ and in a } \textit{specialsubframe} \text{ with configuration 1, 2, 6, or 7} \\ 0, 1 & \text{if } n_s \bmod 2 = 0 \text{ and not in } \textit{specialsubframe} \text{ with configuration 1, 2, 6, or 7} \\ 2, 3 & \text{if } n_s \bmod 2 = 1 \text{ and not in } \textit{specialsubframe} \text{ with configuration 1, 2, 6, or 7} \end{cases}$$

$m' = 0, 1, 2$

[0161] The sequence $\overline{w}_p(i)$ can be given by following table 5.

TABLE 5

The sequence $\overline{w}_p(i)$ for normal cyclic prefix.

Antenna port p	$[\overline{w}_p(0)\ \overline{w}_p(1)\ \overline{w}_p(2)\ \overline{w}_p(3)]$
7	[+1 +1 +1 +1]
8	[+1 −1 +1 −1]
9	[+1 +1 +1 +1]
10	[+1 −1 +1 −1]
11	[+1 +1 −1 −1]
12	[−1 −1 +1 +1]
13	[+1 −1 −1 +1]
14	[−1 +1 +1 −1]

[0162] The above explained RB alternating can be applied to DM-RS. But, the explanation below shall be focused on extension of CSI-RS for massive MIMO system.

[0163] CSI-RS in the LTE system is designed for the following purposes:

1. Feedback by estimating CSI (e.g. PMI, CQI, RI) by the UE from NZP CSI-RS resources

2. Reduce interference from physical channel by setting the resource of NZP CSI-RS of the interfering Node (e.g. transmission point, cell, etc) as ZP CSI-RS to the UE suffering the interference.

3. Estimating by the UE the amount of interference from IM (interference measurement) resource consisting of ZP CSI-RS resource for CQI calculation

[0164] In addition to the above purposes, CSI-RS can be used for defining RSRP(RS received power)/RSRQ (RS received quality) to be used for cell selection/reselection or handover.

[0165] Conventional CSI-RS is mapped to one RE per every RB in the entire system bandwidth. When two or more CSI-RS ports are simultaneously transmitted, two ports are paired and mapped to adjacent OFDM symbols. These two ports are Code Divisional Multiplexed (CDMed). The above ports 15 and 16, 17 and 18, 19 and 20 and 21 and 22 are these examples.

[0166] FIG. **23** shows 2 Tx, 4 Tx, 8 Tx CSI-RS pattern for normal CP structure.

[0167] In FIG. **23**, 0, 1 . . . , 7 corresponds to ports 15, 16, . . . , 22. And, antenna ports adjacent to each other in the time axis are Code Divisional Multiplexed.

[0168] As explained above, CSI-RS pattern is determined based on CSI-RS configuration number. CSI-RS is transmitted one per every 5~80 subframes based on the subframe configuration. That is, period and offset are determined based on CSI-RS subframe configuration number.

[0169] Based on this, one embodiment of the present invention proposes defining new RS resources by dividing the frequency bands by M_f RBs contrary to the conventional technology where CSI-RS is transmitted every RB. Here, the RE position for CSI-RS is not limited to a specific pattern within the subframe where CSI-RS is transmitted.

[0170] The present embodiment is characterized in that the density of CSI-RS in the frequency domain is lower than the conventional art. Specifically, every CSI-RS ports transmit CSI-RS in the prior art, but the present embodiment uses different RBs for different CSI-RS ports. As shown in FIG. **12**, CSI-RSs for antenna ports 15 and 16 are transmitted at RB 1 and RB 3 while CSI-RSs for antenna ports 17 and 18 are transmitted at RB 2 and RB 4. It is different from the prior art where CSI-RSs for antenna ports 15, 16, 17 and 18 are transmitted at every RB.

[0171] It should be noted that M_f shall be more than 1 to reduce the RS overhead in the frequency domain.

[0172] FIG. **24** shows the CSI-RS patterns of one embodiment of the present invention and the prior art where M_f is 2 and the number of antenna is 4. FIG. **25** shows the CSI-RS patterns of one embodiment of the present invention and the prior art where M_f is 2 or 4 and the number of antenna is 8. FIG. **26** shows the CSI-RS patterns of one embodiment of the present invention and the prior art where M_f is 2 or 4 and the number of antenna is 16.

[0173] As can be seen from these figures, the present invention can efficiently reduce the RS overhead caused by the increase of the transmission antennas.

[0174] Meanwhile, it is expected that LTE-A system, which is the standard of a next generation mobile communication system, will support CoMP (coordinated multi point) transmission scheme unsupported by the previous standard in order to enhance a data transmission rate. In this case, the CoMP transmission scheme means a transmission scheme for enabling at least two base stations or cells to coordinately communicate with a user equipment to enhance communication performance between a base station (cell or sector) and a user equipment located in a radio shadow area.

[0175] The CoMP transmission scheme may be categorized into CoMP-JP (CoMP-Joint Processing) of a coordinated MIMO type through data sharing and CoMP-CS/CB (CoMP Coordinated Scheduling/Coordinated Beamforming).

[0176] In CoMP-JP for a case of a downlink, a user equipment can receive data from base stations, each of which performs the CoMP transmission, simultaneously and instantly and is then able to enhance reception performance by combining the signals received from the base stations together [Joint Transmission (JT)]. And, it is able to consider a method for one of the base stations, each of which performs the CoMP transmission, to transmit data to the user equipment at a specific timing point [Dynamic Pont Selection (DPS)].

[0177] On the other hand, in CoMP-CS/CB (CoMP Coordinated Scheduling/Coordinated Beamforming), a user

equipment can instantly receive data from a single base station, and more particularly, from a serving base station by beamforming.

[0178] In CoMP-JP (CoMP-Joint Processing) for a case of an uplink, each base station can receive a PUSCH signal from a user equipment simultaneously [Joint Reception (JR)]. On the other hand, in CoMP-CS/CB (CoMP Coordinated Scheduling/Coordinated Beamforming), a single base station receives PUSCH only. In doing so, determination for using the CoMP-CS/CB (CoMP Coordinated Scheduling/Coordinated Beamforming) is made by coordinated cells (or base stations).

[0179] CS/CB scheme may include SSPS scheme.

[0180] Semi-static point selection (SSPS): Transmission to a specific UE from one point at a time. The transmitting point may only change in a semi-static manner

[0181] On the other hand, Dynamic point selection (DPS)/muting scheme can be employed. In this scheme, data transmission is from one point (within the CoMP cooperating set) in a time-frequency resource. The transmitting/muting point may change from one subframe to another including varying over the RB pairs within a subframe. Data is available simultaneously at multiple points. This may include Dynamic cell selection (DCS).

[0182] Further, the following terminologies are defined for CoMP operation.

CoMP Cooperating Set

[0183] Set of (geographically separated) points directly and/or indirectly participating in data transmission to a UE in a time-frequency resource.

[0184] Direct participation: point(s) actually transmitting data

[0185] Indirect participation: candidate point(s) for data transmission that do not transmit data but contribute in making decisions on the user scheduling/beamforming

CoMP Transmission Point(s): Point or Set of Points Transmitting Data to a UE

[0186] CoMP transmission point(s) is (are) a subset of the CoMP cooperating set

[0187] For JT, CoMP transmission points may include multiple points in the CoMP cooperating set

[0188] For CS/CB, DPS, a single point in the CoMP cooperating set is the CoMP transmission point

[0189] CoMP Measurement Set:

[0190] set of points about which channel state information related to their link to the UE is measured and/or reported.

[0191] In LTE-A system (rel-10), the concept of Quasi Co-Location (QCL) is introduced for supporting the above mentioned CoMP transmission. In one embodiment of the present invention, the number of RB groups (M) is determined based on the number of co-located RS ports.

[0192] Definition of antenna ports quasi co-location (QCL) is defined as following:

[0193] Two antenna ports are said to be quasi co-located if the large-scale properties of the channel over which a symbol on one antenna port is conveyed can be inferred from the channel over which a symbol on the other antenna port is conveyed. The large-scale properties include one or more of delay spread, Doppler spread, Doppler shift, average gain, and average delay.

[0194] Based on this, antenna ports quasi co-location for PDSCH is like the following:

[0195] A UE configured in transmission mode 1-10 may assume the antenna ports 0-3 (CRS ports) of a serving cell are quasi co-located with respect to delay spread, Doppler spread, Doppler shift, average gain, and average delay.

[0196] A UE configured in transmission mode 8-10 may assume the antenna ports 7-14 (DM-RS ports) of a serving cell are quasi co-located for a given subframe with respect to delay spread, Doppler spread, Doppler shift, average gain, and average delay.

[0197] A UE configured in transmission mode 1-9 may assume the antenna ports 0-3, 5, 7-22 of a serving cell are quasi co-located with respect to Doppler shift, Doppler spread, average delay, and delay spread.

[0198] A UE configured in transmission mode 10 is configured with one of two quasi co-location types by higher layer signaling to decode PDSCH according to transmission scheme associated with antenna ports 7-14 (DM-RS ports):

[0199] Type A: The UE may assume the antenna ports 0-3, 7-22 of a serving cell are quasi co-located with respect to delay spread, Doppler spread, Doppler shift, and average delay

[0200] Type B: The UE may assume the antenna ports 15-22 corresponding to the CSI RS resource configuration identified by 'CSI-RS resource configuration identity for PDSCH RE mapping' and the antenna ports 7-14 associated with the PDSCH are quasi co-located with respect to Doppler shift, Doppler spread, average delay, and delay spread.

[0201] PDSCH resource mapping parameters are as follows:

[0202] A UE configured in transmission mode 10 for a given serving cell can be configured with up to 4 parameter sets by higher layer signaling to decode PDSCH according to a detected PDCCH/EPDCCH with DCI format 2D intended for the UE and the given serving cell. The UE shall use the parameter set according to the value of the 'PDSCH RE Mapping and Quasi-Co-Location indicator' field (mapping defined in Table 6) in the detected PDCCH/EPDCCH with DCI format 2D for determining the PDSCH RE mapping and PDSCH antenna port quasi co-location. For PDSCH without a corresponding PDCCH, the UE shall use the parameter set indicated in the PDCCH/EPDCCH with DCI format 2D corresponding to the associated SPS activation for determining the PDSCH RE mapping and PDSCH antenna port quasi co-location.

TABLE 6

PDSCH RE Mapping and Quasi-Co-Location Indicator field in DCI format 2D	
Value of 'PDSCH RE Mapping and Quasi-Co-Location Indicator' field	Description
'00'	Parameter set 1 configured by higher layers
'01'	Parameter set 2 configured by higher layers
'10'	Parameter set 3 configured by higher layers
'11'	Parameter set 4 configured by higher layers

[0203] The following parameters for determining PDSCH RE mapping and PDSCH antenna port quasi co-location are configured via higher layer signaling for each parameter set:
'Number of CRS antenna ports for PDSCH RE mapping'.
'CRS frequency shift for PDSCH RE mapping'.

'MBSFN subframe configuration for PDSCH RE mapping'.
'Zero-power CSI-RS resource configuration for PDSCH RE mapping'.
'PDSCH starting position for PDSCH RE mapping'.
'CSI-RS resource configuration identity for PDSCH RE mapping'.

[0204] A UE configured in transmission mode 10 for a given serving cell can be configured with a parameter set selected from the four parameter sets in Table 6 by higher layer signaling for determining the PDSCH RE mapping and PDSCH antenna port quasi co-location to decode PDSCH according to a detected PDCCH/EPDCCH with DCI format 1A intended for the UE and the given serving cell. The UE shall use the configured parameter set, determining the PDSCH RE mapping and PDSCH antenna port quasi co-location for decoding PDSCH corresponding to detected PDCCH/EPDCCH with DCI format IA and PDSCH without a corresponding PDCCH associated with SPS activation indicated in PDCCH/EPDCCH with DCI format 1A.

[0205] As stated above, the base station in transmission mode 10 may set QCL type by upper layer signaling among QCL type A and QCL type B. QCL type A means CRS, DM-RS (UE-specific RS) and CSI-RS (except average gain point of view) ports are QCLed, and means physical channels and signals are transmitted by the same point/node. In QCL type B, upto 4 CoMP transmission modes including DPS, dynamic muting, JT, etc is available for a UE by upper layer signaling, and DCI format 2D may indicate which of the modes is to be used for receiving PDSCH (and/or E-PDCCH). See. CSI-RS resource configuration identity for PDSCH RE mapping' field in above Table. This transmission mode includes QCL condition between DM-RS and CSI-RS.

[0206] Examples of DPS using QCL type B are as follows:

Node 1 having N_1 antenna ports transmits CSI-RS pattern (resource) #1→Parameter set 1 may include PDSCH RE Mapping and QCL Indicator field

Node 2 having N_2 antenna ports 를 transmits CSI-RS pattern (resource) #2→Parameter set 2 may include PDSCH RE Mapping and QCL Indicator field

The base station may set the parameter set 1 and the parameter set 2 by upper layer signaling to a UE in the common coverage area of node 1 and node 2.

The base station performs dynamic point selection using DCI format 2 by setting parameter set 1 when transmitting data (PDSCH) via node 1 and setting parameter set 2 when transmitting data (PDSCH) via node 2

[0207] The UE suppose by using DCI format 2D that DM-RS and CSI-RS pattern #1 are QCLed when parameter set 1 is set, and DM-RS and CSI-RS pattern #2 are QCLed when parameter set 2 is set

[0208] DM-RS for E-PDCCH is defined for ports 107-110 with similar pattern as UE-specific RS for ports 7-10. The QCL condition for E-PDCCH DM-RS is also defined as types A and B. QCL type A is a case when CRS and E-PDCCH DM-RS are QCLed, and type B is a case when CSI-RS port identified by DC1 format 2D and E-PDCCH DM-RS are QCLed.

[0209] Antenna ports quasi co-location for EPDCCH is as follows:

[0210] For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission modes 1-9, and if the UE is configured to monitor EPDCCH, the UE may assume the antenna ports 0-3, 107-110 of the serving cell are quasi co-located with respect to Doppler shift, Doppler spread, average delay, and delay spread.

[0211] For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission mode 10, and if the UE is configured to monitor EPDCCH, for each EPDCCH-PRB-set, if the UE is configured by higher layers to decode PDSCH according to quasi co-location Type-A, the UE may assume the antenna ports 0-3, 107-110 of the serving cell are quasi co-located with respect to Doppler shift, Doppler spread, average delay, and delay spread. And, if the UE is configured by higher layers to decode PDSCH according to quasi co-location Type-B, the UE may assume antenna ports 15-22 corresponding to the 'CSI-RS resource configuration identity for PDSCH RE mapping' and antenna ports 107-110 are quasi co-located with respect to Doppler shift, Doppler spread, average delay, and delay spread. The UE may assume the antenna ports 0-3 corresponding to the CSI-RS resource configuration identified by 'CSI-RS resource configuration identity for PDSCH RE mapping' and antenna ports 15-22 corresponding to the CSI-RS resource configuration identified by 'CSI-RS resource configuration identity for PDSCH RE mapping' are quasi co-located with respect to Doppler shift, and Doppler spread.

[0212] As stated above, in one embodiment of the present invention, M_f RBs are grouped into one group, one or more antenna ports are grouped into one antenna group, and CSI-RS of one antenna group is only transmitted via one RB among M_f RBs.

[0213] M_f can be predetermined by the system (e.g. M_f=2). Or, it can be set based on configuration by RRC. SIB, MIB or other RRC message can be used for this purpose. In one embodiment, M_f can be adaptively determined based on the number of co-located RS or patterns. That is, M_f can be adaptively determined based on the number of co-located RS or patterns transmitted by the same transmission point. In this case, by increasing M_f when the number of RSs or patterns increase, RS overhead can be efficiently managed.

[0214] M_f can have a value within

$$1 \le M_f \le \left\lfloor \frac{N_{BW}}{N_{sc}^{RB}} \right\rfloor,$$

where N_{BW} represents coherent bandwidth and N_{sc}^{RB} represent the number of subcarrier within one RB. Here, when N_{BW} is large, M_f can be large too. But, M_f can be determined regardless of N_{BW}.

[0215] When the total number of antenna ports is N_p, the number of antenna groups can be

$$\left\lfloor \frac{N_p}{M_f} \right\rfloor \text{ or } \left\lfloor \frac{N_p}{M_f} \right\rfloor + 1.$$

One embodiment of the present invention proposes mapping the CSI-RSs of different antenna groups to different RBs. That is, CSI_RSs of the same antenna groups are mapped to the same RB.

[0216] In one embodiment of the present invention, the RB position of CSI-RS of antenna port p can be determined by following equation.

$$r=\mathrm{mod}(p-15,M_f)+nM_f+o \quad \text{[Equation 15]}$$

[0217] Here, 'r' represents the RB position of antenna port 'p'. 'o' represent offset and it has value within $0\le o\le M_f-1$. The offset value can have one value for each antenna port 'p'. 'n' represents a group index and it may corresponds to the total number of RBs divided by M_f.

[0218] CSI-RS position within a specific RB can be the same as the LTE system or different from the LTE system.

[0219] By the equation 15, when n=0, M_f=2, p={15,16,17,18}, the CSI-RSs of p={15,17} are transmitted at RB #0 and the CSI-RSs of p={16,18} are transmitted at RB #1.

[0220] In another embodiment of the present invention, the RB position of CSI-RS of antenna port p can be determined by following equation.

$$r=\left\lfloor \frac{p-15}{M_f} \right\rfloor + nM_f + o \quad \text{[Equation 16]}$$

[0221] Here, 'r' represents the RB position of antenna port 'p'. 'o' represent offset and it has value within $0\le 0\le M_f-1$ The offset value can have one value for each antenna port 'p'. 'n' represents a group index and it may corresponds to the total number of RBs divided by M_f.

[0222] By the equation 16, when n=0, M_f=2, p={15,16,17,18}, the CSI-RSs of p={15,16} and p={17,18} are transmitted at RB #0 and RB #1, respectively.

[0223] In the above equations, the offset value 'o' can be determined by a function of one or more of the following parameters or signaled by the network.

[0224] Parameters for the offset: physical cell ID (N_{ID}^{cell}) CSI-RS ID (N_{ID}^{CSI}), subframe number or sequence, and port number.

[0225] When the offset value is a function of antenna port, the offset value can be set as 1 when the port number is even, and −1 when the port number if odd.

[0226] The application of the present embodiment (that is, whether RB grouping is applied or not) can be signaled by the upper layer signaling or physical message.

[0227] Or, it can be implicitly determined based on the number of co-located RS ports or patterns. For this purpose, the following embodiments are proposed.

[0228] The base station may explicitly or implicitly indicate the co-location status between RS patterns. For this, QCL condition indication with multiple NZP CSI-RS resources or multiple CSI processes can be used. Or, explicit RRC signaling of co-located NZP CSI-RS resources can be used. For this, the UE may assume that multiple NZP CSI-RS resources within one CSI process are co-located. Based on this, the base station may set co-located NZP CSI-RS resources as one CSI process.

[0229] In contrary, the UE may determine by itself whether the RS patterns are co-located. The UE may determine whether the RSs are co-located based on the reception timing offset of the RS patterns. When the reception timing offset is within a threshold value, the UE may determine that the RSs are co-located.

[0230] Or, the UE may determine this based on the characteristic of the channel (e.g. Doppler spread, Delay spread, Delay profile, etc.). When the characteristics of the RSs are similar, the UE may determine that the RSs are co-located.

[0231] When the network wants to signal (a) M_f and (b) whether RB grouping is applied, it may signal them with one message. Following table is an example for this signaling.

TABLE 7

Message = 00	M_f = 1 (Legacy CSI-RS pattern)
Message = 01	M_f = 2
Message = 10	M_f = 3
Message = 11	M_f = 4

[0232] The above signaling can be combined with CSI-RS configuration.

TABLE 8

PhysicalConfigDedicated information element

```
-- ASN1START
PhysicalConfigDedicated ::=                SEQUENCE {
    pdsch-ConfigDedicated                      PDSCH-ConfigDedicated
OPTIONAL,                  -- Need ON
    pucch-ConfigDedicated                      PUCCH-ConfigDedicated
OPTIONAL,                  -- Need ON
    pusch-ConfigDedicated                      PUSCH-ConfigDedicated
OPTIONAL,                  -- Need ON
    uplinkPowerControlDedicated                UplinkPowerControlDedicated
OPTIONAL,                  -- Need ON
    tpc-PDCCH-ConfigPUCCH                      TPC-PDCCH-Config
    OPTIONAL,              -- Need ON
    tpc-PDCCH-ConfigPUSCH                      TPC-PDCCH-Config
    OPTIONAL,              -- Need ON
    cqi-ReportConfig                           CQI-ReportConfig
OPTIONAL,                  -- Cond CQI-r8
soundingRS-UL-ConfigDedicated              SoundingRS-UL-ConfigDedicated
OPTIONAL                   -- Need ON
    (Ommitted)
    [[ antennaInfoDedConfigToReleaseList-r11       AntennaInfoDedConfigToReleaseList-
r11 OPTIONAL,-- Need ON
        antennaInfoDedConfigToAddModList-r11       AntennaInfoDedConfigToAddModList-
r11 OPTIONAL,-- Need ON
        cqi-ReportConfig-v11x0                 CQI-ReportConfig-v11x0   OPTIONAL,
    -- Need ON
        cqi-ReportPeriodicExtToReleaseList-r11     CQI-ReportPeriodicExtToReleaseList-
r11 OPTIONAL,-- Need ON
        cqi-ReportPeriodicExtToAddModList-r11      CQI-ReportPeriodicExtToAddModList-
```

TABLE 8-continued

PhysicalConfigDedicated information element

```
r11 OPTIONAL,-- Need ON
        csi-IM-ConfigToReleaseList-r11                  CSI-IM-ConfigToReleaseList-r11
    OPTIONAL,                   -- Need ON
        csi-IM-ConfigToAddModList-r11                   CSI-IM-ConfigToAddModList-r11
    OPTIONAL,                   -- Need ON
        csi-ProcessToReleaseList-r11                CSI-ProcessToReleaseList-r11 OPTIONAL,
    -- Need ON
        csi-ProcessToAddModList-r11                     CSI-ProcessToAddModList-r11
    OPTIONAL,                   -- Need ON
        csi-RS-ConfigZPToReleaseList-r11CSI-RS-ConfigZPToReleaseList-r11
    OPTIONAL,                   -- Need ON
        csi-RS-ConfigZPToAddModList-r11                 CSI-RS-ConfigZPToAddModList-r11
    OPTIONAL,                   -- Need ON
        csi-RS-ConfigNZPToReleaseList-r11               CSI-RS-ConfigNZPToReleaseList-r11
    OPTIONAL,                   -- Need ON
        csi-RS-ConfigNZPToAddModList-r11                CSI-RS-ConfigNZPToAddModList-r11
    OPTIONAL,                   -- Need ON
        epdcch-Config-r11                           EPDCCH-Config-r11           OPTIONAL,
    -- Need ON
        pdsch-ConfigDedicated-v11xy                     PDSCH-ConfigDedicated-v11xy
    OPTIONAL,                   -- Need ON
        pucch-ConfigDedicated-v11x0                     PUCCH-ConfigDedicated-v11x0
    OPTIONAL,                   -- Need ON
        pusch-ConfigDedicated-v11xy                     PUSCH-ConfigDedicated-v11xy
    OPTIONAL,                   -- Need ON
        uplinkPowerControlDedicated-v11xy               UplinkPowerControlDedicated-v11xy
    OPTIONAL                    -- Need ON
    ]]
}
PhysicalConfigDedicatedSCell-r10 ::=                    SEQUENCE {
    (Ommitted: Contents is simillat to PhysicalConfigDedicated IE)
}
AntennaInfoDedConfigToAddModList-r11 ::=        SEQUENCE (SIZE (1..maxAID-r11)) OF
AntennaInfoDedConfig-r11
AntennaInfoDedConfigToReleaseList-r11 ::=               SEQUENCE (SIZE (1..maxAID-r11)) OF
AntennaInfoDedConfigId-r11
CSI-IM-ConfigToAddModList-r11 ::=                       SEQUENCE (SIZE (1..maxCSI-IM-r11)) OF
CSI-IM-Config-r11
CSI-IM-ConfigToReleaseList-r11 ::=                      SEQUENCE (SIZE (1..maxCSI-IM-r11)) OF
CSI-IM-Identity-r11
CSI-ProcessToAddModList-r11 ::=                 SEQUENCE (SIZE (1..maxCSI-Proc-r11)) OF CSI-
Process-r11
CSI-ProcessToReleaseList-r11 ::=                SEQUENCE (SIZE (1..maxCSI-Proc-r11)) OF CSI-
ProcessIdentity-r11
CSI-RS-ConfigNZPToAddModList-r11 ::=SEQUENCE (SIZE (1..maxCSI-RS-NZP-r11))
OF CSI-RS-ConfigNZP-r11
CSI-RS-ConfigNZPToReleaseList-r11 ::=                   SEQUENCE (SIZE (1..maxCSI-RS-NZP-r11))
OF CSI-RS-IdentityNZP-r11
CSI-RS-ConfigZPToAddModList-r11 ::=                     SEQUENCE (SIZE (1..maxCSI-RS-ZP-r11))
OF CSI-RS-ConfigZP-r11
CSI-RS-ConfigZPToReleaseList-r11 ::=                    SEQUENCE (SIZE (1..maxCSI-RS-ZP-r11))
OF CSI-RS-IdentityZP-r11
CQI-ReportPeriodicExtToAddModList-r11 ::=                   SEQUENCE (SIZE (1..maxCQI-Ext-
r11)) OF CQI-ReportPeriodicExt-r11
CQI-ReportPeriodicExtToReleaseList-r11 ::=                  SEQUENCE (SIZE (1..maxCQI-Ext-r11))
OF CQI-ReportPeriodicExtId-r11
-- ASN1STOP
```

TABLE 9

CSI-Process information elements [4]

```
-- ASN1START
CSI-Process-r11 ::=                 SEQUENCE {
    csi-ProcessIdentity-r11             CSI-ProcessIdentity-r11,
    csi-RS-IdentityNZP-r11                  CSI-RS-IdentityNZP-r11,
    csi-IM-Identity-r11                 CSI-IM-Identity-r11,
    p-C-AndAntennaInfoDedList-r11   SEQUENCE (SIZE (1..2))OF P-C-
AndAntennaInfoDed-r11,
    cqi-ReportBothPS-r11                CQI-ReportBothPS-r11        OPTIONAL,       -- Need
```

TABLE 9-continued

CSI-Process information elements [4]

```
OR
    cqi-ReportPeriodicId-r11                INTEGER (0..maxCQI-Ext-r11)          OPTIONAL,
    -- Need OR
    cqi-ReportAperiodicPS-r11 CQI-ReportAperiodicPS-r11                          OPTIONAL,      --
Need OR
    ...
}
P-C-r11 ::=                             INTEGER (-8..15)
P-C-AndAntennaInfoDed-r11::=                SEQUENCE {
    p-C-r11                                 P-C-r11,
    antennaInfoDedConfigId-r11                  AntennaInfoDedConfigId-r11
}
-- ASN1STOP
```

TABLE 10

CSI-RS-ConfigNZP information elements

```
-- ASN1START
CSI-RS-ConfigNZP-r11 ::=            SEQUENCE {
    csi-RS-IdentityNZP-r11              CSI-RS-IdentityNZP-r11,
    antennaPortsCount-r11           ENUMERATED {an1, an2, an4, an8},
    resourceConfig-r11              INTEGER (0..31),
    subframeConfig-r11                  INTEGER(0..154),
    scramblingIdentity-r11          INTEGER(0..503),
    qcl-CSR-Info-r11                SEQUENCE {
        qcl-ScramblingIdentity-r11      INTEGER (0..503),
        crs-PortsCourt-r11              ENUMERATED {n1, n2, n4, spare1},
        mbsfn-SubframeConrig-r11        MBSFN-SubframeConfig        OPTIONAL
    -- Need OR
        }                                                           OPTIONAL,   --
        ...
Need OR
}
-- ASN1STOP
```

[0233] As can be seen from the above Tables 8-10, multiple of NZP CSI-RS, ZP CSI-RS, CSI-IM resource, CSI process can be set, and multiple CSI processes can be set for a rel-11 UE. Generally, one CS process corresponds to one CoMP transmission mode (e.g. point A transmission, point B transmission, JT of point A & B), so various transmission modes can be supported by the multiple CSI processes.

[0234] In addition to the above configuration, the M_f value and/or whether RB grouping is applied can be signaled together.

[0235] FIG. **27** is a block diagram for one example of a communication device according to one embodiment of the present invention.

[0236] Referring to FIG. **27**, a communication device **2100** includes a processor **2110**, a memory **2120**, an RF module **2130**, a display module **2140** and a user interface module **2150**.

[0237] The communication device **2100** is illustrated for clarity and convenience of the description and some modules can be omitted. Moreover, the communication device **2100** is able to further include at least one necessary module. And, some modules of the communication device **2100** can be further divided into sub-modules. The processor **2110** is configured to perform operations according to the embodiment of the present invention exemplarily described with reference to the accompanying drawings. In particular, the detailed operations of the processor **2110** can refer to the contents described with reference to FIGS. **1** to **26**.

[0238] The memory **2120** is connected to the processor **2110** and stores operating systems, applications, program codes, data and the like. The RF module **2130** is connected to the processor **2110** and performs a function of converting a baseband signal to a radio signal or converting a radio signal to a baseband signal. For this, the RF module **2130** performs analog conversion, amplification, filtering and frequency uplink transform or inverse processes thereof. The display module **2140** is connected to the processor **2110** and displays various kinds of informations. The display module **2140** can include such a well-known element as LCD (Liquid Crystal Display), LED (Light Emitting Diode), OLED (Organic Light Emitting Diode) and the like, by which the present invention is non-limited. The user interface module **2150** is connected to the processor **2110** and can include a combination of well-known interfaces including a keypad, a touchscreen and the like.

[0239] The above-described embodiments correspond to combination of elements and features of the present invention in prescribed forms. And, it is able to consider that the respective elements or features are selective unless they are explicitly mentioned. Each of the elements or features can be implemented in a form failing to be combined with other elements or features. Moreover, it is able to implement an embodiment of the present invention by combining elements and/or features together in part. A sequence of operations explained for each embodiment of the present invention can be modified. Some configurations or features of one embodiment can be included in another embodiment or can be substituted for

corresponding configurations or features of another embodiment. It is apparent that an embodiment can be configured by combining claims, which are not explicitly cited in-between, together without departing from the spirit and scope of 'what is claimed is' or that those claims can be included as new claims by revision after filing an application.

[0240] In this disclosure, a specific operation explained as performed by a base station can be performed by an upper node of the base station in some cases. In particular, in a network constructed with a plurality of network nodes including a base station, it is apparent that various operations performed for communication with a terminal can be performed by a base station or other network nodes except the base station. In this case, 'base station' can be replaced by such a terminology as a fixed station, a Node B, an eNode B (eNB), an access point and the like.

[0241] Embodiments of the present invention can be implemented using various means. For instance, embodiments of the present invention can be implemented using hardware, firmware, software and/or any combinations thereof. In case of the implementation by hardware, a method according to one embodiment of the present invention can be implemented by at least one selected from the group consisting of ASICs (application specific integrated circuits), DSPs (digital signal processors), DSPDs (digital signal processing devices), PLDs (programmable logic devices), FPGAs (field programmable gate arrays), processor, controller, microcontroller, microprocessor and the like.

[0242] In case of the implementation by firmware or software, a method according to each embodiment of the present invention can be implemented by modules, procedures, and/or functions for performing the above-explained functions or operations. Software code is stored in a memory unit and is then drivable by a processor. The memory unit is provided within or outside the processor to exchange data with the processor through the various means known in public.

[0243] While the present invention has been described and illustrated herein with reference to the preferred embodiments thereof, it will be apparent to those skilled in the art that various modifications and variations can be made therein without departing from the spirit and scope of the invention. Thus, it is intended that the present invention covers the modifications and variations of this invention that come within the scope of the appended claims and their equivalents.

INDUSTRIAL APPLICABILITY

[0244] Although methods of transmitting reference signals for a massive MIMO system and apparatuses therefor are described mainly with reference to examples applied to 3GPP LTE system, as mentioned in the foregoing description, the present invention is applicable to various kinds of wireless communication systems as well as the 3GPP LTE system.

1. A method for a base station having multiple antennas to transmit reference signals to user equipments (UEs), the method comprising:

grouping 'M' resource blocks (RBs) into a resource block group, wherein the 'M' is greater than 1, wherein a number of the multiple antennas is greater than 8;

grouping one or more antenna ports into one antenna group, wherein each of the antenna ports corresponds to each of the multiple antennas;

mapping the reference signals of the one antenna group into only one RB within one resource block group; and

transmitting the reference signals to the UEs.

2. The method of claim **1**, wherein the reference signals of different antenna groups are mapped to different RBs of a same resource block group.

3. The method of claim **1**, wherein the 'M' is based on system information.

4. The method of claim **1**, wherein the 'M' is determined based on a number of co-located Reference Signal ports.

5. The method of claim **1**, wherein the reference signals are CSI-RS reference signals.

6. The method of claim **1**, wherein a reference signal of an antenna port 'p' among the antenna ports are mapped to resource block 'r' based on an equation of:

$$r=P \bmod M+nM+o$$

wherein the 'P' corresponds to a sequence of the antenna port 'p' among the antenna ports transmitting the reference signals, the 'n' corresponds to the number of resource block groups, and the 'o' corresponds to an offset value.

7. The method of claim **6**, wherein the offset value is determined based on a physical cell ID, a CSI-RS ID, a subframe number or an antenna port index.

8. The method of claim **1**, wherein the base station transmits signals based on a 3D beam forming scheme using the multiple antennas.

9. A method for a user equipment (UE) to receive reference signals from one or more base stations, the method comprising:

receiving the reference signals from the base stations, wherein 'M' resource blocks (RBs) are grouped into a resource block group, wherein the 'M' is greater than 1, wherein the reference signals are transmitted by 8 or more antennas, wherein one or more antenna ports are grouped into one antenna group, wherein each of the antenna ports corresponds to each of the multiple antennas, wherein the reference signals of the one antenna group are received via only one RB within one resource block group; and

estimating channel based on the received reference signals.

10. The method of claim **9**, wherein the reference signals of different antenna groups are mapped to different RBs of a same resource block group.

11. The method of claim **9**, wherein the 'M' is determined based on a number of co-located Reference Signal ports.

12. The method of claim **9**, wherein the reference signals are CSI-RS reference signals.

13. The method of claim **9**, wherein a reference signal of an antenna port 'p' among the antenna ports are mapped to resource block 'r' based on an equation of:

$$r=P \bmod M+nM+o$$

wherein the 'P' corresponds to a sequence of the antenna port 'p' among the antenna ports transmitting the reference signals, the 'n' corresponds to the number of resource block groups, and the 'o' corresponds to an offset value.

14. A base station device comprising:

multiple antennas to transmit reference signals to user equipments (UEs), wherein a number of the multiple antennas is greater than 8; and

a processor connected to the multiple antennas, and adapted to:

group 'M' resource blocks (RBs) into a resource block group, wherein the 'M' is greater than 1,

group one or more antenna ports into one antenna group, wherein each of the antenna ports corresponds to each of the multiple antennas;

map the reference signals of the one antenna group into only one RB within one resource block group.

15. A method for a user equipment (UE) to receive reference signals from one or more base stations, the method comprising:

receiving the reference signals from the base stations, wherein 'M' resource blocks (RBs) are grouped into a resource block group, wherein the 'M' is greater than 1, wherein the reference signals are transmitted by 8 or more antennas, wherein one or more antenna ports are grouped into one antenna group, wherein each of the antenna ports corresponds to each of the multiple antennas, wherein the reference signals of the one antenna group are received via only one RB within one resource block group; and

estimating channel based on the received reference signals.

* * * * *

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Luo et al.

(54) **ANTENNA VIRTUALIZATION IN A WIRELESS COMMUNICATION ENVIRONMENT**

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(22) Filed: **Feb. 1, 2010**

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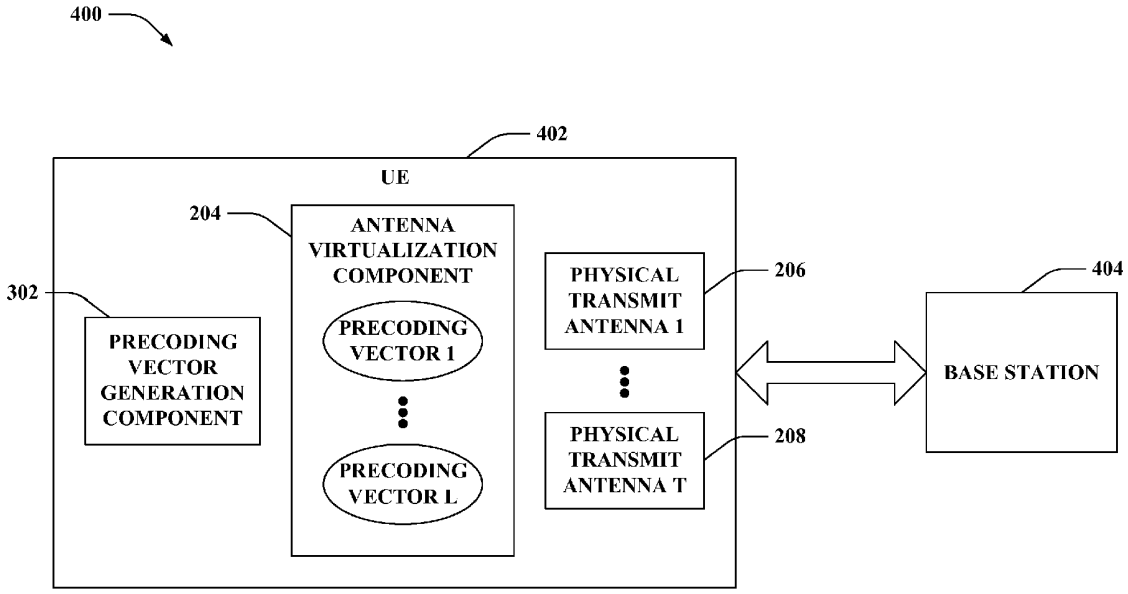
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H04L 27/00 (2006.01)

(52) **U.S. Cl.** **375/295**

(57) **ABSTRACT**

Systems and methodologies are described that facilitate performing antenna virtualization in a wireless communication environment. A set of physical transmit antennas can be partitioned into a plurality of groups of physical transmit antennas. Further, a precoding vector for a particular group of physical transmit antennas from the plurality of groups of physical transmit antennas can be formulated. Moreover, the particular group of physical transmit antennas can form a particular virtual antenna. By way of another example, a disparate precoding vector for a disparate group of physical transmit antennas from the plurality of groups of physical transmit antennas can be formulated, and the disparate group of physical transmit antennas can form a disparate virtual antenna. The precoding vector can be applied to a signal for transmission over the particular virtual antenna, and the disparate precoding vector can be applied to a disparate signal for transmission over the disparate virtual antenna.



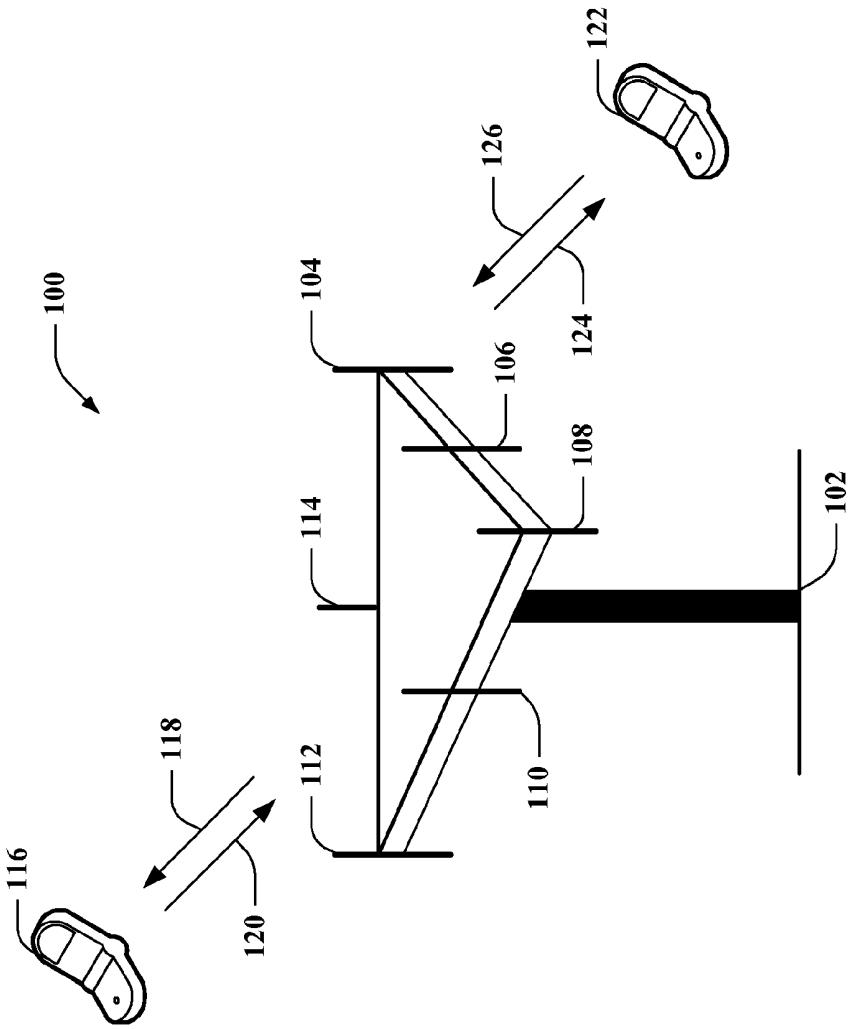


FIG. 1

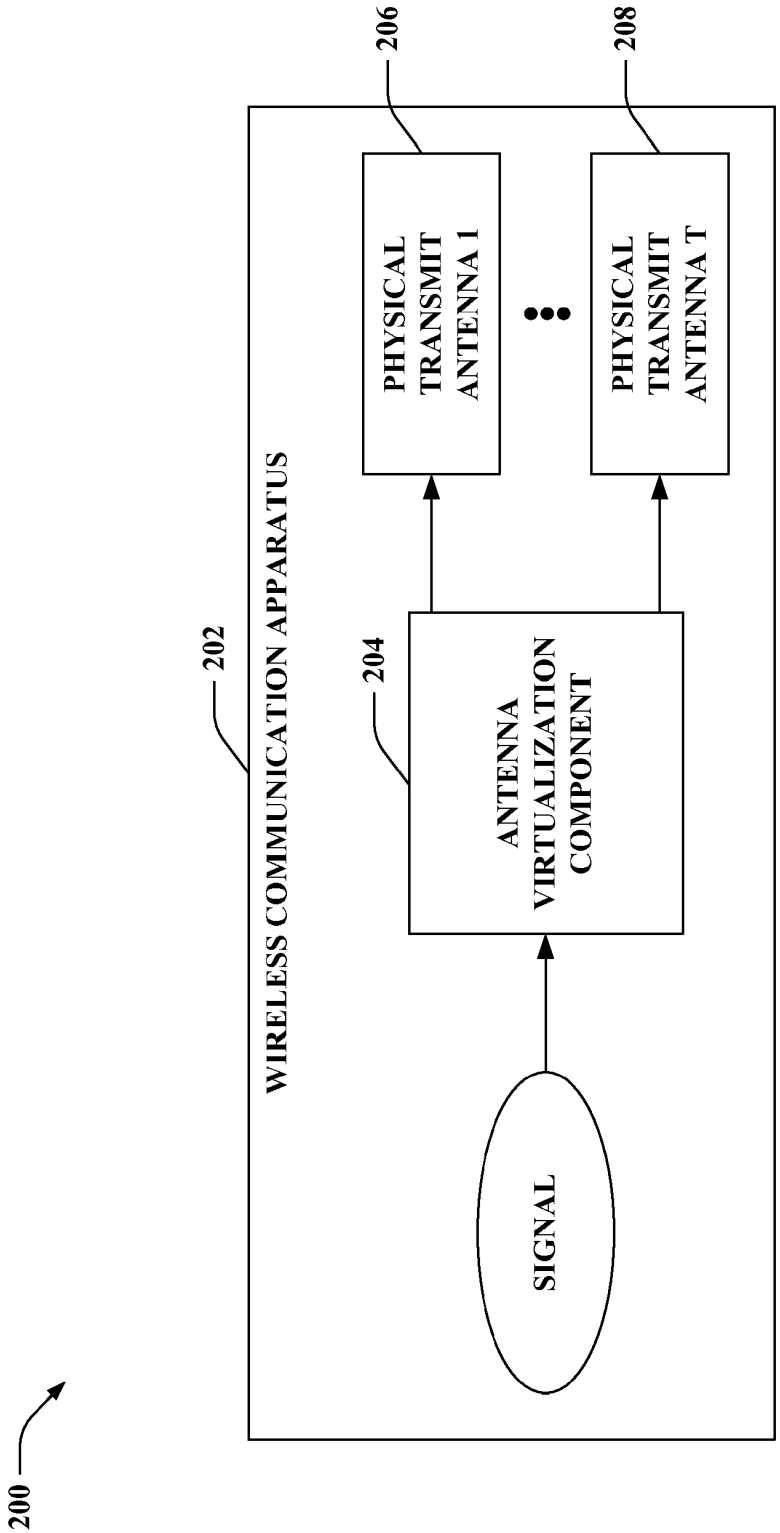

200
202
WIRELESS COMMUNICATION APPARATUS
204
ANTENNA VIRTUALIZATION COMPONENT
206
PHYSICAL TRANSMIT ANTENNA 1
208
PHYSICAL TRANSMIT ANTENNA T
SIGNAL

FIG. 2

831

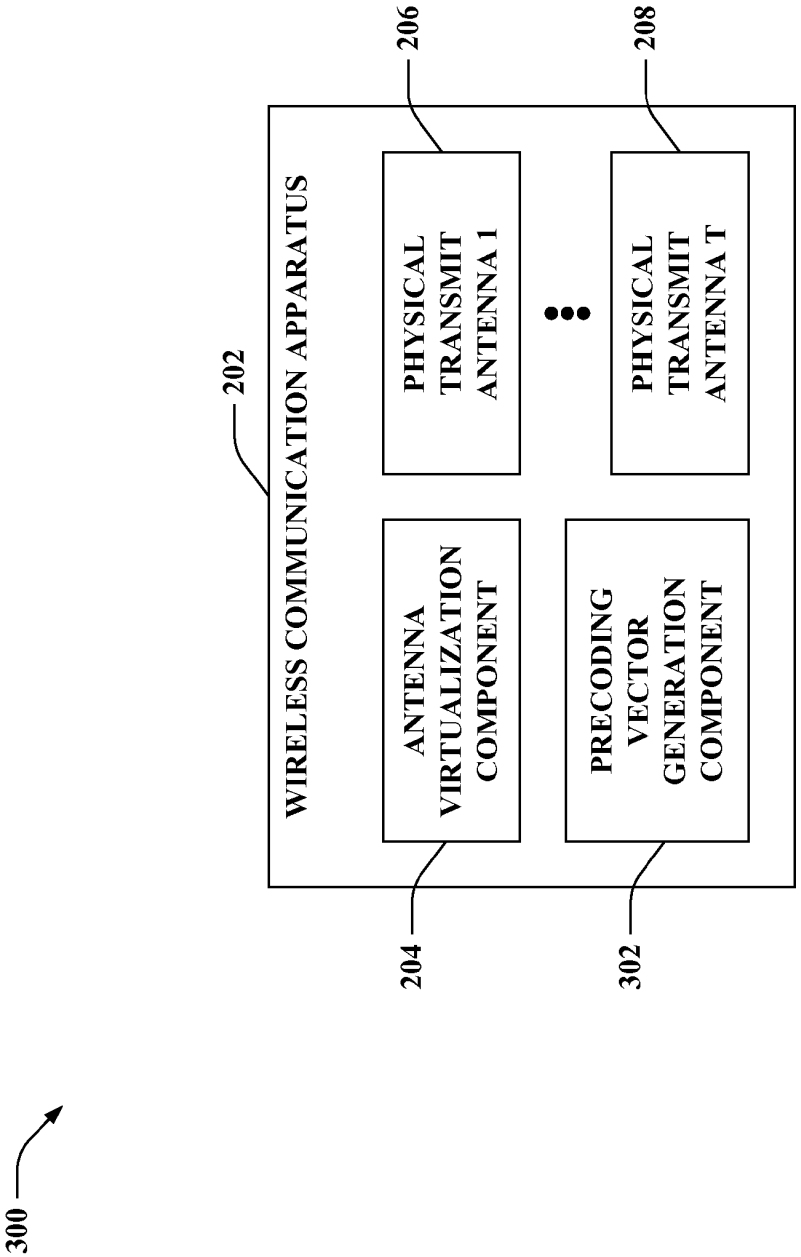

300
202
WIRELESS COMMUNICATION APPARATUS
206
208
PHYSICAL TRANSMIT ANTENNA 1
PHYSICAL TRANSMIT ANTENNA T
ANTENNA VIRTUALIZATION COMPONENT
PRECODING VECTOR GENERATION COMPONENT
204
302
832

FIG. 3

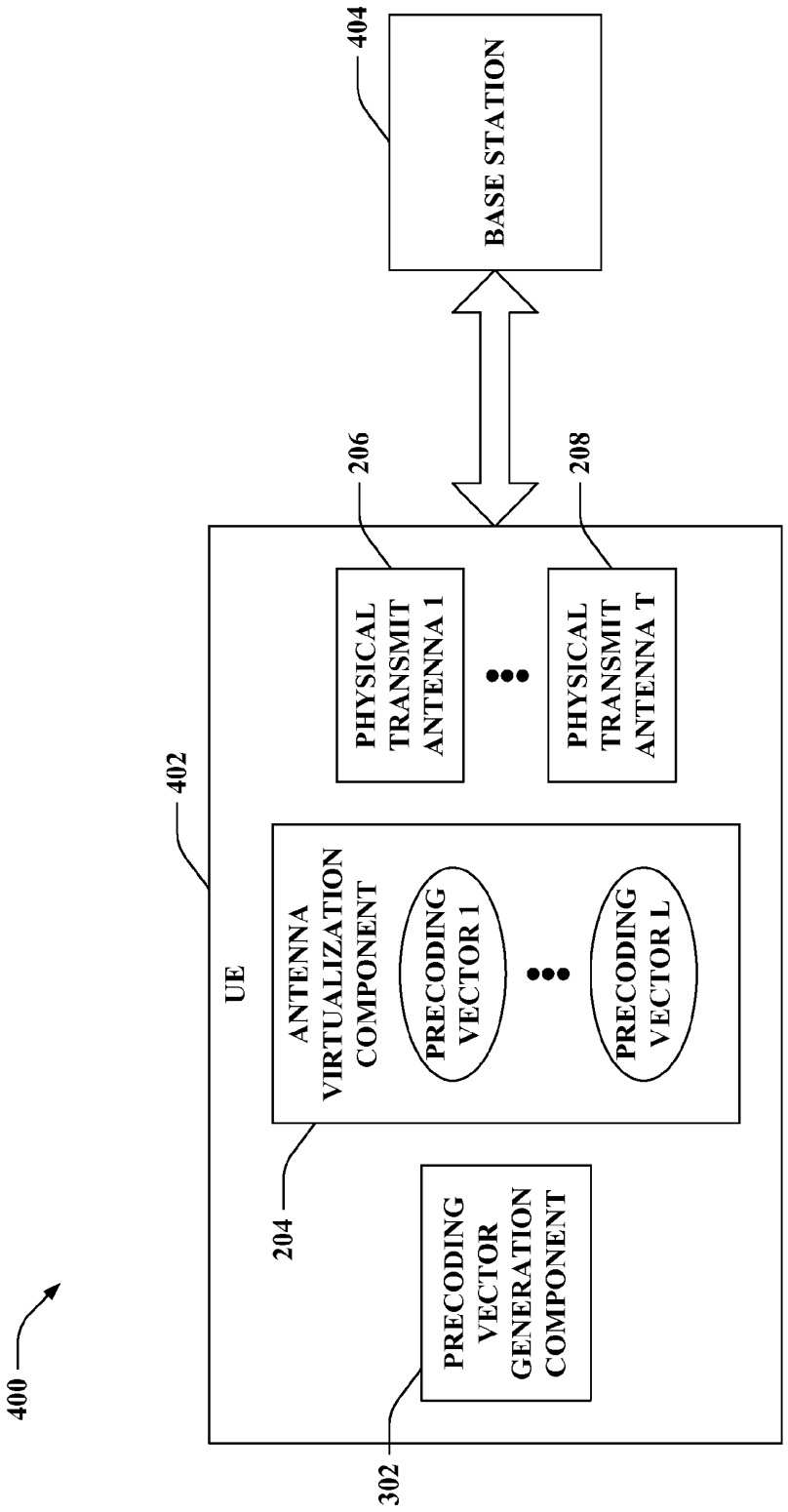

400
402
UE
404
BASE STATION
206
208
PHYSICAL TRANSMIT ANTENNA 1
PHYSICAL TRANSMIT ANTENNA T
ANTENNA VIRTUALIZATION COMPONENT
PRECODING VECTOR 1
PRECODING VECTOR L
204
PRECODING VECTOR GENERATION COMPONENT
302

FIG. 4

833

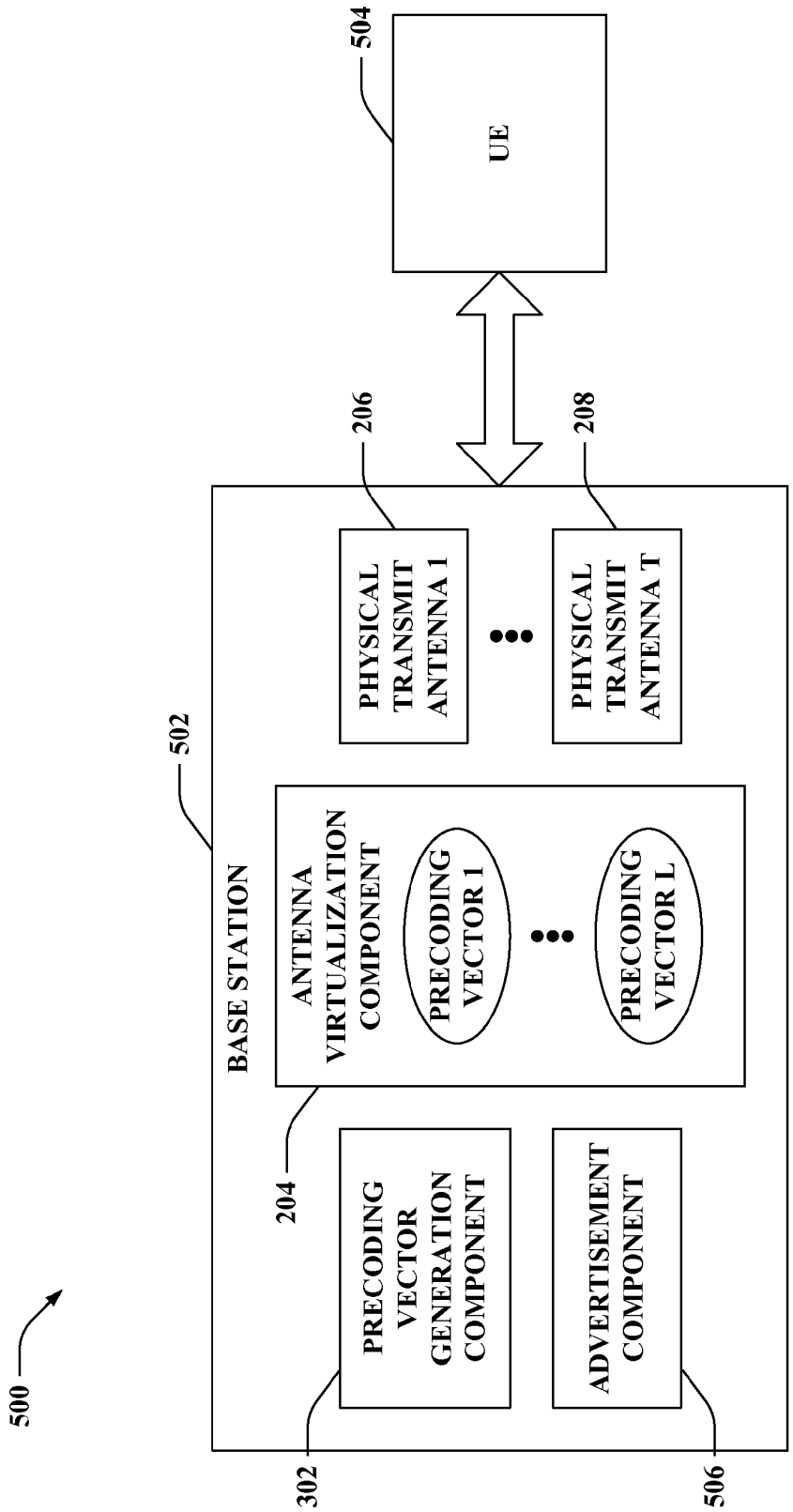

500
502
BASE STATION
504
UE
206
208
PHYSICAL TRANSMIT ANTENNA 1
PHYSICAL TRANSMIT ANTENNA T
ANTENNA VIRTUALIZATION COMPONENT
PRECODING VECTOR 1
PRECODING VECTOR L
204
PRECODING VECTOR GENERATION COMPONENT
ADVERTISEMENT COMPONENT
302
506

FIG. 5

834

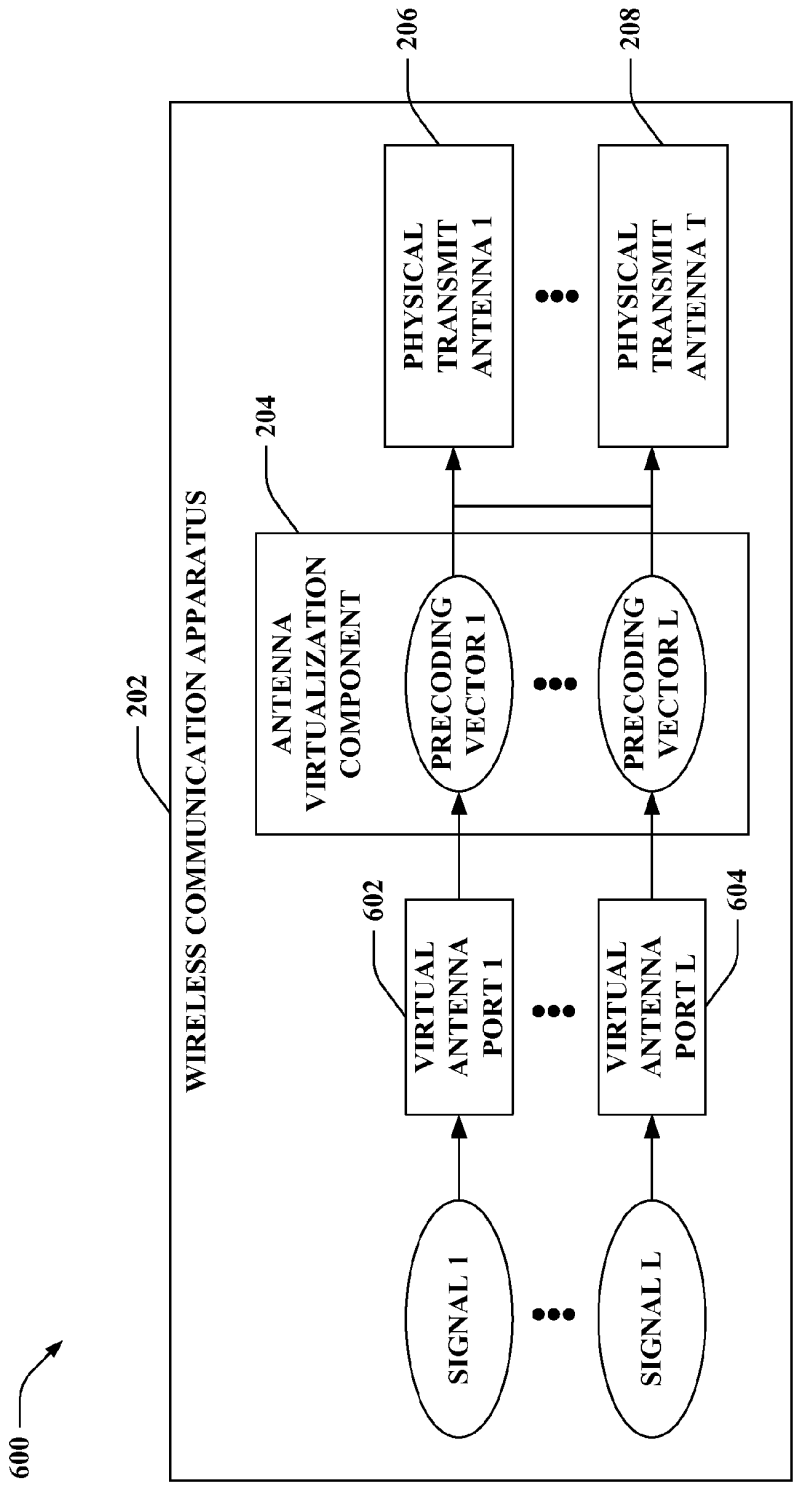

600
202
WIRELESS COMMUNICATION APPARATUS
204
ANTENNA VIRTUALIZATION COMPONENT
206
208
PHYSICAL TRANSMIT ANTENNA 1
PHYSICAL TRANSMIT ANTENNA T
PRECODING VECTOR 1
PRECODING VECTOR L
602
604
VIRTUAL ANTENNA PORT 1
VIRTUAL ANTENNA PORT L
SIGNAL 1
SIGNAL L

FIG. 6

835

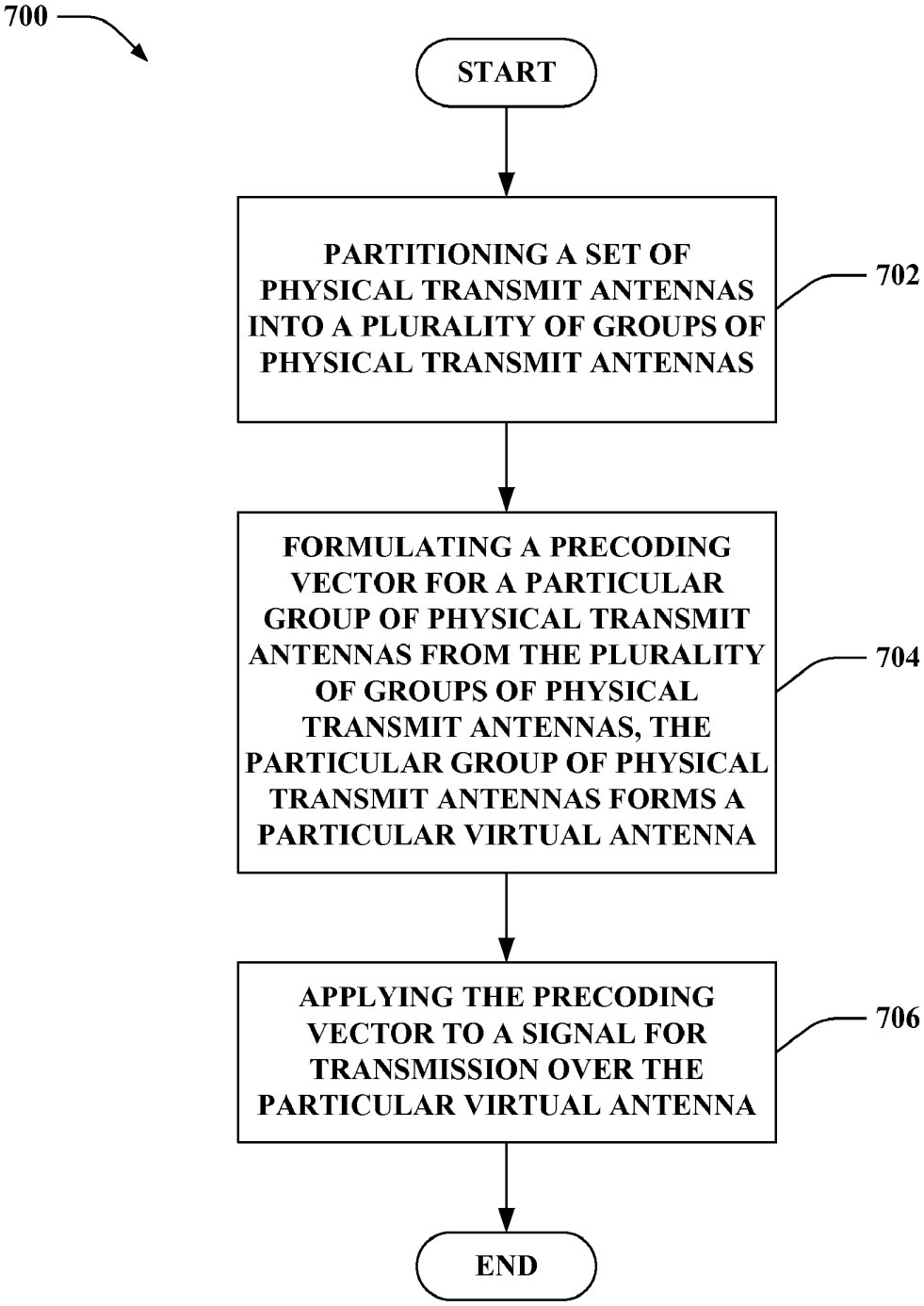

700
START
PARTITIONING A SET OF PHYSICAL TRANSMIT ANTENNAS INTO A PLURALITY OF GROUPS OF PHYSICAL TRANSMIT ANTENNAS
702
FORMULATING A PRECODING VECTOR FOR A PARTICULAR GROUP OF PHYSICAL TRANSMIT ANTENNAS FROM THE PLURALITY OF GROUPS OF PHYSICAL TRANSMIT ANTENNAS, THE PARTICULAR GROUP OF PHYSICAL TRANSMIT ANTENNAS FORMS A PARTICULAR VIRTUAL ANTENNA
704
APPLYING THE PRECODING VECTOR TO A SIGNAL FOR TRANSMISSION OVER THE PARTICULAR VIRTUAL ANTENNA
706
END

FIG. 7

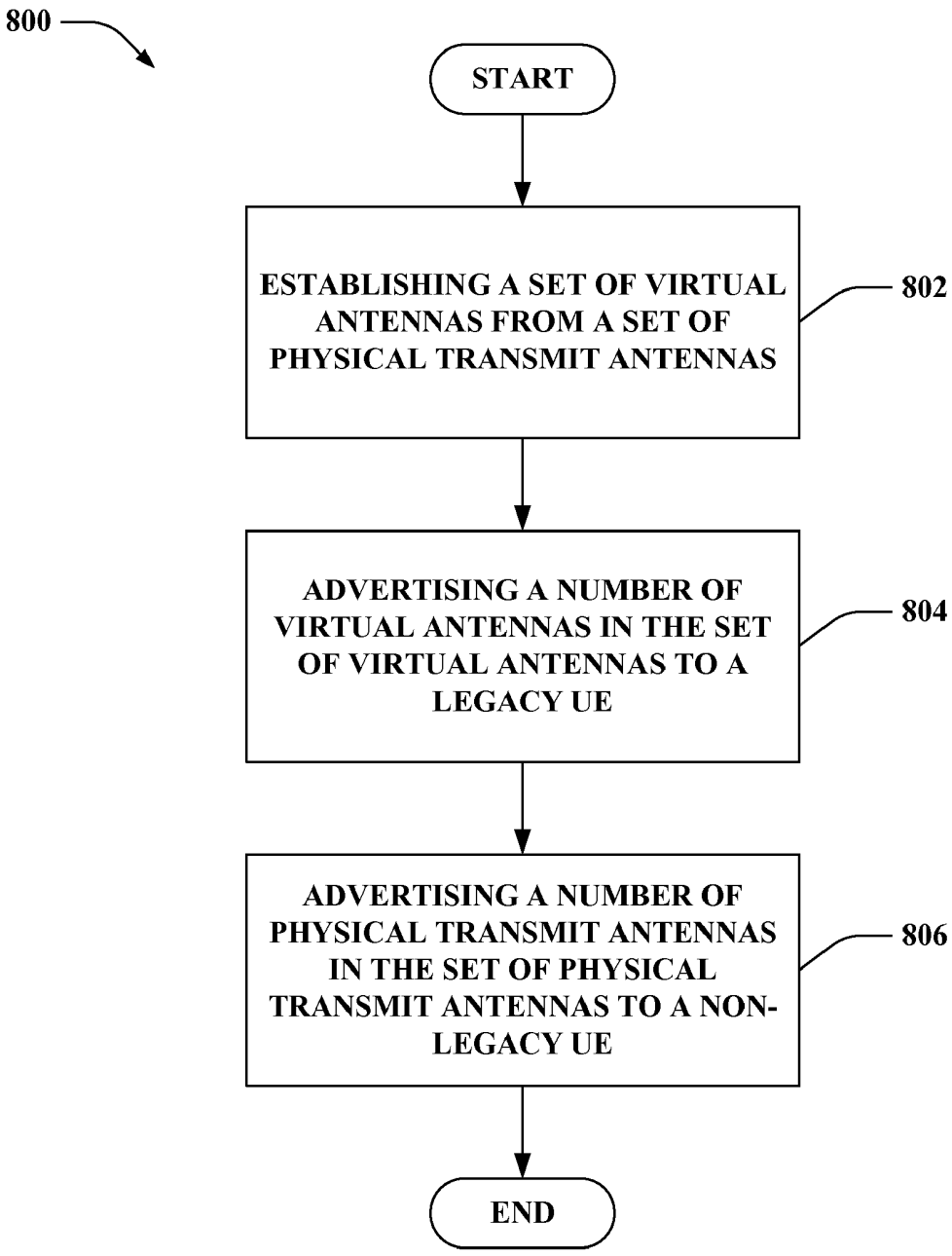

800
START
ESTABLISHING A SET OF VIRTUAL ANTENNAS FROM A SET OF PHYSICAL TRANSMIT ANTENNAS
802
ADVERTISING A NUMBER OF VIRTUAL ANTENNAS IN THE SET OF VIRTUAL ANTENNAS TO A LEGACY UE
804
ADVERTISING A NUMBER OF PHYSICAL TRANSMIT ANTENNAS IN THE SET OF PHYSICAL TRANSMIT ANTENNAS TO A NON-LEGACY UE
806
END

FIG. 8

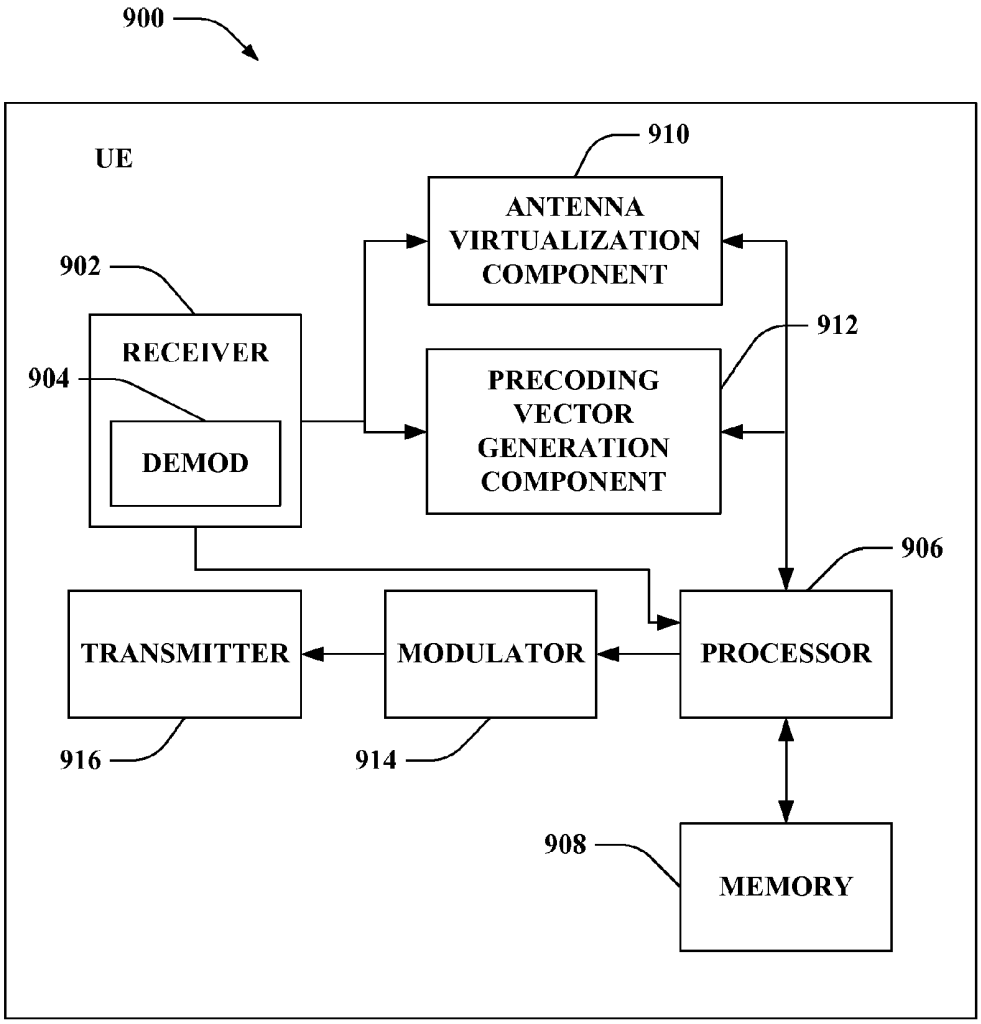

900
UE
910
ANTENNA VIRTUALIZATION COMPONENT
902
RECEIVER
904
DEMOD
912
PRECODING VECTOR GENERATION COMPONENT
906
TRANSMITTER
MODULATOR
PROCESSOR
916
914
908
MEMORY

FIG. 9

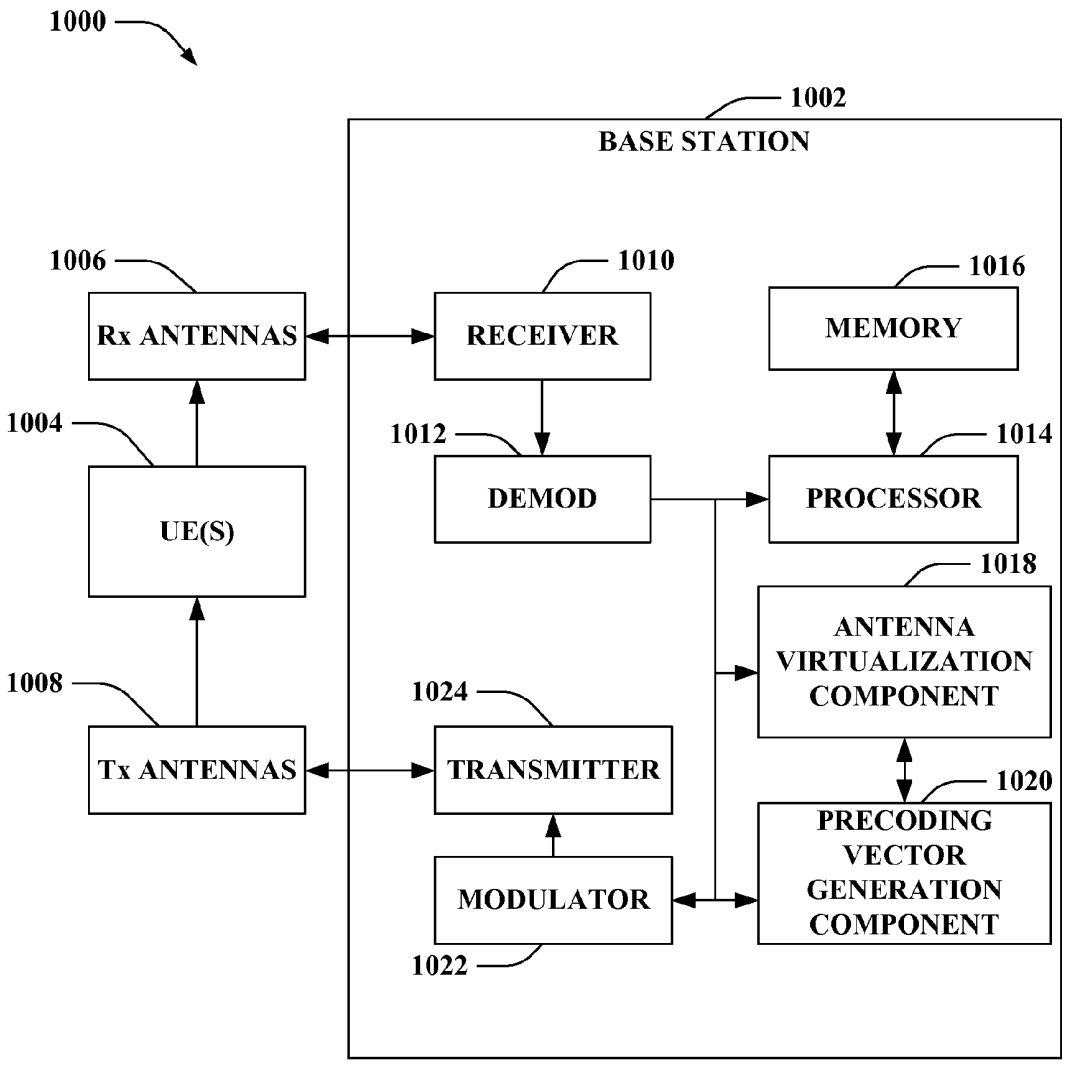

1000
1002
BASE STATION
1006
Rx ANTENNAS
1010
RECEIVER
1016
MEMORY
1004
UE(S)
1012
DEMOD
1014
PROCESSOR
1018
ANTENNA VIRTUALIZATION COMPONENT
1008
Tx ANTENNAS
1024
TRANSMITTER
1020
PRECODING VECTOR GENERATION COMPONENT
MODULATOR
1022

FIG. 10

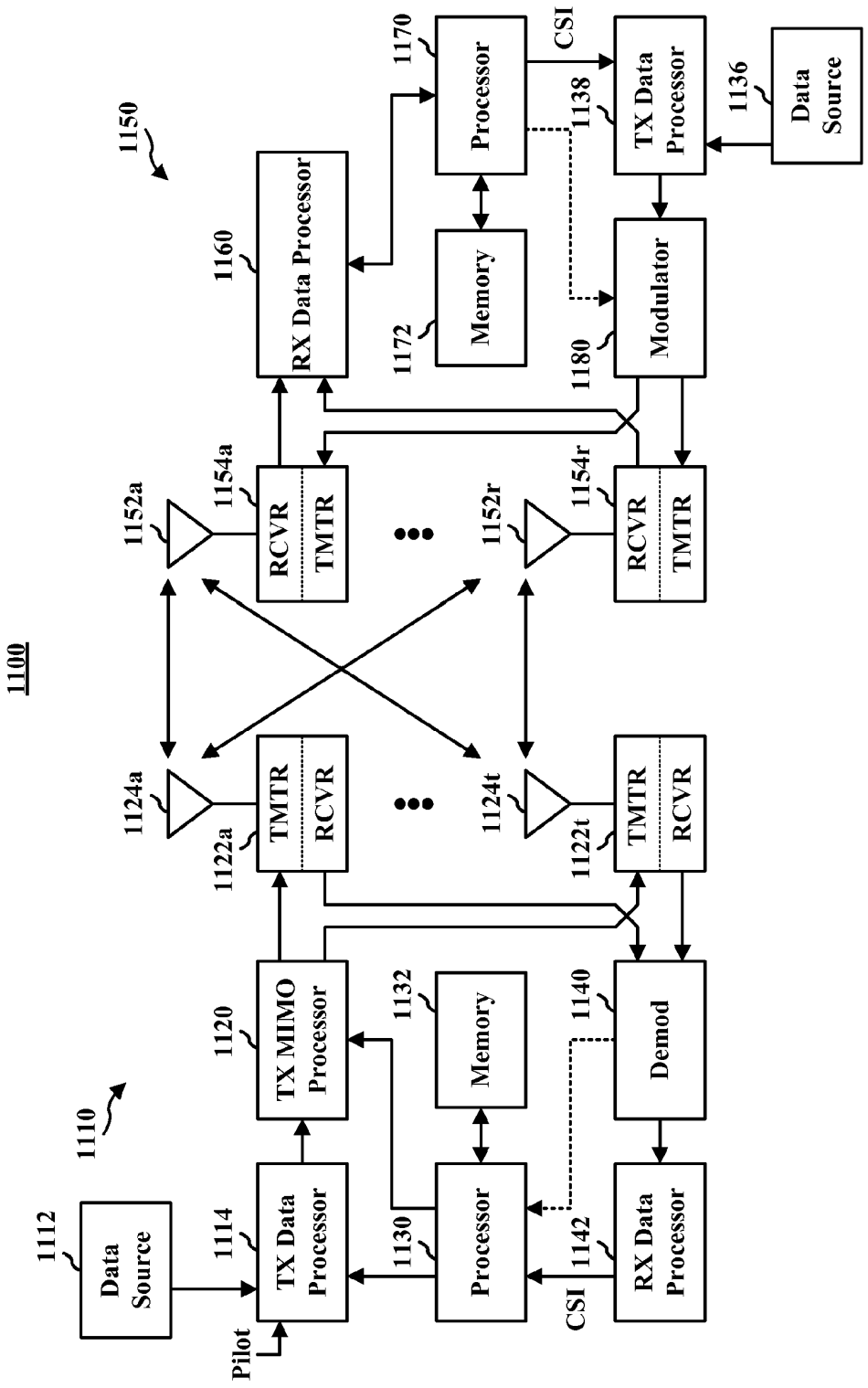

1100
1110
1112
Data Source
1114
TX Data Processor
Pilot
1120
TX MIMO Processor
1122a
TMTR
RCVR
1124a
1130
Processor
1132
Memory
1140
Demod
1142
RX Data Processor
CSI
1150
1152a
1154a
RCVR
TMTR
1152r
1154r
RCVR
TMTR
1160
RX Data Processor
1170
Processor
CSI
1172
Memory
1180
Modulator
1136
Data Source
1138
TX Data Processor
1122t
TMTR
RCVR
1124t

FIG. 11

840

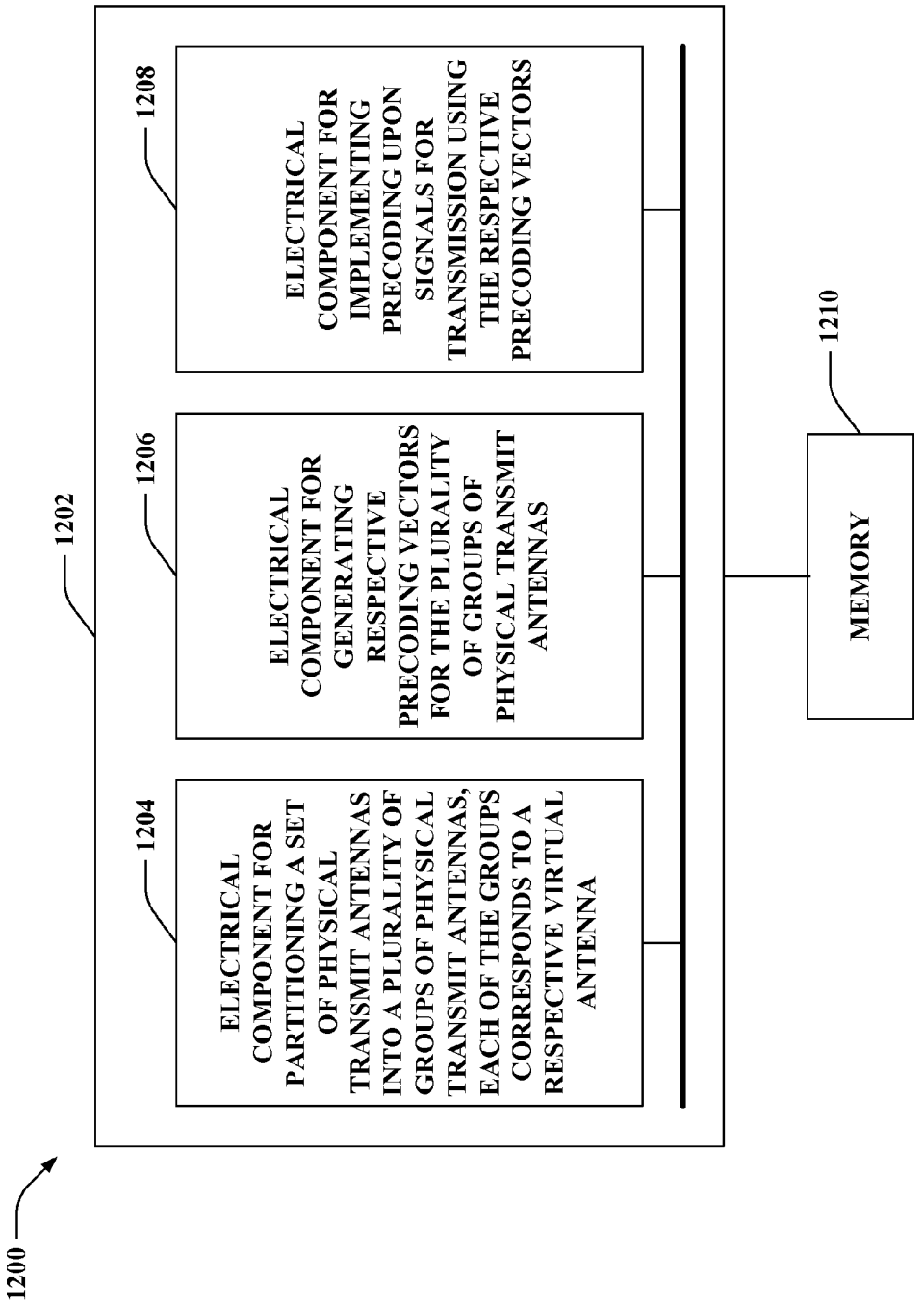

1200
1202
1204
ELECTRICAL COMPONENT FOR PARTITIONING A SET OF PHYSICAL TRANSMIT ANTENNAS INTO A PLURALITY OF GROUPS OF PHYSICAL TRANSMIT ANTENNAS, EACH OF THE GROUPS CORRESPONDS TO A RESPECTIVE VIRTUAL ANTENNA
1206
ELECTRICAL COMPONENT FOR GENERATING RESPECTIVE PRECODING VECTORS FOR THE PLURALITY OF GROUPS OF PHYSICAL TRANSMIT ANTENNAS
1208
ELECTRICAL COMPONENT FOR IMPLEMENTING PRECODING UPON SIGNALS FOR TRANSMISSION USING THE RESPECTIVE PRECODING VECTORS
1210
MEMORY

FIG. 12

841

ANTENNA VIRTUALIZATION IN A WIRELESS COMMUNICATION ENVIRONMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/149,325 entitled "A METHOD AND APPARATUS FOR MAPPING VIRTUAL ANTENNA'S IN A WIRELESS COMMUNICATION SYSTEM" which was filed Feb. 2, 2009. The entirety of the aforementioned application is herein incorporated by reference.

BACKGROUND

[0002] I. Field

[0003] The following description relates generally to wireless communications, and more particularly to implementing antenna virtualization in a wireless communication system.

[0004] II. Background

[0005] Wireless communication systems are widely deployed to provide various types of communication; for instance, voice and/or data can be provided via such wireless communication systems. A typical wireless communication system, or network, can provide multiple users access to one or more shared resources (e.g., bandwidth, transmit power, . . .). For instance, a system can use a variety of multiple access techniques such as Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM), Code Division Multiplexing (CDM), Orthogonal Frequency Division Multiplexing (OFDM), and others.

[0006] Generally, wireless multiple-access communication systems can simultaneously support communication for multiple user equipments (UEs). Each UE can communicate with one or more base stations via transmissions on forward and reverse links. The forward link (or downlink) refers to the communication link from base stations to UEs, and the reverse link (or uplink) refers to the communication link from UEs to base stations. This communication link can be established via a single-in-single-out, a multiple-in-single-out or a multiple-in-multiple-out (MIMO) system.

[0007] MIMO systems commonly employ multiple (N_T) transmit antennas and multiple (N_R) receive antennas for data transmission. A MIMO channel formed by the N_T transmit and N_R receive antennas can be decomposed into N_S independent channels, which can be referred to as spatial channels, where $N_S \leqq \{N_T, N_R\}$. Each of the N_S independent channels corresponds to a dimension. Moreover, MIMO systems can provide improved performance (e.g., increased spectral efficiency, higher throughput and/or greater reliability) if the additional dimensionalities created by the multiple transmit and receive antennas are utilized.

[0008] MIMO systems can support various duplexing techniques to divide forward and reverse link communications over a common physical medium. For instance, frequency division duplex (FDD) systems can utilize disparate frequency regions for forward and reverse link communications. Further, in time division duplex (TDD) systems, forward and reverse link communications can employ a common frequency region so that the reciprocity principle allows estimation of the forward link channel from the reverse link channel.

[0009] Wireless communication systems oftentimes employ one or more base stations that provide a coverage area. A typical base station can transmit multiple data streams for broadcast, multicast and/or unicast services, wherein a data stream may be a stream of data that can be of independent reception interest to a UE. A UE within the coverage area of such base station can be employed to receive one, more than one, or all the data streams carried by the composite stream. Likewise, a UE can transmit data to the base station or another UE.

[0010] A wireless communication apparatus (e.g., UE, base station, . . .) can be equipped with a plurality of physical transmit antennas. Oftentimes, respective signals are provided to utilize the plurality of physical transmit antennas. Thus, for instance, four signals can be provided to employ four physical transmit antennas (e.g., each physical transmit antenna sends a respective one of the four signals, . . .). However, significant overhead can result from the foregoing. Moreover, employment of a subset of the plurality of physical transmit antennas can result in inefficient utilization of the physical transmit antennas, power amplifiers (PAs) associated with the physical transmit antennas, and so forth. According to another illustration, a receiving wireless communication apparatus (e.g., UE, base station, . . .) can be unable to receive and/or process the plurality of signals sent by the plurality of physical transmit antennas. Following this illustration, the number of physical transmit antennas with which the wireless communication apparatus is equipped can exceed a number of physical transmit antennas supported by the receiving wireless communication apparatus.

SUMMARY

[0011] The following presents a simplified summary of one or more embodiments in order to provide a basic understanding of such embodiments. This summary is not an extensive overview of all contemplated embodiments, and is intended to neither identify key or critical elements of all embodiments nor delineate the scope of any or all embodiments. Its sole purpose is to present some concepts of one or more embodiments in a simplified form as a prelude to the more detailed description that is presented later.

[0012] In accordance with one or more embodiments and corresponding disclosure thereof, various aspects are described in connection with facilitating performance of antenna virtualization in a wireless communication environment. A set of physical transmit antennas can be partitioned into a plurality of groups of physical transmit antennas. Further, a precoding vector for a particular group of physical transmit antennas from the plurality of groups of physical transmit antennas can be formulated. Moreover, the particular group of physical transmit antennas can form a particular virtual antenna. By way of another example, a disparate precoding vector for a disparate group of physical transmit antennas from the plurality of groups of physical transmit antennas can be formulated, and the disparate group of physical transmit antennas can form a disparate virtual antenna. The precoding vector can be applied to a signal for transmission over the particular virtual antenna, and the disparate precoding vector can be applied to a disparate signal for transmission over the disparate virtual antenna.

[0013] According to related aspects, a method that facilitates implementing antenna virtualization in a wireless communication environment is described herein. The method can include partitioning a set of physical transmit antennas into a plurality of groups of physical transmit antennas. Further, the method can include formulating a precoding vector for a

particular group of physical transmit antennas from the plurality of groups of physical transmit antennas, the particular group of physical transmit antennas forms a particular virtual antenna. Moreover, the method can comprise applying the precoding vector to a signal for transmission over the particular virtual antenna.

[0014] Another aspect relates to a wireless communications apparatus. The wireless communications apparatus can include a memory that retains instructions related to partitioning a set of physical transmit antennas into a plurality of groups of physical transmit antennas, generating a precoding vector for a particular group of physical transmit antennas from the plurality of groups of physical transmit antennas, wherein the particular group of physical transmit antennas forms a particular virtual antenna, and applying the precoding vector to a signal for transmission over the particular virtual antenna. Further, the wireless communications apparatus can include a processor, coupled to the memory, configured to execute the instructions retained in the memory.

[0015] Yet another aspect relates to a wireless communications apparatus that enables effectuating antenna virtualization in a wireless communication environment. The wireless communications apparatus can include means for partitioning a set of physical transmit antennas into a plurality of groups of physical transmit antennas, each of the groups corresponds to a respective virtual antenna. Further, the wireless communications apparatus can comprise means for generating respective precoding vectors for the plurality of groups of physical transmit antennas. Moreover, the wireless communications apparatus can include means for implementing precoding upon signals for transmission using the respective precoding vectors.

[0016] Still another aspect relates to a computer program product that can comprise a computer-readable medium. The computer-readable medium can include code for partitioning a set of physical transmit antennas into a plurality of groups of physical transmit antennas, each of the groups corresponds to a respective virtual antenna. Moreover, the computer-readable medium can include code for generating respective precoding vectors for the plurality of groups of physical transmit antennas. Further, the computer-readable medium can include code for implementing precoding upon signals for transmission using the respective precoding vectors.

[0017] In accordance with another aspect, a wireless communications apparatus can include a processor, wherein the processor can be configured to partition a set of physical transmit antennas into a plurality of groups of physical transmit antennas. Moreover, the processor can be configured to formulate a precoding vector for a particular group of physical transmit antennas from the plurality of groups of physical transmit antennas, the particular group of physical transmit antennas forms a particular virtual antenna. Further, the processor can be configured to apply the precoding vector to a signal for transmission over the particular virtual antenna.

[0018] Toward the accomplishment of the foregoing and related ends, the one or more embodiments comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth herein detail certain illustrative aspects of the one or more embodiments. These aspects are indicative, however, of but a few of the various ways in which the principles of various embodiments can be employed and the described embodiments are intended to include all such aspects and their equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. **1** is an illustration of a wireless communication system in accordance with various aspects set forth herein.

[0020] FIG. **2** is an illustration of an example system that employs antenna virtualization in a wireless communication environment.

[0021] FIG. **3** is an illustration of an example system that formulates a precoding vector corresponding to a virtual antenna in a wireless communication environment.

[0022] FIG. **4** is an illustration of an example system that performs antenna virtualization at a UE in a wireless communication environment.

[0023] FIG. **5** is an illustration of example system that performs antenna virtualization at a base station in a wireless communication environment.

[0024] FIG. **6** is an illustration of an example system that employs virtual antenna ports for sending signals in a wireless communication environment.

[0025] FIG. **7** is an illustration of an example methodology that facilitates implementing antenna virtualization in a wireless communication environment.

[0026] FIG. **8** is an illustration of an example methodology that facilitates allowing for legacy compatible design by leveraging antenna virtualization in a wireless communication environment.

[0027] FIG. **9** is an illustration of an example UE that employs antenna virtualization in a wireless communication system.

[0028] FIG. **10** is an illustration of an example system that establishes and utilizes virtual antennas in a wireless communication environment.

[0029] FIG. **11** is an illustration of an example wireless network environment that can be employed in conjunction with the various systems and methods described herein.

[0030] FIG. **12** is an illustration of an example system that enables effectuating antenna virtualization in a wireless communication environment.

DETAILED DESCRIPTION

[0031] Various embodiments are now described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of one or more embodiments. It may be evident, however, that such embodiment(s) may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to facilitate describing one or more embodiments.

[0032] As used in this application, the terms "component," "module," "system," and the like are intended to refer to a computer-related entity, either hardware, firmware, a combination of hardware and software, software, or software in execution. For example, a component can be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and/or a computer. By way of illustration, both an application running on a computing device and the computing device can be a component. One or more components can reside within a

process and/or thread of execution and a component can be localized on one computer and/or distributed between two or more computers. In addition, these components can execute from various computer readable media having various data structures stored thereon. The components can communicate by way of local and/or remote processes such as in accordance with a signal having one or more data packets (e.g., data from one component interacting with another component in a local system, distributed system, and/or across a network such as the Internet with other systems by way of the signal).

[0033] The techniques described herein can be used for various wireless communication systems such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal frequency division multiple access (OFDMA), single carrier-frequency division multiple access (SC-FDMA) and other systems. The terms "system" and "network" are often used interchangeably. A CDMA system can implement a radio technology such as Universal Terrestrial Radio Access (UTRA), CDMA2000, etc. UTRA includes Wideband-CDMA (W-CDMA) and other variants of CDMA. CDMA2000 covers IS-2000, IS-95 and IS-856 standards. A TDMA system can implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA system can implement a radio technology such as Evolved UTRA (E-UTRA), Ultra Mobile Broadband (UMB), IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, etc. UTRA and E-UTRA are part of Universal Mobile Telecommunication System (UMTS). 3GPP Long Term Evolution (LTE) is an upcoming release of UMTS that uses E-UTRA, which employs OFDMA on the downlink and SC-FDMA on the uplink. UTRA, E-UTRA, UMTS, LTE and GSM are described in documents from an organization named "3rd Generation Partnership Project" (3GPP). Additionally, CDMA2000 and UMB are described in documents from an organization named "3rd Generation Partnership Project 2" (3GPP2). Further, such wireless communication systems can additionally include peer-to-peer (e.g., mobile-to-mobile) ad hoc network systems often using unpaired unlicensed spectrums, 802.xx wireless LAN, BLUETOOTH and any other short- or long- range, wireless communication techniques.

[0034] Single carrier frequency division multiple access (SC-FDMA) utilizes single carrier modulation and frequency domain equalization. SC-FDMA has similar performance and essentially the same overall complexity as those of an OFDMA system. A SC-FDMA signal has lower peak-to-average power ratio (PAPR) because of its inherent single carrier structure. SC-FDMA can be used, for instance, in uplink communications where lower PAPR greatly benefits UEs in terms of transmit power efficiency. Accordingly, SC-FDMA can be implemented as an uplink multiple access scheme in 3GPP Long Term Evolution (LTE) or Evolved UTRA.

[0035] Furthermore, various embodiments are described herein in connection with a user equipment (UE). A UE can also be called a system, subscriber unit, subscriber station, mobile station, mobile, remote station, remote terminal, mobile device, user terminal, terminal, wireless communication device, user agent, user device, or access terminal A UE can be a cellular telephone, a cordless telephone, a Session Initiation Protocol (SIP) phone, a wireless local loop (WLL) station, a personal digital assistant (PDA), a handheld device having wireless connection capability, computing device, or other processing device connected to a wireless modem. Moreover, various embodiments are described herein in connection with a base station. A base station can be utilized for communicating with UE(s) and can also be referred to as an access point, Node B, Evolved Node B (eNodeB, eNB) or some other terminology.

[0036] Moreover, the term "or" is intended to mean an inclusive "or" rather than an exclusive "or." That is, unless specified otherwise, or clear from the context, the phrase "X employs A or B" is intended to mean any of the natural inclusive permutations. That is, the phrase "X employs A or B" is satisfied by any of the following instances: X employs A; X employs B; or X employs both A and B. In addition, the articles "a" and "an" as used in this application and the appended claims should generally be construed to mean "one or more" unless specified otherwise or clear from the context to be directed to a singular form.

[0037] Various aspects or features described herein can be implemented as a method, apparatus, or article of manufacture using standard programming and/or engineering techniques. The term "article of manufacture" as used herein is intended to encompass a computer program accessible from any computer-readable device, carrier, or media. For example, computer-readable media can include but are not limited to magnetic storage devices (e.g., hard disk, floppy disk, magnetic strips, etc.), optical disks (e.g., compact disk (CD), digital versatile disk (DVD), etc.), smart cards, and flash memory devices (e.g., EPROM, card, stick, key drive, etc.). Additionally, various storage media described herein can represent one or more devices and/or other machine-readable media for storing information. The term "machine-readable medium" can include, without being limited to, wireless channels and various other media capable of storing, containing, and/or carrying instruction(s) and/or data.

[0038] Referring now to FIG. **1**, a system **100** is illustrated in accordance with various embodiments presented herein. System **100** comprises a base station **102** that can include multiple antenna groups. For example, one antenna group can include antennas **104** and **106**, another group can comprise antennas **108** and **110**, and an additional group can include antennas **112** and **114**. Two antennas are illustrated for each antenna group; however, more or fewer antennas can be utilized for each group. Base station **102** can additionally include a transmitter chain and a receiver chain, each of which can in turn comprise a plurality of components associated with signal transmission and reception (e.g., processors, modulators, multiplexers, demodulators, demultiplexers, antennas, etc.), as will be appreciated by one skilled in the art.

[0039] Base station **102** can communicate with one or more user equipments (UEs) such as UE **116** and UE **122**; however, it is to be appreciated that base station **102** can communicate with substantially any number of UEs similar to UEs **116** and **122**. UEs **116** and **122** can be, for example, cellular phones, smart phones, laptops, handheld communication devices, handheld computing devices, satellite radios, global positioning systems, PDAs, and/or any other suitable device for communicating over system **100**. As depicted, UE **116** is in communication with antennas **112** and **114**, where antennas **112** and **114** transmit information to UE **116** over a forward link **118** and receive information from UE **116** over a reverse link **120**. Moreover, UE **122** is in communication with antennas **104** and **106**, where antennas **104** and **106** transmit information to UE **122** over a forward link **124** and receive information from UE **122** over a reverse link **126**. In a frequency

division duplex (FDD) system, forward link **118** can utilize a different frequency band than that used by reverse link **120**, and forward link **124** can employ a different frequency band than that employed by reverse link **126**, for example. Further, in a time division duplex (TDD) system, forward link **118** and reverse link **120** can utilize a common frequency band and forward link **124** and reverse link **126** can utilize a common frequency band.

[0040] Each group of antennas and/or the area in which they are designated to communicate can be referred to as a sector of base station **102**. For example, antenna groups can be designed to communicate to UEs in a sector of the areas covered by base station **102**. In communication over forward links **118** and **124**, the transmitting antennas of base station **102** can utilize beamforming to improve signal-to-noise ratio of forward links **118** and **124** for UEs **116** and **122**. Also, while base station **102** utilizes beamforming to transmit to UEs **116** and **122** scattered randomly through an associated coverage, UEs in neighboring cells can be subject to less interference as compared to a base station transmitting through a single antenna to all its UEs.

[0041] According to an example, a UE (e.g., UE **116**, UE **122**, . . .) can include multiple physical transmit antennas. Conventional UEs oftentimes include one physical transmit antenna; thus, such common UEs typically send a signal over the one physical transmit antenna. In contrast, UE **116** and/or UE **122** can include multiple physical transmit antennas (e.g., two, four, any integer greater than 1, . . .). For instance, UE **116** and/or UE **122** can be Long Term Evolution—Advanced (LTE-A) UEs, which include the multiple physical transmit antennas.

[0042] UE **116** and/or UE **122** can create virtual antenna(s) by implementing precoding. Establishing virtual antenna(s) by applying precoding can enable utilizing power amplifiers (PAs) associated with the multiple physical transmit antennas efficiently while transmitting over the virtual antenna(s). By way of illustration, a UE (e.g., UE **116**, UE **122**, . . .) can include two physical transmit antennas, each of which can be associated with a respective PA. If a virtual antenna is not established and the UE has one signal to send over one of the two physical transmit antennas, then one of the two PAs is utilized while the other PA remains unused; hence, resources of the UE are inefficiently employed. Instead, the UE can virtualize the two physical transmit antennas to be a single virtual antenna. Further, the UE can send one signal over the single virtual antenna, which leads to the signal being transmitted over the two physical transmit antennas using the two PAs associated therewith. Accordingly, resources of the UE can be more efficiently utilized as compared to conventional techniques that fail to leverage virtual antenna(s). Moreover, the two physical transmit antennas that form the virtual antenna can appear to be a single antenna from an offsite point of view (e.g., from a perspective of base station **102** which receives the signal from the UE, . . .). It is to be appreciated, however, that the claimed subject matter is not limited to the aforementioned illustration.

[0043] By way of another example, base station **102** can include multiple physical transmit antennas. The number of physical transmit antennas of base station **102** can be larger than a number of antennas advertised to UE **116** and/or UE **122** (e.g., legacy UE(s), LTE-A UE(s), . . .). Thus, base station **102** can implement antenna virtualization to benefit from full power utilization of PAs associated with the multiple physical transmit antennas and to allow for legacy compatible design.

[0044] As set forth herein, a wireless communication apparatus (e.g., base station **102**, UE **116**, UE **122**, . . .) can establish virtual antenna(s) from a plurality of physical transmit antennas. Moreover, antenna virtualization can be transparent to a receiving wireless communication apparatus (e.g., UE **116**, UE **122**, base station **102**, . . .); thus, the receiving wireless communication apparatus can be unaware of antenna virtualization being effectuated by the wireless communication apparatus, precoding performed by the wireless communication apparatus, and the like. For example, formation of virtual antenna(s) by base station **102** can be transparent to UE **116** and/or UE **122**. Similarly, for instance, establishment of virtual antenna(s) by a UE (e.g., UE **116**, UE **122**, . . .) can be transparent to base station **102**.

[0045] By way of another example, antenna virtualization can be non-transparent. Thus, the wireless communication apparatus that forms the virtual antenna(s) can indicate that antenna virtualization is employed, specify precoding that is utilized, etc. to the receiving wireless communication apparatus. Additionally or alternatively, the receiving wireless communication apparatus can control virtualization details (e.g., via signaling, . . .), and hence, can be aware of the virtualization details implemented by the wireless communication apparatus that forms the virtual antenna(s).

[0046] Now turning to FIG. **2**, illustrated is a system **200** that employs antenna virtualization in a wireless communication environment. System **200** includes a wireless communication apparatus **202** that transmits information, signals, data, instructions, commands, bits, symbols, and the like over a channel (e.g., uplink, downlink, . . .) to a receiving wireless communication apparatus (not shown). Wireless communication apparatus **202**, for instance, can be a base station (e.g., base station **102** of FIG. **1**, . . .), a UE (e.g., UE **116** of FIG. **1**, UE **122** of FIG. **1**, . . .), or the like. Moreover, the receiving wireless communication apparatus can be, for example, a UE (e.g., UE **116** of FIG. **1**, UE **122** of FIG. **1**, . . .), a base station (e.g., base station **102** of FIG. **1**, . . .), etc.

[0047] Wireless communication apparatus **202** can further include an antenna virtualization component **204** and a plurality of physical transmit antennas. Wireless communication apparatus **202** can include T physical transmit antennas (e.g., a physical transmit antenna **1 206**, . . . , and a physical transmit antenna T **208**), where T can be substantially any integer greater than 1. The T physical transmit antennas, including physical transmit antenna **1 206**, . . . , and physical transmit antenna T **208**, is hereinafter referred to as physical transmit antennas **206-208**. Further, antenna virtualization component **204** can support a number of virtual antennas. For instance, the number of virtual antennas provided by antenna virtualization component **204** can be less than or equal to the number of physical transmit antennas **206-208** (e.g., the number of virtual antennas is an integer less than or equal to T, . . .).

[0048] Antenna virtualization component **204** can implement precoding to efficiently utilize physical transmit antennas **206-208**, as well as PAs respectively associated with physical transmit antennas **206-208**. For example, antenna virtualization component **204** can employ a corresponding precoding vector for a virtual antenna supported thereby. Thus, if two virtual antennas are formed, then antenna virtualization component **204** can utilize two precoding vectors, where each of the virtual antennas is associated with a respective one of the precoding vectors; however, it is to be appreciated that the claimed subject matter is not so limited. A precoding vector can be used to formulate a virtual antenna

from a plurality of physical transmit antennas **206-208** (e.g., the set of physical transmit antennas **206-208**, a subset from the set of physical transmit antennas **206-208**, . . .).

[0049] By way of example, wireless communication apparatus **202** can include two physical transmit antennas (e.g., physical transmit antenna **1 206** and physical transmit antenna T **208**, . . .). Moreover, antenna virtualization component **204** can support one virtual antenna formed from the two physical transmit antennas, and thus, can employ one precoding vector. For instance, the precoding vector for the virtual antenna can be a 2-by-1 vector such as [α β]. Following this example, a signal, X, to be sent upon the virtual antenna can be received by antenna virtualization component **204**. Antenna virtualization component **204** can apply the precoding vector to the signal, X. Thus, antenna virtualization component **204** can multiply the signal, X, times α to yield a first output signal to be sent upon a first physical transmit antenna (e.g., physical transmit antenna **1 206**, . . .). Moreover, antenna virtualization component **204** can multiply the signal, X, times β to yield a second output signal to be sent upon a second physical transmit antenna (e.g., physical transmit antenna T **208**, . . .). At a receiver side, a receiving wireless communication apparatus (not shown) can effectively see one transmit antenna after channel combining (e.g., if the receiving wireless communication apparatus has one receive antenna, . . .). It is contemplated, however, that the claimed subject matter is not limited to the foregoing example.

[0050] With reference to FIG. **3**, illustrated is a system **300** that formulates a precoding vector corresponding to a virtual antenna in a wireless communication environment. System **300** includes wireless communication apparatus **202**, which can send signal(s) over a channel (e.g., uplink, downlink, . . .). Wireless communication apparatus **202** can include antenna virtualization component **204** and a plurality of physical transmit antennas (e.g., physical transmit antenna **1 206**, . . . , and physical transmit antenna T **208**).

[0051] Wireless communication apparatus **202** can further include a precoding vector generation component **302** that can formulate a precoding vector for a virtual antenna. For example, precoding vector generation component **302** can select a number of virtual antennas to be formed from the T physical transmit antennas **206-208**. Moreover, precoding vector generation component **302** can generate a respective precoding vector for each virtual antenna to be formed.

[0052] According to an illustration where wireless communication apparatus **202** is a UE, virtualization details including the number of virtual antennas to be formed and the precoding vector for each virtual antenna can be initiated by the UE itself by precoding vector generation component **302**. Additionally or alternatively, such virtualization details can be semi-statically signaled by a base station and received by the UE (e.g., wireless communication apparatus **202**, . . .). Thus, precoding vector generation component **302** (and/or antenna virtualization component **204**, . . .) can collect received information specifying the number of virtual antennas to be formed and/or the precoding vector for each virtual antenna.

[0053] Pursuant to another illustration, wireless communication apparatus **202** can be a base station. Accordingly, the base station can employ precoding vector generation component **302** to yield the virtualization details including the number of virtual antennas to be formed and the precoding vector for each virtual antenna.

[0054] Although not shown, precoding vector(s) yielded, collected, etc. by precoding vector generation component **302** can be retained in memory of wireless communication apparatus **202**. Further, the precoding vector(s) can be retrieved by antenna virtualization component **204** when implementing precoding as described herein. Memory can store data to be transmitted, received data, and any other suitable information related to performing the various actions and functions set forth herein. It will be appreciated that the data store (e.g., memory, . . .) described herein can be either volatile memory or nonvolatile memory, or can include both volatile and nonvolatile memory. By way of illustration, and not limitation, nonvolatile memory can include read only memory (ROM), programmable ROM (PROM), electrically programmable ROM (EPROM), electrically erasable PROM (EEPROM), or flash memory. Volatile memory can include random access memory (RAM), which acts as external cache memory. By way of illustration and not limitation, RAM is available in many forms such as synchronous RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDR SDRAM), enhanced SDRAM (ESDRAM), Synchlink DRAM (SLDRAM), and direct Rambus RAM (DRRAM). Memory of the subject systems and methods is intended to comprise, without being limited to, these and any other suitable types of memory.

[0055] Now turning to FIG. **4**, illustrated is a system **400** that performs antenna virtualization at a UE in a wireless communication environment. System **400** includes a UE **402** (e.g., wireless communication apparatus **202** of FIG. **2**, . . .) and a base station **404** (e.g., a receiving wireless communication apparatus, . . .). UE **402** can transmit and/or receive information, signals, data, instructions, commands, bits, symbols, and the like. UE **402** can communicate with base station **404** via the forward link and/or reverse link. Base station **404** can transmit and/or receive information, signals, data, instructions, commands, bits, symbols, and the like. Moreover, although not shown, it is contemplated that any number of UEs similar to UE **402** can be included in system **400** and/or any number of base stations similar to base station **404** can be included in system **400**.

[0056] UE **402** includes multiple physical transmit antennas (e.g., physical transmit antenna **1 206**, . . . , and physical transmit antennas T **208**). Further, UE **402** can include precoding vector generation component **302** and antenna virtualization component **204**. According to an example, virtual antenna(s) can be created by precoding vector generation component **302** by yielding precoding vector(s). For instance, L precoding vectors can be established by precoding vector generation component **302** (e.g., precoding vector **1**, . . . , and precoding vector L), where L can be substantially any integer less than or equal to T (e.g., where T is the number of physical transmit antennas **206-208**, . . .). Although not shown, it is contemplated that one precoding vector can be created by precoding vector generation component **302**. The precoding vector(s) provided by precoding vector generation component **302** can enable utilizing PAs efficiently while transmitting over the virtual antenna(s).

[0057] According to an example, virtualization details including the number of virtual antennas to be formed and the precoding vector for each virtual antenna can be initiated by UE **402** itself via employing precoding vector generation component **302**. Additionally or alternatively, such virtualization details can be semi-statically signaled by base station **404** to UE **402**. Hence, precoding vector generation compo-

nent **302** (and/or antenna virtualization component **204**, . . .) can collect received information specifying the number of virtual antennas to be formed and/or the precoding vector for each virtual antenna.

[0058] By way of a further example, details on the precoding to form virtual antenna(s) can be transparent to base station **404**. Thus, UE **402** can employ virtual antenna(s) by implementing precoding without indicating to base station **404** that such virtualization is being effectuated. However, it is also contemplated that antenna virtualization performed by UE **402** can be non-transparent to base station **404**, and thus, base station **404** can have knowledge of the antenna virtualization performed by UE **402**.

[0059] UE **402** can transmit information, signals, data, instructions, commands, bits, symbols, and the like over the uplink to base station **404**. The uplink waveform can be a Discrete Fourier Transform (DFT)-precoded OFDM waveform (e.g., a single carrier FDM (SC-FDM) waveform, . . .). A single carrier waveform can have a lower peak-to-average power ratio compared to a multi-carrier waveform, which can result in higher efficiency of a PA. Thus, precoding vector generation component **302** can try to reduce a chance of generating a multi-carrier waveform at physical transmit antennas **206-208** as much as possible while forming the virtual antenna(s). Accordingly, precoding vector generation component **302** can adopt various rules as described herein for yielding antenna-selection based precoding vector(s).

[0060] Precoding vector generation component **302** can form group(s) from physical transmit antennas **206-208** as follows, where a group corresponds to a particular virtual antenna. Assume that precoding vector generation component **302** is to form L virtual antennas from T physical transmit antennas **206-208**. Thus, precoding vector generation component **302** can partition the T physical transmit antennas **206-208** into L groups. Group i determines physical transmit antenna(s) from the T physical transmit antennas **206-208** (e.g., a subset of the T physical transmit antennas **206-208**, . . .) that are used to form a virtual antenna i, where i is an index and i=0, 1, . . . , L−1.

[0061] Moreover, precoding vector generation component **302** can formulate precoding vector(s) for the group(s). Precoding vector generation component **302** can yield a precoding vector in accordance with a particular group, where the precoding vector is a unit norm T-by-1 vector with non-zero entries corresponding to physical transmit antennas in the particular group that participate in forming a particular virtual antenna.

[0062] According to an example, assume that two virtual antennas (e.g., L=2, . . .) are to be formed from four physical transmit antennas **206-208** (e.g., T=4, . . .). The two virtual antennas can include virtual antenna **1** and virtual antenna **2**, and the four physical transmit antennas can include physical transmit antenna **1**, physical transmit antenna **2**, physical transmit antenna **3**, and physical transmit antennas **4**. Following this example, an example grouping that can be formed by precoding vector generation component **302** can be {{3, 4} {1, 2}}, where a first group corresponding to virtual antenna **1** includes physical transmit antenna **3** and physical transmit antenna **4**, and a second grouping corresponding to virtual antenna **2** includes physical transmit antenna **1** and physical transmit antenna **2**. Further, precoding vector generation component **302** can formulate a first precoding vector (e.g., precoding vector **1**, . . .) for virtual antenna **1** such as: [0 0 e^{jD1} e^{jD2}]/sqrt(2), and a second precoding vector (e.g., precoding vector **2**, . . .) for virtual antenna **2** such as: [e^{jD3} e^{jD4} 0 0]/sqrt(2), where phase values can be different for different frequency tones (e.g., resources, . . .) and/or can change in time. It is to be appreciated, however, that the claimed subject matter is not limited to the foregoing example.

[0063] By way of another example, two virtual antennas (e.g., L=2, . . .) can be formed from four physical transmit antennas **206-208** (e.g., T=4, . . .). Again, the two virtual antennas can include virtual antenna **1** and virtual antenna **2**, and the four physical transmit antennas can include physical transmit antenna **1**, physical transmit antenna **2**, physical transmit antenna **3**, and physical transmit antennas **4**. For instance, precoding vector generation component **302** can yield two precoding vectors, each with a size of T-by-1 (e.g., 4-by-1, . . .). A precoding vector **1** for virtual antenna **1** formulated by precoding vector generation component **302** can be [α β γ δ], and a precoding vector **2** for virtual antennas **2** formulated by precoding vector generation component **302** can be [a b c d]. Moreover, a first signal, X, can be sent over virtual antenna **1**, which uses precoding vector **1**, [α β γ δ], while a second signal, Y, can be simultaneously sent over virtual antenna **1**, which uses precoding vector **2**, [a b c d]. Thus, antenna virtualization component **204** can implement precoding upon the first signal, X, and the second signal, Y, utilizing precoding vector **1** and precoding vector **2**. Accordingly, X times α plus Y times a can be sent over physical transmit antenna **1**, X times β plus Y times b can be sent over physical transmit antenna **2**, X times γ plus Y times c can be sent over physical transmit antenna **3**, and X times δ plus Y times d can be sent over physical transmit antenna **4**. To maintain the single carrier nature of the DFT-precoded OFDM waveform transmitted over the uplink by UE **402** to base station **404**, a or α is zero, β or b is zero, γ or c is zero, and δ or d is zero. Accordingly, each physical transmit antenna **206-208** can be used for one virtual antenna (e.g., virtual antenna **1** or virtual antenna **2** in the aforementioned example, . . .) so that transmission of multiple signals over one physical transmit antenna can be avoided; hence, each physical transmit antenna **206-208** can transmit a single carrier waveform regardless whether different signals are simultaneously transmitted over different virtual antennas. It is to be appreciated, however, that the claimed subject matter is not limited to the foregoing example.

[0064] Precoding vector generation component **302** can cause a virtual antenna that is formed to occupy a subset of physical transmit antennas **206-208**. Over all physical transmit antenna(s), non-zero value(s) can be included at corresponding position(s) corresponding to the subset of physical transmit antenna(s) within a precoding vector formed for the virtual antenna. Moreover, for physical transmit antenna(s) that are not included in the subset, zero value(s) can be included at corresponding position(s) within the precoding vector formed for the virtual antenna.

[0065] Moreover, after virtual antennas have been formed, the virtual antennas can be considered to be physical transmit antennas from a point of view of data, a reference signal, and control. For instance, if UE **402** has four physical transmit antennas **206-208**, precoding vector generation component **302** can virtualize the four physical transmit antennas **206-208** into two virtual antennas. After effectuating the virtualization, UE **402** can be treated as having two transmit antennas (e.g., two virtual antennas, . . .) even though it actually has four physical transmit antennas **206-208**. Further, base station **404** can view UE **402** as having two transmit antennas (e.g.,

two virtual antennas, . . .), and different reference signals, control, data, etc. can be received from the two transmit antennas of UE **402**.

[0066] Referring to FIG. **5**, illustrated is a system **500** that performs antenna virtualization at a base station in a wireless communication environment. System **500** includes a base station **502** (e.g., wireless communication apparatus **202** of FIG. **2**, base station **404** of FIG. **4**, . . .) and a UE **504** (e.g., a receiving wireless communication apparatus, UE **402** of FIG. **4**, . . .). Base station **502** can transmit and/or receive information, signals, data, instructions, commands, bits, symbols, and the like. Base station **502** can communicate with UE **504** via the forward link and/or reverse link. UE **504** can transmit and/or receive information, signals, data, instructions, commands, bits, symbols, and the like. Moreover, although not shown, it is contemplated that any number of base stations similar to base station **502** can be included in system **500** and/or any number of UEs similar to UE **504** can be included in system **500**.

[0067] Base station **502** includes multiple physical transmit antennas (e.g., physical transmit antenna **1** **206**, . . . , and physical transmit antennas T **208**). Further, base station **502** can include precoding vector generation component **302** and antenna virtualization component **204**. According to an example, virtual antenna(s) can be created by precoding vector generation component **302** by yielding precoding vector (s). For instance, L precoding vectors can be established by precoding vector generation component **302** (e.g., precoding vector **1**, . . . , and precoding vector L), where L can be substantially any integer less than or equal to T (e.g., where T is the number of physical transmit antennas **206-208**, . . .). Although not shown, it is contemplated that one precoding vector can be created by precoding vector generation component **302**. The precoding vector(s) provided by precoding vector generation component **302** can enable utilizing PAs efficiently while transmitting over the virtual antenna(s), allowing base station **502** to benefit from full power utilization of the PAs.

[0068] Moreover, base station **502** can include an advertisement component **506** that can indicate a number of antennas to UE **504**. For instance, the indicated number of antennas can be a number of virtual antennas formed by precoding vector generation component **302** and/or utilized by antenna virtualization component **204**. A number of physical transmit antennas **206-208** included in base station **502** can be larger than a number of antennas advertised by advertisement component **506** to UE **504** (e.g., a legacy UE, a LTE-A UE, . . .). For instance, in LTE Release 8, a maximum number of downlink physical transmit antennas can be four, while in LTE-A, a maximum number of downlink physical transmit antennas can be eight. Thus, if UE **504** is a legacy UE (e.g., LTE Release 8 UE, . . .) operating in an LTE-A network where base station **502** includes eight physical transmit antennas **206-208** (e.g., T=8, . . .), then advertisement component **506** can signal to UE **504** that base station **502** includes four transmit antennas (or fewer than four transmit antennas). Hence, antenna virtualization can support legacy UEs by providing for legacy compatible design. It is to be appreciated, however, that the claimed subject matter is not limited to the aforementioned illustration.

[0069] Further, legacy UE(s) and non-legacy UE(s) (e.g., LTE-A UE(s), . . .) can coexist and operate in a common network. Antenna virtualization can be employed for legacy UE(s) (e.g., forming four or fewer virtual antennas from eight physical transmit antennas **206-208** of base station **502** for legacy UE(s), . . .). According to an example, antenna virtualization can be employed for non-legacy UE(s) (e.g., forming four or fewer virtual antennas from eight physical transmit antennas **206-208** of base station **502** for non-legacy UE(s), . . .). By way of another example, antenna virtualization need not be employed for non-legacy UE(s), while antenna virtualization is utilized for legacy UE(s). Thus, advertisement component **506** can indicate the number of physical transmit antennas **206-208** of base station **502** or the number of virtual antennas formulated by precoding vector generation component **302** and implemented by antenna virtualization component **204** to a non-legacy UE (e.g., UE **504**, . . .). Following the above illustration where advertisement component **506** signals to a legacy UE that base station **502** includes four (or fewer) transmit antennas (e.g., four or fewer virtual antennas, . . .) rather than eight physical transmit antennas **206-208**, advertisement component **506** can further signal to a non-legacy UE that base station **502** includes four (or fewer) transmit antennas (e.g., four or fewer virtual antennas, . . .) or eight transmit antennas (e.g., eight physical transmit antennas **206-208**, . . .).

[0070] Further, for a downlink scenario, virtualization can be transparent to UE **504**. Thus, UE **504** can lack knowledge of virtualization details employed by base station **502** such as, for instance, that virtualization is effectuated, precoding vector(s) employed, how precoding vector(s) are generated, and the like.

[0071] A waveform employed for the downlink can be an OFDM waveform. Thus, constraints utilized in connection with uplink antenna virtualization (as described in connection with FIG. **4**) need not be employed in system **500**. For instance, multiple signals can be transmitted simultaneously over a particular physical transmit antenna (e.g., from physical transmit antennas **206-208**, . . .), and hence, the waveform need not be a single carrier waveform. However, it is to be appreciated that the claimed subject matter is not so limited.

[0072] Precoding vector generation component **302** can virtualize physical transmit antennas **206-208** as follows. For instance, a mapping from physical transmit antennas **206-208** to virtual antenna(s) can be any unit norm precoding vector. The precoding vector(s) can be designed such that a dimensionality of a virtual channel is not reduced beyond a number of desired virtual antenna(s). For example, precoding vector generation component **302** can partition physical transmit antennas **206-208** into groups, where each group corresponds to one virtual antenna. Precoding vector generation component **302** can yield a precoding vector for each group. For instance, a precoding vector for a particular group can be a unit norm vector with non-zero entries corresponding to physical transmit antennas in the particular group that participate in that virtual antenna. By way of another illustration, precoding vector generation component **302** can utilize fixed precoding vectors (e.g., different columns of a DFT matrix as precoding vectors for virtual antennas, . . .).

[0073] Moreover, after virtual antennas have been formed, the virtual antennas can be considered to be physical transmit antennas from a point of view of data, a reference signal, and control. For instance, if base station **502** has four physical transmit antennas **206-208**, precoding vector generation component **302** can virtualize the four physical transmit antennas **206-208** into two virtual antennas. After effectuating the virtualization, base station **502** can be treated as having two transmit antennas (e.g., two virtual antennas, . . .)

even though it actually has four physical transmit antennas **206-208**. Further, UE **504** can view base station **502** as having two transmit antennas (e.g., two virtual antennas, . . .), and different reference signals, control, data, etc. can be received from the two transmit antennas of base station **502**.

[0074] Now referring to FIG. **6**, illustrated is a system **600** that employs virtual antenna ports for sending signals in a wireless communication environment. System **600** includes wireless communication apparatus **202** (e.g., UE **402** of FIG. **4**, base station **502** of FIG. **5**, . . .). Wireless communication apparatus **202** can further include antenna virtualization component **204** and multiple physical transmit antennas (e.g., physical transmit antenna **1 206**, . . . , and physical transmit antenna T **208**). Moreover, L virtual antennas can be formed from the multiple physical transmit antennas **206-208** (e.g., by precoding vector generation component **302** of FIG. **3**, . . .). Thus, wireless communication apparatus **202** can include L virtual antenna ports (e.g., virtual antenna port **1 602**, . . . , and virtual antenna port L **604**), which can be used to send respective signals.

[0075] According to an illustration, wireless communication apparatus **202** can include four physical transmit antennas **206-208** (e.g., T=4, . . .). Moreover, two virtual antennas (e.g., L=2, . . .) can be formed from the four physical transmit antennas **206-208**. Thus, wireless communication apparatus **202** can include two virtual antenna ports **602-604**. Further, a first signal to be sent over a first virtual antenna can be provided to a first virtual antenna port (e.g., virtual antenna port **1 602**, . . .) and a second signal to be sent over a second virtual antenna can be provided to a second virtual antenna port (e.g., virtual antenna port L **604**, . . .). Antenna virtualization component **204** can apply a first precoding vector (e.g., precoding vector **1**, . . .) to the first signal obtained by the first virtual antenna port and can apply a second precoding vector (e.g., precoding vector L, . . .) to the second signal obtained by the second virtual antenna port. Accordingly, two signals can be sent over the four physical transmit antennas **206-208** following the aforementioned illustration (e.g., which can lead to reduced overhead since fewer reference signals need to be generated by wireless communication apparatus **202** for transmission, . . .).

[0076] Moreover, precoding vectors described herein need not be constant over frequency. Virtualization can be a frequency dependent mapping to provide additional frequency diversity for frequency flat scenarios. Schemes like cyclic delay diversity (CDD) or frequency-dependent phase offset within each group are examples of frequency dependent mapping. Moreover, if wireless communication apparatus **202** is a base station (e.g., base station **502** of FIG. **5**, . . .), then in order to provide a legacy UE (not shown) (e.g., UE **504** of FIG. **5**, . . .) with reasonable channel estimation of the virtual antennas, the frequency dependent mapping can be smooth and may not change rapidly over frequency. Thus, to make a virtual antenna appear similar to a physical transmit antenna, a precoding vector can change smoothly over tones rather than arbitrarily changing over tones.

[0077] Referring to FIGS. **7-8**, methodologies relating to employing antenna virtualization in a wireless communication environment are illustrated. While, for purposes of simplicity of explanation, the methodologies are shown and described as a series of acts, it is to be understood and appreciated that the methodologies are not limited by the order of acts, as some acts can, in accordance with one or more embodiments, occur in different orders and/or concurrently with other acts from that shown and described herein. For example, those skilled in the art will understand and appreciate that a methodology could alternatively be represented as a series of interrelated states or events, such as in a state diagram. Moreover, not all illustrated acts can be required to implement a methodology in accordance with one or more embodiments.

[0078] With reference to FIG. **7**, illustrated is a methodology **700** that facilitates implementing antenna virtualization in a wireless communication environment. At **702**, a set of physical transmit antennas can be partitioned into a plurality of groups of physical transmit antennas. For example, the set of physical transmit antennas can include T physical transmit antennas, where T can be substantially any integer. Moreover, the set of T physical transmit antennas can be partitioned into L groups, where L can be substantially any integer less than or equal to T.

[0079] At **704**, a precoding vector can be formulated for a particular group of physical transmit antennas from the plurality of groups of physical transmit antennas. The particular group of physical transmit antennas can form a particular virtual antenna. Further, if the set of T physical transmit antennas are partitioned into L groups, then L precoding vectors can be formulated. Moreover, the L precoding vectors can correspond to L virtual antennas. According to an example, a disparate precoding vector for a disparate group of physical transmit antennas from the plurality of groups of physical transmit antennas can be formulated, wherein the disparate group of physical transmit antennas can form a disparate virtual antenna. At **706**, the precoding vector can be applied to a signal for transmission over the particular virtual antenna. Moreover, disparate precoding vector(s) corresponding to disparate virtual antenna(s) can be applied to disparate signal(s) for transmission over the disparate virtual antenna(s).

[0080] According to an example, the set of physical transmit antennas can be associated with a user equipment (UE), and the signal can be for transmission over an uplink to a base station. For instance, a number of virtual antennas to form can be selected (e.g., by the UE, . . .), where the number of virtual antennas can be a number of the groups into which the set of physical transmit antennas is partitioned. Further, the precoding vector for the particular group (and/or disparate precoding vector(s) for disparate group(s)) can be chosen (e.g., by the UE, . . .). By way of another illustration, an indication that specifies at least one of a number of virtual antennas to form (e.g., where the number of virtual antennas can be a number of the groups into which the set of physical transmit antennas is partitioned, . . .) or the precoding vector for the particular group (and/or disparate precoding vector(s) for disparate group(s)) can be received from the base station. Moreover, information related to antenna virtualization can be transparent to the base station. Further, a waveform sent over the uplink can be a single carrier waveform (e.g., a Discrete Fourier Transform (DFT)-precoded orthogonal frequency division multiplexing (OFDM) waveform, . . .). By way of another example, the precoding vector can be a unit norm vector of size T-by-1 with non-zero entries corresponding to physical transmit antennas in the particular group that forms the particular virtual antenna, where T is a number of physical transmit antennas in the set. Further, a remainder of entries in the T-by-1 unit norm vector (e.g., corresponding to physical transmit antennas not included in the particular group, corresponding to physical transmit antennas associated with a

differing virtual antenna, . . .) can be zero. Moreover, non-zero entries in the precoding vector can be constant. Further, non-zero entries in the precoding vector can be frequency dependent and/or time dependent.

[0081] By way of another example, the set of physical transmit antennas can be associated with a base station, and the signal can be for transmission over a downlink to a user equipment (UE). For instance, information related to antenna virtualization can be transparent to the UE. Pursuant to an example, the precoding vector can be a unit norm vector. In accordance with another example, the precoding vector can be a unit norm vector with non-zero entries corresponding to physical transmit antennas in the particular group that participate in the particular virtual antenna. Yet another example relates to the precoding vector being a particular column of a Discrete Fourier Transform (DFT) matrix, where different column(s) of the DFT matrix are utilized for disparate virtual antenna(s). Moreover, non-zero entries in the precoding vector can be constant. Further, non-zero entries in the precoding vector can be frequency dependent and/or time dependent.

[0082] Turning to FIG. **8**, illustrated is a methodology **800** that facilitates allowing for legacy compatible design by leveraging antenna virtualization in a wireless communication environment. At **802**, a set of virtual antennas can be established from a set of physical transmit antennas. For instance, the set of virtual antennas can be established by a base station. Moreover, the set of physical transmit antennas associated with the base station can include a larger number of physical transmit antennas as compared to a maximum number of physical transmit antennas that can be employed by a legacy base station. By way of example, the set of physical transmit antennas associated with the base station can include eight physical transmit antennas, while a maximum number of physical transmit antennas that can be employed by the legacy base station can be four physical transmit antennas; however, it is to be appreciated that the claimed subject matter is not so limited. At **804**, a number of virtual antennas in the set of virtual antennas can be advertised to a legacy user equipment (UE). At **806**, a number of physical transmit antennas in the set of physical transmit antennas can be advertised to a non-legacy UE (e.g., Long Term Evolution—Advanced (LTE-A) UE, . . .). Thus, virtualization can be employed for the legacy UE (e.g., when advertising the number of virtual antennas in the set of virtual antennas, . . .), while virtualization need not be employed for the non-legacy UE. However, it is further contemplated that the number of virtual antennas in the set of virtual antennas can be advertised to the non-legacy UE and/or virtualization can be employed for the non-legacy UE.

[0083] It will be appreciated that, in accordance with one or more aspects described herein, inferences can be made pertaining to implementing antenna virtualization in a wireless communication environment. As used herein, the term to "infer" or "inference" refers generally to the process of reasoning about or inferring states of the system, environment, and/or user from a set of observations as captured via events and/or data. Inference can be employed to identify a specific context or action, or can generate a probability distribution over states, for example. The inference can be probabilistic—that is, the computation of a probability distribution over states of interest based on a consideration of data and events. Inference can also refer to techniques employed for composing higher-level events from a set of events and/or data. Such inference results in the construction of new events or actions from a set of observed events and/or stored event data, whether or not the events are correlated in close temporal proximity, and whether the events and data come from one or several event and data sources.

[0084] FIG. **9** is an illustration of a UE **900** that employs antenna virtualization in a wireless communication system. UE **900** comprises a receiver **902** that receives a signal from, for instance, a receive antenna (not shown), and performs typical actions thereon (e.g., filters, amplifies, downconverts, etc.) the received signal and digitizes the conditioned signal to obtain samples. Receiver **902** can be, for example, an MMSE receiver, and can comprise a demodulator **904** that can demodulate received symbols and provide them to a processor **906** for channel estimation. Processor **906** can be a processor dedicated to analyzing information received by receiver **902** and/or generating information for transmission by a transmitter **916**, a processor that controls one or more components of UE **900**, and/or a processor that both analyzes information received by receiver **902**, generates information for transmission by transmitter **916**, and controls one or more components of UE **900**.

[0085] UE **900** can additionally comprise memory **908** that is operatively coupled to processor **906** and that can store data to be transmitted, received data, and any other suitable information related to performing the various actions and functions set forth herein. Memory **908**, for instance, can store protocols and/or algorithms associated with partitioning a plurality of physical transmit antennas into multiple groups, formulating respective precoding vectors for the multiple groups, and the like. Moreover, memory **908** can maintain precoding vectors.

[0086] It will be appreciated that the data store (e.g., memory **908**) described herein can be either volatile memory or nonvolatile memory, or can include both volatile and nonvolatile memory. By way of illustration, and not limitation, nonvolatile memory can include read only memory (ROM), programmable ROM (PROM), electrically programmable ROM (EPROM), electrically erasable PROM (EEPROM), or flash memory. Volatile memory can include random access memory (RAM), which acts as external cache memory. By way of illustration and not limitation, RAM is available in many forms such as static RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDR SDRAM), enhanced SDRAM (ESDRAM), Synchlink DRAM (SLDRAM), and direct Rambus RAM (DRRAM). The memory **908** of the subject systems and methods is intended to comprise, without being limited to, these and any other suitable types of memory.

[0087] Processor **906** can be operatively coupled to an antenna virtualization component **910** and/or a precoding vector generation component **912**. Antenna virtualization component **910** can be substantially similar to antenna virtualization component **204** of FIG. **2** and/or precoding vector generation component **912** can be substantially similar to precoding vector generation component **302** of FIG. **3**. Precoding vector generation component **912** can yield precoding vector(s) associated with virtual antenna(s) formed from a plurality of physical transmit antennas (not shown) of UE **900**. Moreover, antenna virtualization component **910** can implement precoding (e.g., using the precoding vector(s) yielded by precoding vector generation component **912**, . . .) to send signal(s) for transmission over the virtual antenna(s). UE **900** still further comprises a modulator **914** and a transmitter **916** that transmits data, signals, etc. to a base station.

Although depicted as being separate from the processor **906**, it is to be appreciated that antenna virtualization component **910**, precoding vector generation component **912**, and/or modulator **914** can be part of processor **906** or a number of processors (not shown).

[0088] FIG. **10** is an illustration of a system **1000** that establishes and utilizes virtual antennas in a wireless communication environment. System **1000** comprises a base station **1002** (e.g., access point, . . .) with a receiver **1010** that receives signal(s) from one or more UEs **1004** through a plurality of receive antennas **1006**, and a transmitter **1024** that transmits to the one or more UEs **1004** through a plurality of transmit antennas **1008**. Receiver **1010** can receive information from receive antennas **1006** and is operatively associated with a demodulator **1012** that demodulates received information. Demodulated symbols are analyzed by a processor **1014** that can be similar to the processor described above with regard to FIG. **9**, and which is coupled to a memory **1016** that stores data to be transmitted to or received from UE(s) **1004** and/or any other suitable information related to performing the various actions and functions set forth herein. Processor **1014** is further coupled to an antenna virtualization component **1018** and/or a precoding vector generation component **1020**. Antenna virtualization component **1018** can be substantially similar to antenna virtualization component **204** of FIG. **2** and/or precoding vector generation component **1020** can be substantially similar to precoding vector generation component **302** of FIG. **3**. Precoding vector generation component **1020** can yield precoding vector(s) associated with virtual antenna(s) formed from the plurality of physical transmit antennas **1008** of base station **1002**. Moreover, antenna virtualization component **1018** can implement precoding (e.g., using the precoding vector(s) yielded by precoding vector generation component **1020**, . . .) to send signal(s) for transmission over the virtual antenna(s). Although not shown, it is contemplated that base station **1002** can further include an advertisement component, which can be substantially similar to advertisement component **506** of FIG. **5**. Base station **1002** can further include a modulator **1022**. Modulator **1022** can multiplex a frame for transmission by a transmitter **1024** through antennas **1008** to UE(s) **1004** in accordance with the aforementioned description. Although depicted as being separate from the processor **1014**, it is to be appreciated that antenna virtualization component **1018**, precoding vector generation component **1020**, and/or modulator **1022** can be part of processor **1014** or a number of processors (not shown).

[0089] FIG. **11** shows an example wireless communication system **1100**. The wireless communication system **1100** depicts one base station **1110** and one UE **1150** for sake of brevity. However, it is to be appreciated that system **1100** can include more than one base station and/or more than one UE, wherein additional base stations and/or UEs can be substantially similar or different from example base station **1110** and UE **1150** described below. In addition, it is to be appreciated that base station **1110** and/or UE **1150** can employ the systems (FIGS. **1-6**, **9-10**, and **12**) and/or methods (FIGS. **7-8**) described herein to facilitate wireless communication there between.

[0090] At base station **1110**, traffic data for a number of data streams is provided from a data source **1112** to a transmit (TX) data processor **1114**. According to an example, each data stream can be transmitted over a respective antenna. TX data processor **1114** formats, codes, and interleaves the traffic data stream based on a particular coding scheme selected for that data stream to provide coded data.

[0091] The coded data for each data stream can be multiplexed with pilot data using orthogonal frequency division multiplexing (OFDM) techniques. Additionally or alternatively, the pilot symbols can be frequency division multiplexed (FDM), time division multiplexed (TDM), or code division multiplexed (CDM). The pilot data is typically a known data pattern that is processed in a known manner and can be used at UE **1150** to estimate channel response. The multiplexed pilot and coded data for each data stream can be modulated (e.g., symbol mapped) based on a particular modulation scheme (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM), etc.) selected for that data stream to provide modulation symbols. The data rate, coding, and modulation for each data stream can be determined by instructions performed or provided by processor **1130**.

[0092] The modulation symbols for the data streams can be provided to a TX MIMO processor **1120**, which can further process the modulation symbols (e.g., for OFDM). TX MIMO processor **1120** then provides N_T modulation symbol streams to N_T transmitters (TMTR) **1122***a* through **1122***t*. In various embodiments, TX MIMO processor **1120** applies beamforming weights to the symbols of the data streams and to the antenna from which the symbol is being transmitted.

[0093] Each transmitter **1122** receives and processes a respective symbol stream to provide one or more analog signals, and further conditions (e.g., amplifies, filters, and upconverts) the analog signals to provide a modulated signal suitable for transmission over the MIMO channel. Further, N_T modulated signals from transmitters **1122***a* through **1122***t* are transmitted from N_T antennas **1124***a* through **1124***t*, respectively.

[0094] At UE **1150**, the transmitted modulated signals are received by N_R antennas **1152***a* through **1152***r* and the received signal from each antenna **1152** is provided to a respective receiver (RCVR) **1154***a* through **1154***r*. Each receiver **1154** conditions (e.g., filters, amplifies, and downconverts) a respective signal, digitizes the conditioned signal to provide samples, and further processes the samples to provide a corresponding "received" symbol stream.

[0095] An RX data processor **1160** can receive and process the N_R received symbol streams from N_R receivers **1154** based on a particular receiver processing technique to provide N_T "detected" symbol streams. RX data processor **1160** can demodulate, deinterleave, and decode each detected symbol stream to recover the traffic data for the data stream. The processing by RX data processor **1160** is complementary to that performed by TX MIMO processor **1120** and TX data processor **1114** at base station **1110**.

[0096] A processor **1170** can periodically determine which available technology to utilize as discussed above. Further, processor **1170** can formulate a reverse link message comprising a matrix index portion and a rank value portion.

[0097] The reverse link message can comprise various types of information regarding the communication link and/or the received data stream. The reverse link message can be processed by a TX data processor **1138**, which also receives traffic data for a number of data streams from a data source **1136**, modulated by a modulator **1180**, conditioned by transmitters **1154***a* through **1154***r*, and transmitted back to base station **1110**.

[0098] At base station **1110**, the modulated signals from UE **1150** are received by antennas **1124**, conditioned by receivers **1122**, demodulated by a demodulator **1140**, and processed by a RX data processor **1142** to extract the reverse link message transmitted by UE **1150**. Further, processor **1130** can process the extracted message to determine which precoding matrix to use for determining the beamforming weights.

[0099] Processors **1130** and **1170** can direct (e.g., control, coordinate, manage, etc.) operation at base station **1110** and UE **1150**, respectively. Respective processors **1130** and **1170** can be associated with memory **1132** and **1172** that store program codes and data. Processors **1130** and **1170** can also perform computations to derive frequency and impulse response estimates for the uplink and downlink, respectively.

[0100] In an aspect, logical channels are classified into Control Channels and Traffic Channels. Logical Control Channels can include a Broadcast Control Channel (BCCH), which is a DL channel for broadcasting system control information. Further, Logical Control Channels can include a Paging Control Channel (PCCH), which is a DL channel that transfers paging information. Moreover, the Logical Control Channels can comprise a Multicast Control Channel (MCCH), which is a Point-to-multipoint DL channel used for transmitting Multimedia Broadcast and Multicast Service (MBMS) scheduling and control information for one or several MTCHs. Generally, after establishing a Radio Resource Control (RRC) connection, this channel is only used by UEs that receive MBMS (e.g., old MCCH+MSCH). Additionally, the Logical Control Channels can include a Dedicated Control Channel (DCCH), which is a Point-to-point bi-directional channel that transmits dedicated control information and can be used by UEs having a RRC connection. In an aspect, the Logical Traffic Channels can comprise a Dedicated Traffic Channel (DTCH), which is a Point-to-point bi-directional channel dedicated to one UE for the transfer of user information. Also, the Logical Traffic Channels can include a Multicast Traffic Channel (MTCH) for Point-to-multipoint DL channel for transmitting traffic data.

[0101] In an aspect, Transport Channels are classified into DL and UL. DL Transport Channels comprise a Broadcast Channel (BCH), a Downlink Shared Data Channel (DL-SDCH) and a Paging Channel (PCH). The PCH can support UE power saving (e.g., Discontinuous Reception (DRX) cycle can be indicated by the network to the UE, . . .) by being broadcasted over an entire cell and being mapped to Physical layer (PHY) resources that can be used for other control/traffic channels. The UL Transport Channels can comprise a Random Access Channel (RACH), a Request Channel (REQCH), a Uplink Shared Data Channel (UL-SDCH) and a plurality of PHY channels.

[0102] The PHY channels can include a set of DL channels and UL channels. For example, the DL PHY channels can include: Common Pilot Channel (CPICH); Synchronization Channel (SCH); Common Control Channel (CCCH); Shared DL Control Channel (SDCCH); Multicast Control Channel (MCCH); Shared UL Assignment Channel (SUACH); Acknowledgement Channel (ACKCH); DL Physical Shared Data Channel (DL-PSDCH); UL Power Control Channel (UPCCH); Paging Indicator Channel (PICH); and/or Load Indicator Channel (LICH). By way of further illustration, the UL PHY Channels can include: Physical Random Access Channel (PRACH); Channel Quality Indicator Channel (CQICH); Acknowledgement Channel (ACKCH); Antenna Subset Indicator Channel (ASICH); Shared Request Channel (SREQCH); UL Physical Shared Data Channel (UL-PSDCH); and/or Broadband Pilot Channel (BPICH).

[0103] It is to be understood that the embodiments described herein can be implemented in hardware, software, firmware, middleware, microcode, or any combination thereof. For a hardware implementation, the processing units can be implemented within one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described herein, or a combination thereof.

[0104] When the embodiments are implemented in software, firmware, middleware or microcode, program code or code segments, they can be stored in a machine-readable medium, such as a storage component. A code segment can represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a class, or any combination of instructions, data structures, or program statements. A code segment can be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters, or memory contents. Information, arguments, parameters, data, etc. can be passed, forwarded, or transmitted using any suitable means including memory sharing, message passing, token passing, network transmission, etc.

[0105] For a software implementation, the techniques described herein can be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The software codes can be stored in memory units and executed by processors. The memory unit can be implemented within the processor or external to the processor, in which case it can be communicatively coupled to the processor via various means as is known in the art.

[0106] With reference to FIG. **12**, illustrated is a system **1200** that enables effectuating antenna virtualization in a wireless communication environment. For example, system **1200** can reside within a UE. By way of another example, system **1200** can reside at least partially within a base station. It is to be appreciated that system **1200** is represented as including functional blocks, which can be functional blocks that represent functions implemented by a processor, software, or combination thereof (e.g., firmware). System **1200** includes a logical grouping **1202** of electrical components that can act in conjunction. For instance, logical grouping **1202** can include an electrical component for partitioning a set of physical transmit antennas into a plurality of groups of physical transmit antennas **1204**. Further, each of the groups can correspond to a respective virtual antenna. Moreover, logical grouping **1202** can include an electrical component for generating respective precoding vectors for the plurality of groups of physical transmit antennas **1206**. Further, logical grouping **1202** can include an electrical component for implementing precoding upon signals for transmission using the respective precoding vectors **1208**. Additionally, system **1200** can include a memory **1210** that retains instructions for executing functions associated with electrical components **1204**, **1206**, and **1208**. While shown as being external to memory **1210**, it is to be understood that one or more of electrical components **1204**, **1206**, and **1208** can exist within memory **1210**.

[0107] What has been described above includes examples of one or more embodiments. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the aforementioned embodiments, but one of ordinary skill in the art may recognize that many further combinations and permutations of various embodiments are possible. Accordingly, the described embodiments are intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

What is claimed is:

1. A method that facilitates implementing antenna virtualization in a wireless communication environment, comprising:

partitioning a set of physical transmit antennas into a plurality of groups of physical transmit antennas;

formulating a precoding vector for a particular group of physical transmit antennas from the plurality of groups of physical transmit antennas, the particular group of physical transmit antennas forms a particular virtual antenna; and

applying the precoding vector to a signal for transmission over the particular virtual antenna.

2. The method of claim **1**, wherein the set of physical transmit antennas includes T physical transmit antennas, and the set of the T physical transmit antennas is partitioned into L groups of physical transmit antennas, wherein T is an integer and L is an integer less than or equal to T.

3. The method of claim **2**, wherein L precoding vectors corresponding to L virtual antennas are formulated.

4. The method of claim **1**, further comprising:

formulating a disparate precoding vector for a disparate group of physical transmit antennas from the plurality of groups of physical transmit antennas, the disparate group of physical transmit antennas forms a disparate virtual antenna; and

applying the disparate precoding vector to a disparate signal for transmission over the disparate virtual antenna.

5. The method of claim **1**, wherein the set of physical transmit antennas is associated with a user equipment (UE), and the signal is for transmission over an uplink to a base station.

6. The method of claim **5**, further comprising selecting a number of virtual antennas to form, wherein the number of virtual antennas is a number of the groups into which the set of physical transmit antennas is partitioned.

7. The method of claim **5**, further comprising choosing the precoding vector for the particular group.

8. The method of claim **5**, further comprising receiving an indication from the base station that specifies at least one of a number of virtual antennas to form or the precoding vector for the particular group.

9. The method of claim **5**, wherein information related to antenna virtualization is transparent to the base station.

10. The method of claim **5**, wherein the precoding vector is a unit norm vector of size T-by-1 with non-zero entries corresponding to physical transmit antennas in the particular group that forms the particular virtual antenna, wherein T is a number of physical transmit antennas in the set.

11. The method of claim **10**, wherein a remainder of entries in the precoding vector corresponding to physical transmit antennas associated with a differing virtual antenna are zero.

12. The method of claim **10**, wherein the non-zero entries in the precoding vector are constant.

13. The method of claim **10**, wherein the non-zero entries in the precoding vector are at least one of frequency dependent or time dependent.

14. The method of claim **1**, wherein the set of physical transmit antennas is associated with a base station, and the signal is for transmission over a downlink to a user equipment (UE).

15. The method of claim **14**, wherein information related to antenna virtualization is transparent to the UE.

16. The method of claim **14**, wherein the precoding vector is a unit norm vector.

17. The method of claim **14**, wherein the precoding vector is a unit norm vector with non-zero entries corresponding to physical transmit antennas in the particular group that participate in the particular virtual antenna.

18. The method of claim **14**, wherein the precoding vector is a particular column of a Discrete Fourier Transform (DFT) matrix, wherein a disparate column of the DFT matrix is utilized for a disparate virtual antenna.

19. The method of claim **14**, further comprising:

establishing a set of virtual antennas from the set of physical transmit antennas;

advertising a number of the virtual antennas in the set of virtual antennas to a legacy UE; and

advertising a number of physical transmit antennas in the set of physical transmit antennas to a non-legacy UE.

20. A wireless communications apparatus, comprising:

a memory that retains instructions related to partitioning a set of physical transmit antennas into a plurality of groups of physical transmit antennas, generating a precoding vector for a particular group of physical transmit antennas from the plurality of groups of physical transmit antennas, wherein the particular group of physical transmit antennas forms a particular virtual antenna, and applying the precoding vector to a signal for transmission over the particular virtual antenna; and

a processor, coupled to the memory, configured to execute the instructions retained in the memory.

21. The wireless communications apparatus of claim **20**, wherein information related to antenna virtualization is transparent to a receiving wireless communication apparatus.

22. The wireless communications apparatus of claim **20**, wherein the set of physical transmit antennas is associated with a user equipment (UE), and the signal is for transmission over an uplink to a base station.

23. The wireless communications apparatus of claim **22**, wherein the memory further retains instructions related to selecting a number of virtual antennas to form, wherein the number of virtual antennas is a number of the groups into which the set of physical transmit antennas is partitioned, and selecting the precoding vector for the particular group.

24. The wireless communications apparatus of claim **22**, wherein the memory further retains instructions related to receiving an indication from the base station that specifies at least one of a number of virtual antennas to form, wherein the number of virtual antennas is a number of the groups into which the set of physical transmit antennas is partitioned, or the precoding vector for the particular group.

25. The wireless communications apparatus of claim 22, wherein the precoding vector is a unit norm vector of size T-by-1 with non-zero entries corresponding to physical transmit antennas in the particular group that forms the particular virtual antenna, wherein T is a number of physical transmit antennas in the set and a remainder of entries in the precoding vector are zero.

26. The wireless communications apparatus of claim 20, wherein the set of physical transmit antennas is associated with a base station, and the signal is for transmission over a downlink to a user equipment (UE).

27. The wireless communications apparatus of claim 26, wherein the precoding vector is a unit norm vector with non-zero entries corresponding to physical transmit antennas in the particular group that participate in the particular virtual antenna.

28. The wireless communications apparatus of claim 27, wherein the non-zero entries in the precoding vector are constant.

29. The wireless communications apparatus of claim 27, wherein the non-zero entries in the precoding vector are at least one of frequency dependent or time dependent.

30. The wireless communications apparatus of claim 26, wherein the precoding vector is a particular column of a Discrete Fourier Transform (DFT) matrix, wherein a disparate column of the DFT matrix is utilized for a disparate virtual antenna.

31. The wireless communications apparatus of claim 26, wherein the memory further retains instructions related to advertising a number of virtual antennas corresponding to a number of the groups to a legacy UE, and advertising a number of physical transmit antennas in the set of physical transmit antennas to a non-legacy UE.

32. A wireless communications apparatus that enables effectuating antenna virtualization in a wireless communication environment, comprising:

means for partitioning a set of physical transmit antennas into a plurality of groups of physical transmit antennas, each of the groups corresponds to a respective virtual antenna;

means for generating respective precoding vectors for the plurality of groups of physical transmit antennas; and

means for implementing precoding upon signals for transmission using the respective precoding vectors.

33. The wireless communications apparatus of claim 32, wherein the respective precoding vectors are respective unit norm vectors of size T-by-1 with non-zero entries corresponding to physical transmit antennas that respectively form each respective virtual antenna, wherein T is a number of physical transmit antennas in the set.

34. The wireless communications apparatus of claim 32, wherein the respective precoding vectors are respective unit norm vectors.

35. The wireless communications apparatus of claim 32, wherein the respective precoding vectors are respective columns of a Discrete Fourier Transform (DFT) matrix.

36. The wireless communications apparatus of claim 32, wherein information related to antenna virtualization is transparent to a receiving wireless communication apparatus.

37. A computer program product, comprising:

a computer-readable medium comprising:

code for partitioning a set of physical transmit antennas into a plurality of groups of physical transmit antennas, each of the groups corresponds to a respective virtual antenna;

code for generating respective precoding vectors for the plurality of groups of physical transmit antennas; and

code for implementing precoding upon signals for transmission using the respective precoding vectors.

38. The computer program product of claim 37, wherein the respective precoding vectors are respective unit norm vectors of size T-by-1 with non-zero entries corresponding to physical transmit antennas that respectively form each respective virtual antenna, wherein T is a number of physical transmit antennas in the set.

39. The computer program product of claim 37, wherein the respective precoding vectors are respective columns of a Discrete Fourier Transform (DFT) matrix.

40. The computer program product of claim 37, wherein information related to antenna virtualization is transparent to a receiving wireless communication apparatus.

41. A wireless communications apparatus, comprising:

a processor configured to:

partition a set of physical transmit antennas into a plurality of groups of physical transmit antennas;

formulate a precoding vector for a particular group of physical transmit antennas from the plurality of groups of physical transmit antennas, the particular group of physical transmit antennas forms a particular virtual antenna; and

apply the precoding vector to a signal for transmission over the particular virtual antenna.

* * * * *

Our Docket No: ZL0205-0002-PCT-US-CON2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	Examiner: DEEPA BELUR
	)	
Xiaobo ZHANG	)	Art Unit: 2472
	)	
Application No: 18/089,999	)	Confirmation No.: 9408
	)	
Filed: December 28, 2022	)	
	)	
For: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	)	

AMENDMENT ACCOMPANYING AN RCE

E-Filed via EFS-Web
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir/Madam:

In response to the final Office action mailed on May 28, 2024, applicant respectfully requests the Examiner to enter the following amendments and to consider the following remarks in view of the concurrently-submitted Request for Continued Examination (RCE).

Amendments to the Claims are reflected in the listing of claims which begin on page 2 of this document.

Remarks begin on page 9 of this document.

In the claims:

For the Examiner's convenience, all pending claims are presented below with changes shown in accordance with the mandatory amendment format.

What is claimed is:

1. (Currently amended) A method for multi-antenna transmission in a user equipment, comprising:

receiving a first radio signal; and

receiving a first signaling;

wherein the first radio signal is collectively transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal).

2. (Previously presented) The method of claim 1, further comprising:

receiving a second signaling; and

operating a second radio signal in a first time resource sub-pool;

wherein the operating is one of receiving or transmitting the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; and the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI and (a) transmitting antenna port(s) of the second radio signal.

3. (Original) The method of claim 1, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, comprising:

receiving first information, wherein the first information is used to determine the first antenna port group.

4. (Original) The method of claim 1, further comprising:

transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

5. (Original) The method of claim 1, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

6. (Currently amended) A method for multi-antenna transmitting in a base station, comprising:

transmitting a first radio signal; and

transmitting a first signaling;

wherein the first radio signal is collectively transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource

pool that comprises a collection of time resources for shared use; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

7. (Previously presented) The method of claim 6, further comprising:

transmitting a second signaling; and

performing a second radio signal in a first time resource sub-pool;

wherein the performing is one of transmitting or receiving the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI and (a) transmitting antenna port(s) of the second radio signal.

8. (Original) The method of claim 6, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, comprising:

transmitting first information, wherein the first information is used to determine the first antenna port group.

9. (Original) The method of claim 6, further comprising:

receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s)

indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

10. (Original) The method of claim 6, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

11. (Currently amended) A user equipment (UE) for multi-antenna transmission, comprising:

a first transceiver, receiving a first radio signal; and

a second receiver, receiving a first signaling;

wherein the first radio signal is collectively transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal).

12. (Previously presented) The UE of claim 11, comprising:

a third receiver, receiving a second signaling; and

a second transceiver, operating a second radio signal in a first time resource sub-pool;

wherein the operating is one of receiving or transmitting the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; and the second signaling is used to determine at least one of occupied frequency domain resources, a MCS, a HARQ process number, a RV, a NDI and (a) transmitting antenna port(s) of the second radio signal.

13. (Original) The UE of claim 11, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, the second receiver further receives first information, wherein the first information is used to determine the first antenna port group.

14. (Original) The UE of claim 11, wherein:

the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

15. (Original) The UE of claim 11, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer

signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

16. (Currently amended) A base station equipment for multi-antenna transmission, comprising:

a third transceiver, transmitting a first radio signal; and

a second transmitter, transmitting a first signaling;

wherein the first radio signal is collectively transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool that comprises a collection of time resources for shared use; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

17. (Previously presented) The base station equipment of claim 16, further comprising:

a third transmitter, transmitting a second signaling; and

a fourth transceiver, performing a second radio signal in a first time resource sub-pool;

wherein the performing is one of transmitting or receiving the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, a MCS, a HARQ process number, a RV, a NDI and (a) transmitting antenna port(s) of the second radio signal.

18. (Original) The base station equipment of claim 16, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, the second transmitter further transmits first information, wherein the first information is used to determine the first antenna port group.

19. (Original) The base station equipment of claim 16, wherein:

the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

20. (Original) The base station equipment of claim 16, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

REMARKS

Applicant respectfully requests reconsideration of this application. Claims 1, 6, 11, and 16 are amended. No claims have been canceled. No new claims have been added.

Applicant respectfully submits that the amendments to the Specification and Claims do not add new matters and respectfully requests the entry of the amendments to the Specification and Claims.

Summary of the Office Action

Claims 1 and 2 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claim 1 of the US Patent No. 10,944,527 ('527 Patent).

Claims 1, 3-6, 8-11, 13-16, 18-20 are rejected under 35 U.S.C. 101 as claiming the same invention as that of claims 1, 3-6, 8-11, 13-16, and 18-20 respectively of prior U.S. Patent No. 11,546,110 ('110 Patent).

Double Patenting Rejection

Claims 1 and 2 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claim 1 of the '527 Patent.

Claims 1, 3-6, 8-11, 13-16, 18-20 are rejected under 35 U.S.C. 101 as claiming the same invention as that of claims 1, 3-6, 8-11, 13-16, and 18-20 respectively of '110 Patent.

Independent claims 1, 6, 11, and 16 are hereby amended to clarify the subject matter and overcome the rejection. Support for the amendments can be found in the specification (e.g., at paragraphs 0047 and 0301). Applicant respectfully request that the Office withhold the double patenting rejection in abeyance because of the amendment to the claims until the claims are in condition for allowance.

The Examiner is requested to call the undersigned at (908) 591-2738 if there remains any issue with allowance of the case.

Please charge any shortage to our Deposit Account No. 60-2313.

Respectfully submitted,

ZHONG LAW, LLC

Date: September 25, 2024

/Jialin Zhong/
Jialin Zhong
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/089,999	12/28/2022	Xiaobo ZHANG	ZL0205-0002-PCT-US-CON2	9408

155075 7590 05/28/2024

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EXAMINER	
BELUR, DEEPA	

ART UNIT	PAPER NUMBER
2472	

NOTIFICATION DATE	DELIVERY MODE
05/28/2024	ELECTRONIC

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

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

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

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

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No. 18/089,999	Applicant(s) ZHANG, Xiaobo	
	Examiner DEEPA BELUR	Art Unit 2472	AIA (FITF) Status Yes

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 04/15/2024.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☑ This action is **FINAL.** 2b) ☐ This action is non-final.

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

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-20 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-20 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

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

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☑ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

2. This action is in response to the amendments filed on 04/15/2024.

3. Claims 1-2, 7, 11-12, 17 are amended.

4. The statutory double patenting rejection has been overcome based on claim amendments.

5. The non-statutory double patenting rejections has been maintained as detailed below.

6. Please refer to the Examiner Initiated summary dated 05/06/2024.

7. Claims 1-20 have been examined and rejected.

Double Patenting

8. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed.

Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

9. Claim 1 together with claim 2 of the instant application are non-provisionally rejected on the ground of **nonstatutory double patenting** as being unpatentable over

claim 1 of the **US Patent No. 10,944,527.** Although the claims at issue are not identical, they are not patentably distinct from each other because claims 1-2 are generic to all that is recited in claim 1 of the US patent. That is, claims 1-2 are anticipated by claim 1 of the US Patent.

Claim 1 of the instant application is directed to a method for multi-antenna transmission in a user equipment, comprising: receiving a first radio signal; and receiving a first signaling; wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

Claim 1 of the US Patent No. 10,944,527 is directed to a method for multi-antenna transmission in a user equipment, comprising: receiving a first radio signal; and receiving a first signaling; wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of the antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; at least one first antenna virtualization vector and a second antenna virtualization vector is associated with the first antenna

port group; the first antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; the K is a positive integer greater than 1.

This is a non-provisional nonstatutory double patenting rejection because the patentably indistinct claims have in fact been patented. Firstly, the underlined limitation of claim 1 of the instant application is used to determine first resource pool using the second antenna vector. The underlined limitation of claim 1 of the US patent is used to determine the resource pool using both the first antenna vector and the second antenna vector. Secondly, the italicized limitations in claim 2 of the instant application map to the italicized limitations in claim 1 of the US Patent, with the second signaling is used to determine at least one of occupied frequency domain resources representing the scheduling information of claim 1 of the reference application.

10. Claims 1, 3-6, 8-11, 13-16, 18-20 of the instant application are rejected on the ground of **nonstatutory double patenting** as being unpatentable over claims 1, 3-6, 8-11, 13-16, 18-20 respectively of prior **U.S. Patent No. 11,546,110 B2. This is a non-statutory double patenting rejection**. Although the claims at issue are not identical, they are not patentably distinct from each other because claims 1, 3-6, 8-11, 13-16, 18-20 are generic to all that is recited in claims 1, 3-6, 8-11, 13-16, 18-20 of the US patent. That is, claims 1, 3-6, 8-11, 13-16, 18-20 are anticipated by claims 1, 3-6, 8-11, 13-16, 18-20 of the US Patent.

The differences in the claims are underlined and bold. Please refer to details below:

Claim number	Instant Application	Claim number	U.S. Patent No. 11,546,110 B2
1	A method for multi-antenna transmission in a user equipment, comprising: receiving a first radio signal; and receiving a first signaling; wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a	1	A method for multi-antenna transmission in a user equipment, comprising: receiving a first radio signal; and receiving a first signaling; wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization

	positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal).		vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); **the first signaling is a downlink signaling**.
3	The method of claim 1, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);or, comprising: receiving first	3	The method of claim 1, wherein the first signaling indicates the first antenna port group from the K antenna port group(s); or,

	information, wherein the first information is used to determine the first antenna port group.		comprising: receiving first information, wherein the first information is used to determine the first antenna port group.
4	The method of claim 1, further comprising: transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1	4	The method of claim 1, further comprising: transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s)

	is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups; or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to		belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups; or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is

	determine the first antenna port group.		one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.
5	The method of claim 1, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first	5	The method of claim 1, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first

	signaling is cell-common; or the first signaling is for the UE.		signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.
6	A method for multi-antenna transmitting in a base station, comprising: transmitting a first radio signal; and transmitting a first signaling; wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna	6	A method for multi-antenna transmitting in a base station, comprising: transmitting a first radio signal; and transmitting a first signaling; wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector

	virtualization vector available to a target receiver of the first signaling in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.		is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); **the first signaling is a downlink signaling.**
8	The method of claim 6, wherein the first signaling indicates the first	8	The method of claim 6, wherein the first signaling

	antenna port group from the K antenna port group(s);or, comprising: transmitting first information, wherein the first information is used to determine the first antenna port group.		indicates the first antenna port group from the K antenna port group(s); or, comprising: transmitting first information, wherein the first information is used to determine the first antenna port group.
9	The method of claim 6, further comprising: receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K	9	The method of claim 6, further comprising: receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; or, receiving second information, wherein the second information is used to

	antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s)indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups; or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-		determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups; or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna

	frequency resource occupied by the RACH preamble is used to determine the first antenna port group.		port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.
10	The method of claim 6, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or	10	The method of claim 6, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer

	the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.		signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.
11	A user equipment (UE) for multi-antenna transmission, comprising: a first transceiver, receiving a first radio signal; and a second receiver, receiving a first signaling; wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna	11	A user equipment (UE) for multi-antenna transmission, comprising: a first transceiver, receiving a first radio signal; and a second receiver, receiving a first signaling; wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups;

	virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal)		the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than **1**; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); **the first**

			signaling is a downlink signaling.
13	The UE of claim 11, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);or, the second receiver further receives first information, wherein the first information is used to determine the first antenna port group.	13	The UE of claim 11, wherein the first signaling indicates the first antenna port group from the K antenna port group(s); or, the second receiver further receives first information, wherein the first information is used to determine the first antenna port group.
14	The UE of claim 11, wherein: the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; or, the first	14	The UE of claim 11, wherein: the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port

	transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups; or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to		group(s); the K1 is a positive integer; or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups; or, the

	the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.		first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K**1** antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.
15	The UE of claim 11, wherein the first time resource pool is discontinuous in time domain; or	15	The UE of claim 11, wherein the first time resource pool is discontinuous in time

	the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.		domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.
16	A base station equipment for multi-antenna transmission, comprising: a third transceiver, transmitting a first radio signal; and a second transmitter, transmitting a first signaling; wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer	16	A base station equipment for multi-antenna transmission, comprising: a third transceiver, transmitting a first radio signal; and a second transmitter, transmitting a first signaling; wherein the first radio signal is transmitted by K antenna

	number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.		port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary

			Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); **the first signaling is a downlink signaling.**
18	The base station equipment of claim 16, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);or, the second transmitter further transmits first information, wherein the first information is used to determine the first antenna port group.	18	The base station equipment of claim 16, wherein the first signaling indicates the first antenna port group from the K antenna port group(s); or, the second transmitter further transmits first information, wherein the first information is used to determine the first antenna port group.
19	The base station equipment of claim 16, wherein: the third transceiver further receives second information, wherein the	19	The base station equipment of claim 16, wherein: the third transceiver further receives second information,

	second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s)		wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS

	from the CSI-RS resources corresponding to the K antenna port groups; or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.		Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups; or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH

			preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.
20	The base station equipment of claim 16, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.	20	The base station equipment of claim 16, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

Conclusion

11. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

12. Any inquiry concerning this communication or earlier communications from the examiner should be directed to DEEPA BELUR whose telephone number is (571)270-3722. The examiner can normally be reached M-F 8 am - 4:30 pm.

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

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chi Pham can be reached on 571-272-3179. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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

/DEEPA BELUR/
Primary Examiner, Art Unit 2472

Examiner-Initiated Interview Summary	Application No. 18/089,999	Applicant(s) ZHANG, Xiaobo		
	Examiner DEEPA BELUR	Art Unit 2472	AIA (First Inventor to File) Status Yes	Page 1 of 1

All Participants (applicant, applicants representative, PTO personnel)	**Title**	**Type**
DEEPA BELUR	Primary Examiner	Telephonic
Mr. Jilian Zhong	Attorney	

Date of Interview: 06 May 2024

Issues Discussed:

Non-statutory Double Patenting

1. The Applicant was informed that the non-statutory double patenting rejection over US Patent No. 10,944,527 was not overcome, and a terminal disclaimer was needed for to overcome this rejection.
2. The statutory double patenting rejection was overcome, based on claim amendments. However, the pending claims have been rejected based on non-statutory double patenting rejection U.S. Patent No. 11,546,110 B2 as detailed in the rejection.

/DEEPA BELUR/ Primary Examiner, Art Unit 2472	

Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04
Please further see:
MPEP 713.04
Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b)
37 CFR § 1.2 Business to be transacted in writing

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

Notice of References Cited	Application/Control No. 18/089,999	Applicant(s)/Patent Under Reexamination ZHANG, Xiaobo	
	Examiner DEEPA BELUR	Art Unit 2472	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Name	CPC Classification	US Classification
*	A	US-20210250935-A1	2021-08-12	VENUGOPAL; Kiran	H04W76/11	1/1
*	B	US-20180294847-A1	2018-10-11	Lee; Moon-il	H04L5/0048	1/1
*	C	US-20190288807-A1	2019-09-19	ZHANG; Xiaobo	H04B7/0456	1/1
	D					
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	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in YYYY-MM-DD format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	**Art Unit**
	DEEPA BELUR	2472

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04L5/005.cpc.	01/10/2024	DB
H04B7/0408.cpc.	01/10/2024	DB
H04B7/0413.cpc.	01/10/2024	DB
H04B7/06.cpc.	01/10/2024	DB
H04B7/0617.cpc.	01/10/2024	DB
H04L1/1819.cpc.	01/10/2024	DB
H04L1/0003.cpc.	01/10/2024	DB
H04L5/0082.cpc.	01/10/2024	DB
H04W88/02.cpc.	01/10/2024	DB

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

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

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

/DEEPA BELUR/ Primary Examiner, Art Unit 2472	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	Art Unit
	DEEPA BELUR	2472

Search Notes		
Search Notes	**Date**	**Examiner**
H04L5/005.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/0408.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/0413.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/06.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/0617.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04L1/1819.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04L1/0003.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04L5/0082.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04W88/02.cpc.in combination with text search, see search history printout	01/10/2024	DB
Inventor and Assignee search in PE2E, see search history printout	01/09/2024	DB
NPL search in Chrome, see web search history	01/10/2024	DB
search updated	05/22/2024	

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**

/DEEPA BELUR/ Primary Examiner, Art Unit 2472	

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	Art Unit
	DEEPA BELUR	2472

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

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

CLAIM		DATE								
Final	Original	01/10/2024	05/22/2024							
	1	✓	✓							
	2	✓	✓							
	3	✓	✓							
	4	✓	✓							
	5	✓	✓							
	6	✓	✓							
	7	✓	✓							
	8	✓	✓							
	9	✓	✓							
	10	✓	✓							
	11	✓	✓							
	12	✓	✓							
	13	✓	✓							
	14	✓	✓							
	15	✓	✓							
	16	✓	✓							
	17	✓	✓							
	18	✓	✓							
	19	✓	✓							
	20	✓	✓							

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	5	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2024/01/09 01:51 PM
L2	1198	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/01/09 01:51 PM
L3	477901	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:34 PM
L5	34	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:39 PM
L6	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE,	OR	ON	ON	2024/01/09 02:42 PM

			SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L7	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:51 PM
L8	10	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:39 AM
L9	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:48 AM
L10	14	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2024/01/10 09:48 AM

		near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L11	13	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:49 AM
L12	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:07 AM
L13	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2024/01/10 10:09 AM

			TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L14	2371	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:14 AM
L15	115	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:15 AM
L18	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:19 AM
L19	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2024/01/10 10:21 AM

			HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L20	38	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:22 AM
L21	80	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:49 AM
L22	16	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:38 AM

L23	22	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:39 AM
L24	21	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:41 AM
L25	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:41 AM
L26	28	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2024/01/10 11:42 AM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L27	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L28	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L29	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L30	15	(resource WITH pool)	(US-PGPUB; USPAT;	OR	ON	ON	2024/01/10

		WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				11:44 AM
L31	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 12:45 PM
L32	15	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/01/10 12:48 PM
L34	11	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2024/05/22 08:44 AM

			TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L35	44	(Artificial Intelligence) Publication Status Unavailable from Similarity Search Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2 OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:35 AM

		US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L36	40	(Artificial Intelligence) Publication Status Unavailable from Similarity Search Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:35 AM

		OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					
L37	8	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2024/05/22 09:38 AM
L38	1316	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/05/22 09:38 AM
L39	486671	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L40	35	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L41	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV,	OR	ON	ON	2024/05/22 09:38 AM

		time) WITH (antenna near5 vector)) AND @AD< "20161203"	MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L42	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L43	10	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L44	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM

L45	14	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L46	13	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L47	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L48	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO,	OR	ON	ON	2024/05/22 09:38 AM

			MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L49	2378	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L50	118	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L51	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L52	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY,	OR	ON	ON	2024/05/22 09:38 AM

			CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L53	39	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L54	85	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L55	16	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO;	OR	ON	ON	2024/05/22 09:38 AM

			JPO; DERWENT; IBM_TDB)				
L56	22	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L57	21	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L58	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L59	28	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2024/05/22 09:38 AM

			HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L60	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L61	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L62	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2024/05/22 09:38 AM

			IBM_TDB)				
L63	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L64	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/05/22 09:38 AM
L65	15	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/05/22 09:38 AM
L66	11	"11546110"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO,	OR	ON	ON	2024/05/22 09:38 AM

			MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L67	44	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 0 Text Selections Text: (US-20230361963-A1 OR US-11546110-B2 OR US-20210126751-A1 OR US-20190288807-A1 OR US-10944527-B2 OR CN-111585619-A OR CN-111585699-A OR CN-111585699-B OR WO-2018099293-A1 OR US-11949469-B2 OR US-20230261702-A1 OR US-11683075-B2 OR CN-108155923-B OR US-20220216901-A1 OR CN-111479328-B OR CN-111479327-A OR CN-111479328-A OR WO-2018095201-A1 OR US-11316563-B2 OR US-20190280746-A1 OR CN-108111198-B OR CN-108155923-A OR US-11863481-B2 OR US-20220173861-A1 OR CN-108111198-A OR US-11290234-B2 OR CN-107547118-B OR US-20200313820-A1 OR US-10568113-B2 OR CN-111769854-A OR US-11950272-B2 OR US-20210258972-A1 OR CN-114244408-B OR US-20230275633-A1 OR US-20220352944-A1 OR US-11695460-B2 OR CN-114244408-A OR CN-108702183-B OR CN-116095703-A OR US-11418242-B2 OR US-20210250072-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:38 AM

		A1 OR US-11019634-B2 OR US-20210136743-A1 OR US-11445508-B2 OR US-11206098-B2 OR US-20230224885-A1 OR US-11963153-B2 OR US-20190268921-A1 OR US-10785785-B2 OR US-11343834-B2).did.					
L68	40	(Artificial Intelligence) Similar to: 18/089,999 with 0 CPC Selections and 1 Text Selection Text: (US-11223394-B2 OR EP-3219021-A1 OR CN-108155923-A OR CN-108155923-B OR CN-112202537-A OR CN-111585699-B OR CN-107113037-A OR CN-111585699-A OR CN-111585619-A OR US-20180294847-A1 OR US-20190288807-A1 OR US-10944527-B2 OR US-20230361963-A1 OR US-11546110-B2 OR WO-2018099293-A1 OR US-20210126751-A1 OR JP-6388969-B2 OR US-20210250935-A1 OR CN-113615119-A OR EP-2892269-B1 OR WO-2014035216-A1 OR CN-105577318-B OR CN-105577318-A OR BR-112019011295-A2 OR WO-2021159528-A1 OR CN-115088343-A OR CN-114342275-A OR CN-114430317-A OR CN-108242944-A OR CN-115942479-A OR CN-116438747-A OR CN-113518434-A OR CN-114342275-B OR CN-114513289-A OR EP-4187828-B1 OR WO-2022017130-A1 OR CN-110226342-B OR CN-111769854-A	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/05/22 09:38 AM

		OR CN-107547118-B OR CN-116471687-A OR WO-2021203956-A1 OR CN-116436582-A OR CN-113225812-A OR WO-2021066733-A1 OR CN-113225812-B OR CN-113225815-A OR CN-113225815-B OR CN-113973373-A OR WO-2018202217-A1 OR CN-111865542-A).did.					

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, Virginia 22313-1450
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ACKNOWLEDGEMENT OF LOSS OF ENTITLEMENT TO ENTITY STATUS DISCOUNT

APPLICATION #	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET #	REQUEST ID
18/089,999	12/28/2022	Xiaobo ZHANG	ZL0205-0002-PCT-US-CON2	210366

The entity status change request below filed through Patent Center on 05/06/2024 has been accepted.

Certifications

APPLICANT CHANGING TO REGULAR UNDISCOUNTED FEE STATUS

Signature

I certify, in accordance with 37 CFR 1.4(d)(4), that I am one of the signatories making the entity status change.

Signature	Name	Registration #
/Jialin Zhong/	Jialin Zhong	62937

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/089,999	**04/15/2024 11:39:59 AM Z ET**	**ZL0205-0002-PCT-US-CON2**

Title of Invention

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9408	FILED BY	Jialin Zhong
PATENT CENTER #	65091651	FILING DATE	12/28/2022
CUSTOMER #	155075	FIRST NAMED INVENTOR	Xiaobo ZHANG
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ZL0205-0002-PCT-US-CON2 Response to NFOA.pdf	11	Amendment/Request for Reconsideration-After Non-Final Rejection	119 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
ZL0205-0002-PCT-US-CON2 Response to NFOA.pdf	E60E03B0A5C47580219A417DC453BDD0727466770B9DA9A4B4757C1F80738055CBC245A5B623327174 1C1594912F9EC2F57667D0A2FA86606F6AD1F1EEFC6521

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

New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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

Our Docket No: ZL0205-0002-PCT-US-CON2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	Examiner: DEEPA BELUR
	)	
Xiaobo ZHANG	)	Art Unit: 2472
	)	
Application No: 18/089,999	)	Confirmation No.: 9408
	)	
Filed: December 28, 2022	)	
	)	
For: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	)	

AMENDMENT

E-Filed via EFS-Web
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir/Madam:

In response to the Non-final Office action mailed on January 16, 2024, applicant respectfully requests the Examiner to enter the following amendments and to consider the following remarks.

Amendments to the Specification begin on page 2 of this document.

Amendments to the Claims are reflected in the listing of claims which begin on page 3 of this document.

Remarks begin on page 10 of this document.

AMENDMENTS TO THE SPECIFICATION

Please amend the first paragraph as reflected in the following marked-up version:

[0001] This application is a continuation of the United States Application No. 17/143,180, filed on January 7, 2021, which is a continuation of the United States Application No.16/429,077, ~~field~~ filed on June 3, 2019, which is a continuation of International Application No. PCT/CN2017/l 12033, filed on November 21, 2017, claiming the priority benefit of Chinese Patent Application Serial Number 201611098328.7, filed on December 3, 2016. The afore-mentioned patent applications are hereby incorporated by reference in their entireties.

In the claims:

For the Examiner's convenience, all pending claims are presented below with changes shown in accordance with the mandatory amendment format.

What is claimed is:

1. (Currently amended) A method for multi-antenna transmission in a user equipment, comprising:

receiving a first radio signal; and

receiving a first signaling;

wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal)~~; the first signaling is a downlink signaling~~.

2. (Currently amended) The method of claim 1, further comprising:

receiving a second signaling; and

operating a second radio signal in a first time resource sub-pool;

wherein the operating is <u>one of</u> receiving[[,]] or ~~the operating is~~ transmitting <u>the second radio signal</u>; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; and the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI and (a) transmitting antenna port(s) of the second radio signal.

3. (Original) The method of claim 1, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, comprising:

receiving first information, wherein the first information is used to determine the first antenna port group.

4. (Original) The method of claim 1, further comprising:

transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

5. (Original) The method of claim 1, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

6. (Original) A method for multi-antenna transmitting in a base station, comprising:

transmitting a first radio signal; and

transmitting a first signaling;

wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a

second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

7. (Currently amended) The method of claim 6, further comprising:

transmitting a second signaling; and

performing a second radio signal in a first time resource sub-pool;

wherein the performing is one of transmitting[[,]] or ~~the performing is~~ receiving the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI and (a) transmitting antenna port(s) of the second radio signal.

8. (Original) The method of claim 6, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, comprising:

transmitting first information, wherein the first information is used to determine the first antenna port group.

9. (Original) The method of claim 6, further comprising:

receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s)

indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

10. (Original) The method of claim 6, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

11. (Currently amended) A user equipment (UE) for multi-antenna transmission, comprising:

a first transceiver, receiving a first radio signal; and

a second receiver, receiving a first signaling;

wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal)~~; the first signaling is a downlink signaling~~.

12. (Currently amended) The UE of claim 11, comprising:

a third receiver, receiving a second signaling; and

a second transceiver, operating a second radio signal in a first time resource sub-pool;

wherein the operating is one of receiving[[,]] or ~~the operating is~~ transmitting the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; and the second signaling is used to determine at least one of occupied frequency domain resources, a MCS, a HARQ process number, a RV, a NDI and (a) transmitting antenna port(s) of the second radio signal.

13. (Original) The UE of claim 11, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, the second receiver further receives first information, wherein the first information is used to determine the first antenna port group.

14. (Original) The UE of claim 11, wherein:

the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

15. (Original) The UE of claim 11, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer

signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

16. (Original) A base station equipment for multi-antenna transmission, comprising:

a third transceiver, transmitting a first radio signal; and

a second transmitter, transmitting a first signaling;

wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

17. (Currently amended) The base station equipment of claim 16, further comprising:

a third transmitter, transmitting a second signaling; and

a fourth transceiver, performing a second radio signal in a first time resource sub-pool;

wherein the performing is one of transmitting[[,]] or ~~the performing is~~ receiving the second radio signal; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, a MCS, a HARQ process number, a RV, a NDI and (a) transmitting antenna port(s) of the second radio signal.

18. (Original) The base station equipment of claim 16, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, the second transmitter further transmits first information, wherein the first information is used to determine the first antenna port group.

19. (Original) The base station equipment of claim 16, wherein:

the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

20. (Original) The base station equipment of claim 16, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

REMARKS

Applicant respectfully requests reconsideration of this application. The Specification is amended. Claims 1, 2, 7, 11, 12, and 17 are amended. No claims have been canceled. No new claims have been added.

Applicant respectfully submits that the amendments to the Specification and Claims do not add new matters and respectfully requests the entry of the amendments to the Specification and Claims.

Summary of the Office Action

Claims 1 and 2 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claim 1 of the US Patent No. 10,944,527 ('527 Patent).

Claims 1, 3-6, 8-11, 13-16, 18-20 are rejected under 35 U.S.C. 101 as claiming the same invention as that of claims 1, 3-6, 8-11, 13-16, and 18-20 respectively of prior U.S. Patent No. 11,546,110 ('110 Patent).

Double Patenting Rejection

Claims 1 and 2 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claim 1 of the '527 Patent.

Claims 1, 3-6, 8-11, 13-16, 18-20 are rejected under 35 U.S.C. 101 as claiming the same invention as that of claims 1, 3-6, 8-11, 13-16, and 18-20 respectively of '110 Patent.

Claims 1, 2, 7, 11, 12, and 17 are hereby amended to overcome the rejections. Applicant respectfully request that the Office withhold the double patenting rejection in abeyance because of the amendment to the claims until the claims are in condition for allowance.

The Examiner is requested to call the undersigned at (908) 591-2738 if there remains any issue with allowance of the case.

Please charge any shortage to our Deposit Account No. 60-2313.

Respectfully submitted,

ZHONG LAW, LLC

Date: April 15, 2024

/Jialin Zhong/
Jialin Zhong
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51 JFK Parkway, First Floor West
Short Hills, New Jersey 07078

PTO/SB/06 (09-11)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 18/089,999	Filing Date 12/28/2022	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

	(Column 1)	(Column 2)			
FOR	NUMBER FILED	NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	04/15/2024	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0		x $40 =	0
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 4	= 0		x $192 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/PEARLIE A FENNELL/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/089,999	12/28/2022	Xiaobo ZHANG	ZL0205-0002-PCT-US-CON2	9408

155075 7590 01/16/2024

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

EXAMINER	
BELUR, DEEPA	

ART UNIT	PAPER NUMBER
2472	

NOTIFICATION DATE	DELIVERY MODE
01/16/2024	ELECTRONIC

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

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

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

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

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No. 18/089,999	Applicant(s) ZHANG, Xiaobo	
	Examiner DEEPA BELUR	Art Unit 2472	AIA (FITF) Status Yes

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 12/28/2022.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

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

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-20 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-20 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 12/28/2022 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

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

Certified copies:

a)☑ All b)☐ Some** c)☐ None of the:

1.☑ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

2. This action is in response to the continuation application filed on 12/28/2022.

3. Claims 1-20 have been examined and rejected.

Double Patenting

4. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a

result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

5. Claim 1 together with claim 2 of the instant application are provisionally rejected on the ground of **nonstatutory double patenting** as being unpatentable over claim 1 of the US Patent No. 10,944,527 (reference application). Although the claims at issue are not identical, they are not patentably distinct from each other because claims 1-2 are generic to all that is recited in claim 1 of the US patent. That is, claims 1-2 are anticipated by claim 1 of the US Patent.

Claim 1 of the instant application is directed to a method for multi-antenna transmission in a user equipment, comprising: receiving a first radio signal; and receiving a first signaling; wherein the first radio signal is transmitted by K antenna port groups; the

antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

Claim 1 of the US Patent No. 10,944,527 is directed to a method for multi-antenna transmission in a user equipment, comprising: receiving a first radio signal; and receiving a first signaling; wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of the antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; at least one first antenna virtualization vector and a second antenna virtualization vector is associated with the first antenna port group; the first antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; the K is a positive integer greater than 1.

This is a non-provisional nonstatutory double patenting rejection because the patentably indistinct claims have in fact been patented. Firstly, the underlined limitation of claim 1 of the instant application is used to determine first resource pool using the second

antenna vector. The underlined limitation of claim 1 of the US patent is used to determine the resource pool using both the first antenna vector and the second antenna vector. Secondly, the italicized limitations in claim 2 of the instant application map to the italicized limitations in claim 1 of the US Patent, with the second signaling is used to determine at least one of occupied frequency domain resources representing the scheduling information of claim 1 of the reference application.

6. A rejection based on double patenting of the "same invention" type finds its support in the language of 35 U.S.C. 101 which states that "whoever invents or discovers any new and useful process... may obtain a patent therefor..." (Emphasis added). Thus, the term "same invention," in this context, means an invention drawn to identical subject matter. See *Miller v. Eagle Mfg. Co.*, 151 U.S. 186 (1894); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Ockert*, 245 F.2d 467, 114 USPQ 330 (CCPA 1957).

A statutory type (35 U.S.C. 101) double patenting rejection can be overcome by canceling or amending the claims that are directed to the same invention so they are no longer coextensive in scope. The filing of a terminal disclaimer cannot overcome a double patenting rejection based upon 35 U.S.C. 101.

Claims 1, 3-6, 8-11, 13-16, 18-20 are rejected under 35 U.S.C. 101 as claiming the same invention as that of claims 1, 3-6, 8-11, 13-16, 18-20 respectively of prior U.S. Patent No. 11,546,110 B2. **This is a statutory double patenting rejection**.

Conclusion

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to DEEPA BELUR whose telephone number is (571)270-3722. The examiner can normally be reached M-F 8 am - 4:30 pm.

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

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, **Chi Pham** can be reached on 571-272-3179. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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

/DEEPA BELUR/
Primary Examiner, Art Unit 2472

Notice of References Cited	Application/Control No. 18/089,999	Applicant(s)/Patent Under Reexamination ZHANG, Xiaobo	
	Examiner DEEPA BELUR	Art Unit 2472	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Name	CPC Classification	US Classification
*	A	US-20190386729-A1	2019-12-19	ZHANG; XiaoBo	H04B7/0617	1/1
*	B	US-20190207661-A1	2019-07-04	Fröberg Olsson; Jonas	H04B17/373	1/1
*	C	US-20180262252-A1	2018-09-13	OH; Jin-Young	H04B7/0636	1/1
*	D	US-20170041113-A1	2017-02-09	Park; Hanjun	H04B7/0634	1/1
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Country	Name	CPC Classification
	N	WO-2016019749-A1	2016-02-11	WO	BO L	H04B7/0413
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in YYYY-MM-DD format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	Art Unit
	DEEPA BELUR	2472

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04L5/005.cpc.	01/10/2024	DB
H04B7/0408.cpc.	01/10/2024	DB
H04B7/0413.cpc.	01/10/2024	DB
H04B7/06.cpc.	01/10/2024	DB
H04B7/0617.cpc.	01/10/2024	DB
H04L1/1819.cpc.	01/10/2024	DB
H04L1/0003.cpc.	01/10/2024	DB
H04L5/0082.cpc.	01/10/2024	DB
H04W88/02.cpc.	01/10/2024	DB

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

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

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

/DEEPA BELUR/ Primary Examiner, Art Unit 2472	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	Art Unit
	DEEPA BELUR	2472

Search Notes		
Search Notes	**Date**	**Examiner**
H04L5/005.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/0408.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/0413.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/06.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04B7/0617.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04L1/1819.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04L1/0003.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04L5/0082.cpc.in combination with text search, see search history printout	01/10/2024	DB
H04W88/02.cpc.in combination with text search, see search history printout	01/10/2024	DB
Inventor and Assignee search in PE2E, see search history printout	01/09/2024	DB
NPL search in Chrome, see web search history	01/10/2024	DB

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**

/DEEPA BELUR/ Primary Examiner, Art Unit 2472	

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/089,999	ZHANG, Xiaobo
	Examiner	Art Unit
	DEEPA BELUR	2472

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

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

CLAIM		DATE								
Final	Original	01/10/2024								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
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	15	✓								
	16	✓								
	17	✓								
	18	✓								
	19	✓								
	20	✓								

Bibliographic Data

Application No: 18/089,999

Foreign Priority claimed: (•) Yes ( ) No

35 USC 119 (a-d) conditions met: [✓] Yes [ ] No [ ] Met After Allowance

Verified and Acknowledged: /DEEPA BELUR/ Examiner's Signature [ ] Initials

Title: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
12/28/2022 **RULE**	370	2472	ZL0205-0002-PCT-US-CON2

APPLICANTS

APEX BEAM TECHNOLOGIES LLC,

INVENTORS

Xiaobo ZHANG, Shanghai, CHINA

CONTINUING DATA

This application is a CON of 17143180 01/07/2021 PAT 11546110

17143180 is a CON of 16429077 06/03/2019 PAT 10944527

16429077 is a CON of PCT/CN2017/112033 11/21/2017

FOREIGN APPLICATIONS

CHINA CN201611098328.7 12/03/2016

IF REQUIRED, FOREIGN LICENSE GRANTED**

01/23/2023

**** SMALL ENTITY ****

STATE OR COUNTRY

CHINA

ADDRESS

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

FILING FEE RECEIVED

$1,656

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

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Xiaobo ZHANG
Art Unit	
Examiner Name	
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	11245449	B2	2022-02-08	Frenne et al.	
	2	11139875	B2	2021-10-05	Chao Wei	

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

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20190288807	A1	2019-09-19	Xiaobo Zhang	
	2	20170373743	A1	2017-12-28	Park et al.	
	3	20160157218	A1	2016-06-02	Nam et al.	
	4	20150341100	A1	2015-11-26	Kwak et al.	

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /D.B/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	
	First Named Inventor	Xiaobo ZHANG
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	5	20160094326	A1	2016-03-31	Moon et al.	
	6	20150010106	A1	2015-01-08	Skov et al.	
	7	20110223876	A1	2011-09-15	Jee Woong Kang	

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FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	105207705	CN	A	2015-12-30	Zhang et al.		☒
	2	101447815	CN	A	2009-06-03	Shiqiang et al.		☒
	3	105656607	CN	A	2016-06-08	Xiaobo Zhang		☒
	4	2016077584	WO	A1	2016-05-19	Lee et al.		☐
	5	104853417	CN	B	2015-08-19	Duan et al.		☐
	6	104852756	CN	B	2015-08-19	Duan et al.		☐

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	First Named Inventor	Xiaobo ZHANG
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	7	105577318	CN	A	2016-05-11	Xiaobo Zhang		☐
	8	103687010	CN	A	2014-03-26	Jing et al.		☐
	9	101567865	CN	A	2009-10-28	Gaishi et al.		☐
	10	2016018100	WO	A1	2016-02-04	Kim et al.		☐

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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Chinese Notice of Allowance dated January 21, 2022 received in Chinese Application No. 2020103207574, pp. 3	
	2	TSG RAN WG1, "R1-1608690 Remaining issues on aperiodic CSI-RS," 3GPP20161001, 2016, pp. 1-5	
	3	Nortel Discussion on RS Designfor Higher-order MIMOin L TE-A,2009.03.27 3GPPTSG-RAN Working Group 1 Meeting#56bis R 1-091591	
	4	LG Electronics RS designenhancements forsupporting EB and FD-MIMO,2014.10.10,3GPP TSG RAN WG1 Meeting #78bisR1-144047	
	5	Ericsson Phasee2modeling of 2D AntennaArrays,2014.11.21,3GPP TSG-RAN WG1#79 R1-145169	

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	Examiner Name	
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	6	Texas InstrumentsRemaining Issues onULMIMO TransmissionMode and DCI FormatDesign,2010.07.02,3GGP TSG RAN WG161bis R1-103705	
	7	ISR received in application No. PCT/CN2017/112033 dated 07 February 2018	
	8	Frirst Office Action received from the no. 201611098328.7 dated January 06, 2020.	
	9	First Search Report received from the no. 201611098328.7 dated December 26, 2019	
	10	Notice of Granting Patent Right for Invention received from the no. 201611098328.7 dated April 21, 2020	

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

EXAMINER SIGNATURE

Examiner Signature	/DEEPA BELUR/ (01/09/2024)	Date Considered	01/09/2024

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

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

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /D.B/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Xiaobo ZHANG
Art Unit	
Examiner Name	
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

CERTIFICATION STATEMENT

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

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

OR

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

See attached certification statement.

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

☒ A certification statement is not submitted herewith.

SIGNATURE

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

Signature	/Jialin Zhong/	Date (YYYY-MM-DD)	2022-12-28
Name/Print	Jialin Zhong	Registration Number	62937

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

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /D.B/

Privacy Act Statement

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

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

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

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

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

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

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

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

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

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

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

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /D.B/

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Web Search History

date, time	web site	search string
1/9/2024 3:32:35 PM	Google	antenna virtualization vector of an antenna port group
1/10/2024 1:52:14 PM	Google	multi antenna transmission using virtual antenna and resource pools
1/10/2024 1:53:05 PM	Google	antenna port groups to determine resource pools

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	5	((("APEX") near3 ("BEAM") near3 ("TECHNOLOGIES") near3 ("LLC"))).AS,AANM.	(USPAT)	OR	ON	ON	2024/01/09 01:51 PM
L2	1198	((("ZHANG") near3 ("Xiaobo"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/01/09 01:51 PM
L3	477901	(H04L5/005 OR H04B7/0408 OR H04B7/0413 OR H04B7/06 OR H04B7/0617 OR H04L1/0003 OR H04L1/1819 OR H04L5/0082 OR H04W88/02).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:34 PM
L5	34	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:39 PM
L6	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE,	OR	ON	ON	2024/01/09 02:42 PM

			SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L7	10	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) WITH (antenna near3 port) WITH ((signal$4 indication receiv$3) WITH (resource near5 time) WITH (antenna near5 vector)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/09 02:51 PM
L8	10	"20150010106"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:39 AM
L9	43	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual) WITH (antenna near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:48 AM
L10	14	(PSS SSS MIB SIB CSI$1RS signal) WITH (virtual near3 antenna	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY,	OR	ON	ON	2024/01/10 09:48 AM

		near3 ports) WITH ((signal$4 indication receiv$3) WITH (resource near5 time))	CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L11	13	(PSS SSS MIB SIB CSI$1RS reference near3 signal) WITH (virtual near3 antenna near3 ports) WITH (resource near5 time)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 09:49 AM
L12	24	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH ((resource near5 time) WITH (antenna near5 virtual$7)) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:07 AM
L13	4	"60735416".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK,	OR	ON	ON	2024/01/10 10:09 AM

			TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L14	2371	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:14 AM
L15	115	L14 AND (H04L5/005).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:15 AM
L18	9	(antenna near5 virtual$7) WITH (resource near4 pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:19 AM
L19	2	"41657461".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB,	OR	ON	ON	2024/01/10 10:21 AM

			HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)				
L20	38	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (resource WITH pool) AND @AD< "20161203"	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:22 AM
L21	80	(PSS SSS MIB SIB CSI$1RS signal) WITH (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 10:49 AM
L22	16	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0408).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:38 AM

L23	22	(resource WITH pool) SAME (multi plural$3 many several groups sets mimo) near3 (antennas) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:39 AM
L24	21	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0413).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:41 AM
L25	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/06).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:41 AM
L26	28	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04B7/0617).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL,	OR	ON	ON	2024/01/10 11:42 AM

			NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L27	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/0003).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L28	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L1/1819).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L29	15	(resource WITH pool) WITH (antenna near5 virtual$7) AND (H04L5/0082).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 11:43 AM
L30	15	(resource WITH pool)	(US-PGPUB; USPAT;	OR	ON	ON	2024/01/10

		WITH (antenna near5 virtual$7) AND (H04W88/02).cpc.	USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				11:44 AM
L31	6	"17143180"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/01/10 12:45 PM
L32	15	"62241193".fmid.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; JPO)	OR	ON	ON	2024/01/10 12:48 PM

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
18/089,999	12/28/2022	Xiaobo ZHANG	ZL0205-0002-PCT-US-CON2

CONFIRMATION NO. 9408

155075
Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

PUBLICATION NOTICE

OC000000064393800

Date Mailed: 11/09/2023

Title:METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Publication No.US-2023-0361963-A1
Publication Date:11/09/2023

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently https://portal.uspto.gov/pair/PublicPair. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
18/089,999	12/28/2022		920	ZL0205-0002-PCT-US-CON2	20	4

CONFIRMATION NO. 9408

UPDATED FILING RECEIPT

155075
Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

OC00000005987563

Date Mailed: 07/31/2023

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Xiaobo ZHANG, Shanghai, CHINA;

Applicant(s)

APEX BEAM TECHNOLOGIES LLC, MARSHALL, TX;

Assignment For Published Patent Application

APEX BEAM TECHNOLOGIES LLC, MARSHALL, TX

Power of Attorney: The patent practitioners associated with Customer Number 155075

Domestic Priority data as claimed by applicant

This application is a CON of 17/143,180 01/07/2021 PAT 11,546,110
which is a CON of 16/429,077 06/03/2019 PAT 10,944,527
which is a CON of PCT/CN2017/112033 11/21/2017

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
CHINA 201611098328.7 12/03/2016 No Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 01/23/2023

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 18/089,999**

Projected Publication Date: 11/09/2023

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

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This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 18/089,999

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	64		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	280		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	320		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	* 0	x =	0	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1	x 192 =	192			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	856		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

Electronic Patent Application Fee Transmittal

Application Number:	18089999
Filing Date:	28-Dec-2022
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Filer:	Jialin Zhong/Eddie Rowell
Attorney Docket Number:	ZL0205-0002-PCT-US-CON2

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
INDEPENDENT CLAIMS IN EXCESS OF 3	2201	1	192	192
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**192**

Electronic Acknowledgement Receipt

EFS ID:	48335668
Application Number:	18089999
International Application Number:	
Confirmation Number:	9408
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Customer Number:	155075
Filer:	Jialin Zhong/Eddie Rowell
Filer Authorized By:	Jialin Zhong
Attorney Docket Number:	ZL0205-0002-PCT-US-CON2
Receipt Date:	24-JUL-2023
Filing Date:	28-DEC-2022
Time Stamp:	08:36:10
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$192
RAM confirmation Number	E20237N936307225
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Fee Worksheet (SB06)	fee-info.pdf	38059 e18b2c2506c8eeea5fd27b4e0644104b56f4a2f5	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	38059		

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

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES
PATENT AND TRADEMARK OFFICE

Application No.	: 18/089,999	Confirmation No. 9408
Inventors	: Xiaobo Zhang	
Filed	: December 28, 2022	
Docket No.	: ZL0205-0002-PCT-US-CON2	
Title	: METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	

Commissioner for Patents
PO Box 1450
Alexandria, Virginia 22313-1450.

RESPONSE TO NOTICE TO FILE MISSING PARTS

Sir:

In response to the Notice to file Missing Parts dated January 4, 2023, submitted herewith are the following fees:

□ Basic filing fee ($64)

□ Application search fee ($280)

□ Application examination fee ($320)

□ Surcharge ($64)

□ 1 independent claims over 3 ($192)

Also submitted herewith is a 4 month extension of time.

The Commissioner is hereby authorized to charge any additional fees or credit any overpayment to Deposit Account 60-2313.

Respectfully submitted,

ZHONG LAW, LLC
Attorneys/Agents for Applicants

Date: July 24, 2023

/Jialin Zhong/
Jialin Zhong
Registration No. 62,937

51 JFK Parkway, 1st Floor West
Short Hills, New Jersey 07078

Electronic Patent Application Fee Transmittal

Application Number:	18089999
Filing Date:	28-Dec-2022
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Filer:	Jialin Zhong/Eddie Rowell
Attorney Docket Number:	ZL0205-0002-PCT-US-CON2

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	64	64
UTILITY SEARCH FEE	2111	1	280	280
UTILITY EXAMINATION FEE	2311	1	320	320
Pages:				
Claims:				
Miscellaneous-Filing:				
LATE FILING FEE FOR OATH OR DECLARATION	2051	1	64	64
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 4 months with $0 paid	2254	1	928	928
Miscellaneous:				
		Total in USD ($)		**1656**

Electronic Acknowledgement Receipt

EFS ID:	48335562
Application Number:	18089999
International Application Number:	
Confirmation Number:	9408
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Customer Number:	155075
Filer:	Jialin Zhong/Eddie Rowell
Filer Authorized By:	Jialin Zhong
Attorney Docket Number:	ZL0205-0002-PCT-US-CON2
Receipt Date:	24-JUL-2023
Filing Date:	28-DEC-2022
Time Stamp:	08:28:49
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1656
RAM confirmation Number	E20237N931507119
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	Response_to_Notice_to_File_Missing_Parts.pdf	23847 91461c21882d2af878f882ec196b23f1287e372c	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	49286 8398905db5e5d5e9c7d4926fd97b4fe1c4c21236	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	73133		

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

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
18/089,999	12/28/2022	Xiaobo ZHANG	ZL0205-0002-PCT-US-CON2

CONFIRMATION NO. 9408

155075
Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

FORMALITIES LETTER

OC000000052957335

Date Mailed: 01/24/2023

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

An application number and filing date have been accorded to the above-identified nonprovisional application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee has not been received.
- The application search fee must be submitted.
- The application examination fee must be submitted.
- Additional claim fees of $**192** as a small entity, including any required multiple dependent claim fee, are required. Applicant must submit the additional claim fees or cancel the additional claims for which fees are due.
- Surcharge as set forth in 37 CFR 1.16(f) has not been received.

  The surcharge is due for any one of:
  - late submission of the basic filing fee, search fee, or examination fee,
  - late submission of inventor's oath or declaration,
  - filing an application that does not contain at least one claim on filing, or
  - submission of an application filed by reference to a previously filed application.

SUMMARY OF FEES DUE:

The fee(s) required (including the fees noted above) are as follows. Small entity discount is in effect. If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- $**64** basic filing fee.
- $**64** surcharge.
- $**280** search fee.
- $**320** examination fee.
- $**192** for 1 independent claims over 3.
- $(**0**) previous unapplied payment amount.

- $**920** TOTAL FEE BALANCE DUE.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be addressed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

REPLY VIA ELECTRONIC FILING

A reply may be submitted via electronic filing only by registered users of the appropriate USPTO patent electronic filing system and must include:

- A separate document having the document description, "**Applicant response to Pre-Exam Formalities Notice**"; and
- the item(s) for which a reply period is set forth above.

For more information about electronic filing, contact the Patent Electronic Business Center (EBC) 1-866-217-9197 or visit https://www.uspto.gov/ebc

NOTE: If the reply is not being submitted electronically, a copy of this notice must be included.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/mabebe/

UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
18/089,999	12/28/2022		0	ZL0205-0002-PCT-US-CON2	20	4

CONFIRMATION NO. 9408

155075
Zhong Law, LLC
51 JFK Parkway
1st Floor West
Short Hills, NJ 07078

FILING RECEIPT

OC000000052957333

Date Mailed: 01/24/2023

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Xiaobo ZHANG, Shanghai, CHINA;

Applicant(s)

APEX BEAM TECHNOLOGIES LLC, MARSHALL, TX;

Assignment For Published Patent Application

APEX BEAM TECHNOLOGIES LLC, MARSHALL, TX

Power of Attorney: The patent practitioners associated with Customer Number 155075

Domestic Priority data as claimed by applicant

This application is a CON of 17/143,180 01/07/2021 PAT 11,546,110
which is a CON of 16/429,077 06/03/2019 PAT 10,944,527
which is a CON of PCT/CN2017/112033 11/21/2017

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
CHINA 201611098328.7 12/03/2016 No Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 01/23/2023

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 18/089,999**

Projected Publication Date: To Be Determined - pending completion of Missing Parts.

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

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Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 18/089,999

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	64		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	280		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	320		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	* 0	x =	0	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1	x 192 =	192			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	856		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 01/31/2018. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 155075

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

APEX BEAM TECHNOLOGIES LLC

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature	Deepak Kumar Sharma	Date (Optional)	11/10/2021
Name	Deepak Sharma		
Title	Managing Director		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

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

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

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PTO/SB/08a (02-18)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Xiaobo ZHANG
Art Unit	
Examiner Name	
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	11245449	B2	2022-02-08	Frenne et al.	
	2	11139875	B2	2021-10-05	Chao Wei	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20190288807	A1	2019-09-19	Xiaobo Zhang	
	2	20170373743	A1	2017-12-28	Park et al.	
	3	20160157218	A1	2016-06-02	Nam et al.	
	4	20150341100	A1	2015-11-26	Kwak et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	
	First Named Inventor	Xiaobo ZHANG
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	5	20160094326	A1	2016-03-31	Moon et al.	
	6	20150010106	A1	2015-01-08	Skov et al.	
	7	20110223876	A1	2011-09-15	Jee Woong Kang	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	105207705	CN	A	2015-12-30	Zhang et al.		☒
	2	101447815	CN	A	2009-06-03	Shiqiang et al.		☒
	3	105656607	CN	A	2016-06-08	Xiaobo Zhang		☒
	4	2016077584	WO	A1	2016-05-19	Lee et al.		☐
	5	104853417	CN	B	2015-08-19	Duan et al.		☐
	6	104852756	CN	B	2015-08-19	Duan et al.		☐

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	
	First Named Inventor	Xiaobo ZHANG
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	7	105577318	CN	A	2016-05-11	Xiaobo Zhang		☐
	8	103687010	CN	A	2014-03-26	Jing et al.		☐
	9	101567865	CN	A	2009-10-28	Gaishi et al.		☐
	10	2016018100	WO	A1	2016-02-04	Kim et al.		☐

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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Chinese Notice of Allowance dated January 21, 2022 received in Chinese Application No. 2020103207574, pp. 3	
	2	TSG RAN WG1, "R1-1608690 Remaining issues on aperiodic CSI-RS," 3GPP20161001, 2016, pp. 1-5	
	3	Nortel Discussion on RS Designfor Higher-order MIMOin L TE-A,2009.03.27 3GPPTSG-RAN Working Group 1 Meeting#56bis R 1-091591	
	4	LG Electronics RS designenhancements forsupporting EB and FD-MIMO,2014.10.10,3GPP TSG RAN WG1 Meeting #78bisR1-144047	
	5	Ericsson Phasee2modeling of 2D AntennaArrays,2014.11.21,3GPP TSG-RAN WG1#79 R1-145169	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	
	First Named Inventor	Xiaobo ZHANG
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

	6	Texas InstrumentsRemaining Issues onULMIMO TransmissionMode and DCI FormatDesign,2010.07.02,3GGP TSG RAN WG161bis R1-103705
	7	ISR received in application No. PCT/CN2017/112033 dated 07 February 2018
	8	Frirst Office Action received from the no. 201611098328.7 dated January 06, 2020.
	9	First Search Report received from the no. 201611098328.7 dated December 26, 2019
	10	Notice of Granting Patent Right for Invention received from the no. 201611098328.7 dated April 21, 2020

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

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

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

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	
	First Named Inventor	Xiaobo ZHANG
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ZL0205-0002-PCT-US-CON2

CERTIFICATION STATEMENT

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

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

OR

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

See attached certification statement.

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

☒ A certification statement is not submitted herewith.

SIGNATURE

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

Signature	/Jialin Zhong/	Date (YYYY-MM-DD)	2022-12-28
Name/Print	Jialin Zhong	Registration Number	62937

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

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

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

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

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

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

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

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

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

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

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

Electronic Acknowledgement Receipt

EFS ID:	47284704
Application Number:	18089999
International Application Number:	
Confirmation Number:	9408
Title of Invention:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING
First Named Inventor/Applicant Name:	Xiaobo ZHANG
Customer Number:	155075
Filer:	Jialin Zhong/Eddie Rowell
Filer Authorized By:	Jialin Zhong
Attorney Docket Number:	ZL0205-0002-PCT-US-CON2
Receipt Date:	28-DEC-2022
Filing Date:	
Time Stamp:	15:07:19
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	ZL0205-0002-PCT-US-CON2_ADS.pdf	1256697 1fa33a975cc8a68254b36fef7bd864cc92fdf0b3	no	8

Warnings:

Information:					
2		155075_17143180_01-06-2021_Application.pdf	12261134 d48d9b7ca30e9e32d73286d9929d5563c986ce03	yes	48
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Specification		1	41	
	Claims		42	47	
	Abstract		48	48	
Warnings:					
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3	Drawings-only black and white line drawings	155075_17143180_01-06-2021_DRW.pdf	308585 464dd04cfb86bfbfa9aaeb8624ce35235e3ff02b	no	15
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4	Oath or Declaration filed	ZL0205-0002-PCT-US-CON1_Declaration.pdf	274403 19c4b8bf78c238bbaffe9e8855928db6ac2a17be	no	2
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5	Power of Attorney	ZL0205_82A.pdf	235387 fa9d12264dfe34cdf0dc72c99e29c2392f9c7261	no	1
Warnings:					
Information:					
6	Power of Attorney	POA82B_Apex_signed_by_DS.pdf	473848 df45826c83093493b1c49fe4916cfa8682f8e311	no	2
Warnings:					
Information:					
7	Information Disclosure Statement (IDS) Form (SB08)	ZL0205-0002-PCT-US-CON2_IDS.pdf	1035770 010632c014eea8f5ed83a6d06b54dcfb30ed4391	no	6

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Total Files Size (in bytes):	15845824

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ZL0205-0002-PCT-US-CON2
	Application Number	
Title of Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
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☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Xiaobo		ZHANG	

Residence Information (Select One) US Residency ● Non US Residency Active US Military Service

City	Shanghai	Country of Residence [i]	CN

Mailing Address of Inventor:

Address 1	ROOM 601, BUILDING 34, NO. 2777 EAST JINXIU ROAD		
Address 2	Pudong District		
City	Shanghai	State/Province	
Postal Code	201206	Country [i]	CN

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	155075		
Email Address	zhong@zhong-law.com	Add Email	Remove Email
Email Address	ip@remotedocket.com	Add Email	Remove Email

Application Information:

Title of the Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING		
Attorney Docket Number	ZL0205-0002-PCT-US-CON2	Small Entity Status Claimed	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	15	Suggested Figure for Publication (if any)	12

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For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	155075		

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This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	17143180	2021-01-07

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ZL0205-0002-PCT-US-CON2
	Application Number	
Title of Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
17143180	Continuation of	16429077	2019-06-03	10944527	2021-03-09

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
16429077	Continuation of	PCT/CN2017/112033	2017-11-21

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Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

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Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)
201611098328.7	CN	2016-12-03	

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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	Application Number	
Title of Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	

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Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

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1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

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The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

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☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ZL0205-0002-PCT-US-CON2
	Application Number	
Title of Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	APEX BEAM TECHNOLOGIES LLC		
Mailing Address Information For Applicant:			
Address 1	104 EAST HOUSTON STREET		
Address 2	SUITE 180		
City	MARSHALL	**State/Province**	TX
Country	US	Postal Code	75670
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

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Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

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Organization Name	APEX BEAM TECHNOLOGIES LLC

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	APEX BEAM TECHNOLOGIES LLC		
Address 2	SUITE 180		
City	MARSHALL	**State/Province**	TX
Country i	US	Postal Code	75670
Phone Number		Fax Number	
Email Address			

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Signature	/Jialin Zhong/			Date (YYYY-MM-DD)	2022-12-28
First Name	Jialin	Last Name	Zhong	Registration Number	62,937

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	Application Number	
Title of Invention	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	

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

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Method and Device for Multi-Antenna Transmission in UE and Base Station

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of the United States Application No.16/429,077, field on June 3, 2019, which is a continuation of International Application No. PCT/CN2017/112033, filed on November 21, 2017, claiming the priority benefit of Chinese Patent Application Serial Number 201611098328.7, filed on December 3, 2016. The afore-mentioned patent applications are hereby incorporated by reference in their entireties.

BACKGROUND

TECHNICAL FIELD

[0002] The present disclosure relates to a multiple antenna transmission method in a wireless communication system.

RELATED ART

[0003] Massive Multiple-Input Multiple-Output (MIMO) has become a research hotspot for next-generation mobile communications. In massive MIMO, multiple antennas can improve communication quality by forming narrower beams pointing to a specific direction through beamforming.

[0004] According to the discussion of 3rd Generation Partner Project (3GPP) Radio Access Network (RAN), the hybrid beamforming combining analog beamforming and digital beamforming has become an important research direction of New Radio (NR) system.

SUMMARY

[0005] In a massive MIMO system, the total throughput of a cell can be greatly increased by the number of massive antennas, so the number of single-cell users can be greatly increased. However, an increase in the number of cell users will lead to a large amount of signaling overhead for dynamic scheduling of wireless time-frequency resources. The signaling overhead of wireless resource dynamic scheduling is an urgent problem to be solved in massive MIMO system.

[0006] In view of the above problem, the present disclosure provides a solution. It should be noted that, in the case of no conflict, the features in the embodiments and embodiments in the user equipment of the present disclosure can be applied to the base station, and vice versa. The features of the embodiments and the embodiments of the present disclosure may be combined with each other arbitrarily if no conflict is incurred.

[0007] The present disclosure discloses a method for multi-antenna transmission in a user equipment (UE), comprising:

[0008] receiving first radio signal; and

[0009] receiving a first signaling;

[0010] wherein the first radio signal is transmitted by K antenna port groups; the antenna port group(s) include a positive integer number of the antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; at least one of a first antenna virtualization vector and a second antenna virtualization vector is associated with the first antenna port group; the firs antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; the K is a positive integer greater than 1 .

[0011] In one embodiment, the foregoing method is advantageous in that, by associating the first time resource pool with the first antenna port group, the UE can quickly determines the location of the first time resource pool in the time domain by the index of the first antenna port group in the K antenna port groups.

[0012] In one embodiment, the foregoing method is advantageous in that, by associating the first time resource pool with the first antenna port group, the UE can quickly determine the antenna virtualization vectors which used for receiving radio signal transmitted on the first time resource pool by the location of the first time resource pool in the time domain.

[0013] In one embodiment, the first radio signal is a multi-carrier symbol.

[0014] In one embodiment, the first radio signal is a single carrier symbol.

[0015] In one embodiment, the first radio signal is an OFDM symbol.

[0016] In one embodiment, the first radio signal is an FBMC symbol.

[0017] In one embodiment, the first radio signal is an SC-FDMA symbol.

[0018] In one embodiment, the first radio signal is reference signal(s) associated with the K antenna port groups.

[0019] In one embodiment, the first radio signal is wireless resource block(s) transmitted by the K antenna port groups.

[0020] In one embodiment, the first radio signal includes one or more of Primary Synchronization Signal (PSS), Secondary Synchronization Signal (SSS), Master Information Block (MIB)/System Information Block (SIB), and Channel State Information Reference signal(s) (CSI-RS).

[0021] In one embodiment, the antenna port is formed by superposing multiple physical antennas through antenna virtualization; the mapping coefficients from the multiple physical antennas to the antenna port(s) constitute an antenna virtualization vector for the antenna virtualization.

[0022] In one embodiment, the beamforming vectors corresponding to any two different antenna ports cannot be assumed to be the same.

[0023] In one embodiment, the small-scale characteristics of a wireless channel experienced by a signal transmitted by one antenna port and cannot be used to infer the small-scale characteristics of a wireless channel experienced by a signal transmitted by another antenna port.

[0024] In one embodiment, an antenna port is associated with a reference signal.

[0025] In one embodiment, an antenna port is used to transmit a reference signal associated therewith.

[0026] In one embodiment, the pattern of the time-frequency resource occupied by the reference signal(s) in one subframe reuses the pattern of the CSI-RS in one subframe.

[0027] In one embodiment, the reference signal is a CSI-RS.

[0028] In one embodiment, the sequence corresponding to the reference signal is a Zadoff-Chu sequence.

[0029] In one embodiment, the sequence corresponding to the reference signal is a pseudo-random sequence.

[0030] In an embodiment, the time domain resources occupied by the reference signal(s) is(are) associated with at least one of time domain resources occupied by the first signaling and time domain resources occupied by the first radio signal.

[0031] In one embodiment, the frequency domain resources occupied by the reference signal(s) is associated with at least one of a frequency domain resources occupied by the first signaling and frequency domain resources occupied by the first radio signal.

[0032] In one embodiment, the frequency domain resources occupied by the reference signal(s) are configurable.

[0033] In one embodiment, the K antenna port groups are associated with K reference signal group(s), respectively.

[0034] In one embodiment, the K antenna port groups are respectively used to transmit K reference signal(s) groups.

[0035] In one embodiment, the K antenna port groups are used to transmit K CSI-RS group(s).

[0036] In one embodiment, the K antenna port groups correspond to K reference signal resources, and the first antenna port group corresponds to one of the K reference signal resources.

[0037] In one embodiment, the K reference signal groups are respectively transmitted on K reference signal resources.

[0038] In one embodiment, one reference signal resource includes a plurality of Resource Elements (REs).

[0039] In one embodiment, the K reference signal resources are pairwise orthogonal in the time-frequency domain.

[0040] In one embodiment, the antenna port group includes only one antenna port.

[0041] In one embodiment, the antenna port group includes two antenna ports. In one embodiment, the air interface resource(s) occupied by one antenna port is different from the air interface resource(s) occupied by another antenna port.

[0042] In one embodiment, the air interface resource(s) occupied by one reference signal is different from the air interface resource(s) occupied by another reference signal.

[0043] In one embodiment, the air interface resource(s) includes(include) at least one of time domain resources, frequency domain resources, and code domain resources.

[0044] In one embodiment, the pattern of the reference signal(s) transmitted by at least two antenna ports in the K antenna port groups are the same in the time-frequency resource block(s).

[0045] In one embodiment, the time-frequency resource block(s) is a Physical Resource block Pair (PRBP).

[0046] In one embodiment, the time-frequency resource block(s) occupies W subcarriers on the frequency domain and occupies a wideband symbol in the time domain, wherein the W is a positive integer greater than 1. In a sub-embodiment of this sub-embodiment, the wideband symbol is one of an OFDM symbol, an SC-FDMA symbol, and an SCMA symbol.

[0047] In one embodiment, the first radio signal is transmitted by the K antenna port groups in a manner that the first radio signal carries the K reference signal groups, and the antenna virtualization vectors corresponding to the K reference signal groups are respectively used to map the K reference signal groups to a set of physical antennas to be transmitted.

[0048] In one embodiment, the time resources respectively corresponding to the K antenna port groups are orthogonal.

[0049] In one embodiment, the first signaling is a semi-static signaling.

[0050] In one embodiment, the first signaling is a high layer signaling.

[0051] In one embodiment, the first signaling includes one or more RRC Information Elements (IEs).

[0052] In one embodiment, the first signaling is a dynamic signaling.

[0053] In one embodiment, the first signaling is a physical layer signaling.

[0054] In one embodiment, the first signaling is carried by a downlink physical layer control channel (i.e. a downlink channel that can only be used to carry physical layer signaling).

[0055] In one embodiment, the downlink physical layer control channel is a Physical Downlink Control Channel (PDCCH).

[0056] In one embodiment, the downlink physical layer control channel is a short PDCCH (sPDCCH).

[0057] In one embodiment, the first signaling carries downlink control information (DCI).

[0058] In one embodiment, the first signaling carries fast downlink control information (fast DCI).

[0059] In one embodiment, the first signaling is cell-common.

[0060] In one embodiment, the first signaling is UE-specific.

[0061] In one embodiment, the first signaling is specific to a terminal group, the terminal group includes multiple terminals, and the UE is one of the terminals of the terminal group.

[0062] In one embodiment, the first signaling is transmitted on a broadcast channel (i.e., a downlink channel that can only be used to carry broadcast signals).

[0063] In one embodiment, the broadcast channel includes a Physical Broadcast Channel (PBCH).

[0064] In one embodiment, the first signaling is transmitted by the first antenna port group.

[0065] In one embodiment, the first antenna port group includes L antenna port(s), the first signaling includes L first sub-signals, the L first sub-signals carry the same bit block, and the L first sub-signals are respectively transmitted by the L antenna port(s). The bit block includes a positive integer number of bit(s), and the L is a positive integer.

[0066] In one embodiment, the index of the first antenna port group in the K antenna port groups is a non-negative integer smaller than the K.

[0067] In one embodiment, the index of the first antenna port group in the K antenna port groups is used to generate the first signaling.

[0068] In one embodiment, a receiving beamforming vector for the first antenna port group is used to determine a receiving beamforming vector for the first signaling.

[0069] In one embodiment, the first signaling indicates the first antenna port group from the K antenna port groups.

[0070] In one embodiment, the first signaling explicitly indicates the first time resource pool.

[0071] In one embodiment, the first signaling implicitly indicates the first time resource pool.

[0072] In one embodiment, the first time resource pool is discontinuous in the time domain.

[0073] In one embodiment, a transmitter of the first signaling generates the transmitting analog beam corresponding to the first antenna port group by adopting the first antenna virtualization vector.

[0074] In one embodiment, the first antenna port group is used to transmit a first reference signal(s) group, and the first antenna virtualization vector is used to transmit the first reference signal(s) group.

[0075] In one embodiment, the UE generates the receiving analog beam corresponding to the first antenna port group(s) by adopting the second antenna virtualization vector.

[0076] In one embodiment, the second antenna virtualization vector is used to receive the first reference signal group(s).

[0077] In one embodiment, the first antenna virtualization vector is associated with the first antenna port group

[0078] In one embodiment, the second antenna virtualization vector is associated with the first antenna port group.

[0079] In one embodiment, the first antenna virtualization vector and the second antenna virtualization vector are both associated with the first antenna port group.

[0080] In one embodiment, the third radio signal is a radio signal transmitted in a time resource within the first time resource pool. The first antenna virtualization vector is used by a transmitter of the first signaling to transmit an analog beamforming of the third radio signal.

[0081] In one embodiment, the third radio signal is a radio signal transmitted in a time resource within the first time resource pool. The second antenna virtualization vector is used by the UE to receive an analog beamforming of the third radio signal.

[0082] In one embodiment, the third radio signal is a radio signal transmitted in a time resource within the first time resource pool. The first antenna virtualization vector is used by a transmitter of the first signaling to receive an analog beamforming of the third radio signal.

[0083] In one embodiment, the third radio signal is a radio signal transmitted in a time resource within the first time resource pool. The second antenna virtualization vector is used by the U E to transmit an analog beamforming of the third radio signal.

[0084] In one embodiment, the first antenna port group includes L antenna port(s), the first antenna port is one of the L antenna port(s), and the first antenna virtualization vector is associated with the first antenna port.

[0085] In one embodiment, the second antenna virtualization vector is associated with the first antenna port.

[0086] According to one aspect of the present disclosure, the method comprises:

[0087] receiving a second signaling; and

[0088] operating a second radio signal in a first time resource sub-pool;

[0089] wherein the operating is receiving; or the operating is transmitting; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI, (a) transmitting antenna port(s) of the second radio signal.

[0090] In one embodiment, the advantages of the above method is that by the method of receiving the second signal to determine the first time resource sub-pool from the first time resource pool, the UE can significantly reduce the signaling overhead for determining the frequency domain resources occupied by the second radio signal.

[0091] In one embodiment, the second signaling is dynamic signaling.

[0092] In one embodiment, the second signaling is physical layer signaling.

[0093] In one embodiment, the second signaling is carried by a downlink physical layer control channel.

[0094] In one embodiment, the second signaling is a physical layer downlink control indication.

[0095] In one embodiment, the second signaling consists of two physical layer downlink control indications.

[0096] In one embodiment, the second signaling is for the UE.

[0097] In one embodiment, the second signaling is transmitted by the first antenna port group.

[0098] In one embodiment, the first antenna virtualization vector is used to transmit the second signaling.

[0099] In one embodiment, the first time resource sub-pool is discontinuous in the time domain.

[0100] In one embodiment, the time resource included in the first time resource sub-pool is a subset of the first time resource pool.

[0101] In one embodiment, the first time resource pool includes N1 time resources, and the first time resource sub-pool includes N2 time resources in the N1 time resources.

[0102] In one embodiment, the time resource is a sub-frame.

[0103] In one embodiment, the time resource is an OFDM symbol.

[0104] In one embodiment, the time resource is an SC-FDMA symbol.

[0105] In one embodiment, the time resource is an FBMC symbol.

[0106] In one embodiment, the UE determines the time resource included in the first time resource sub-pool by the joint indication of the second signaling and the first signaling.

[0107] In an embodiment, the second signaling is used to determine a relative position of the time resource comprised in the first time resource sub-pool in the first time resource pool.

[0108] In one embodiment, the second signaling indicates that the time resource comprised in the first time resource sub-pool corresponds to a bitmap of the first time resource pool.

[0109] In an embodiment, the second signaling indicates an index of a time resource comprised in the first time resource sub-pool in the first time resource pool.

[0110] In one embodiment, the second radio signal is a radio resource block(s).

[0111] In one embodiment, the time domain resources occupied by the second radio signal are the first time resource sub-pool, and the frequency domain resources occupied by the second radio signal are indicated by the second signaling.

[0112] In one embodiment, the second signaling is divided into M fields, and the first field and the second field are respectively two fields in the M fields. The first field is used to determine the first time resource sub-pool from the first time resource pool, and the second field is used to determine frequency domain resources occupied by the second radio signal.

[0113] In one embodiment, the second signaling is divided into M fields, and the first field is one of the M fields. The first field is configured to determine the first time resource sub-pool from the first time resource pool and is used to determine frequency domain resources occupied by the second radio signal.

[0114] In one embodiment, the transmitting channel corresponding to the second radio signal is a DL-SCH, and the operation is receiving.

[0115] In one embodiment, the physical layer channel corresponding to the second radio signal is a PDSCH, and the operation is receiving.

[0116] In one embodiment, the transmitting channel corresponding to the second radio signal is a UL-SCH, and the operation is transmitting.

[0117] In one embodiment, the physical layer channel corresponding to the second radio signal is a PUSCH, and the operation is transmitting.

[0118] In one embodiment, the operation is receiving, and the first antenna virtualization vector is used to transmit an analog beamforming of the second radio signal.

[0119] In one embodiment, the operation is receiving, and the second antenna virtualization vector is used to receive an analog beamforming of the second radio signal.

[0120] In one embodiment, the operation is transmitting, and the first antenna virtualization vector is used to receive an analog beamforming of the second radio signal.

[0121] In one embodiment, the operation is transmitting, and the second antenna virtualization vector is used to transmit an analog beamforming of the second radio signal.

[0122] In one embodiment, the second signaling explicitly indicates at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI, (a) transmitting antenna port(s).

[0123] In one embodiment, the second signaling implicitly indicates at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI, (a) transmitting antenna port(s).

[0124] In one embodiment, the first antenna port group is used to transmit first reference signal group, and the second radio signal and the first reference signal group are spatially Quasi Co-Located (QCL).

[0125] In one embodiment, the first antenna virtualization vector is used to transmit the second radio signal.

[0126] In one embodiment, the second antenna virtualization vector is used to receive the second radio signal.

[0127] According to another embodiment of the present disclosure, the method comprises:

[0128] receiving first information;

[0129] wherein the first information is used to determine the first antenna port group.

[0130] In one embodiment, the first information is used to determine the first antenna port group from the K antenna port groups.

[0131] In one embodiment, the first information explicitly indicates the first antenna port group.

[0132] In one embodiment, the first information implicitly indicates the first antenna port group.

[0133] In one embodiment, the first signaling includes the first information.

[0134] In one embodiment, a field in the first signaling indicates an index of the first antenna port group in the K antenna port groups.

[0135] In one embodiment, the first information is transmitted before the first signaling.

[0136] In one embodiment, the first information is used to determine a time resource pool in which the first signaling is located.

[0137] In one embodiment, the first information is used to determine a search space in which the first signaling is located.

[0138] According to another embodiment of the present disclosure, the method comprises:

[0139] transmitting second information;

[0140] wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer.

[0141] In one embodiment, the second information is used to determine the first antenna port group from the K antenna port groups.

[0142] In one embodiment, the second information explicitly indicates the K1 antenna port group(s).

[0143] In one embodiment, the second information implicitly indicates the K1 antenna port group(s).

[0144] In an embodiment, the second information is time domain information corresponding to the K1 antenna port group(s).

[0145] In one embodiment, the second information includes a CSI-RS Resource Indicator (CRI) (), and the CRI indicates the CSI-RS resources corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups.

[0146] In one embodiment, the physical layer channel corresponding to the second information includes an uplink physical layer control channel (i.e., an uplink channel that can only be used to carry physical layer signaling). In a sub-embodiment, the uplink physical layer control channel is a Physical Uplink Control Channel (PUCCH).

[0147] In one embodiment, the second information is a RACH preamble, and at least one of the sequences of the RACH preamble, and the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

[0148] In one embodiment, the physical layer channel corresponding to the second information includes a PRACH (Physical Random Access Channel).

[0149] In one embodiment, the K1 is equal to one.

[0150] In one embodiment, the K1 is greater than 1.

[0151] According to one aspect of the present disclosure, the method comprises:

[0152] monitoring the second signaling in a second time resource pool;

[0153] wherein the second signaling occupies at most one time resource block in the second time resource pool; the second time resource pool includes a positive integer number of the time resource block(s).

[0154] In one embodiment, the second time resource pool is discontinuous in the time domain.

[0155] In one embodiment, the time resource block is discontinuous in the time domain.

[0156] In one embodiment, the time resource block is continuous in the time domain.

[0157] In an embodiment, the second time resource pool is a UE-specific time resource pool.

[0158] In an embodiment, the second time resource pool is a specific time resource pool of the first antenna port group.

[0159] In one embodiment, the first antenna port group is used to determine the second time resource pool.

[0160] In one embodiment, the first antenna virtualization vector is used for transmitting analog beamforming of the second signaling.

[0161] In one embodiment, the second antenna virtualization vector is used for receiving analog beamforming of the second signaling.

[0162] In one embodiment, the second signaling is on the UE-specific search space.

[0163] In one embodiment, the second signaling is dynamic.

[0164] In one embodiment, the second signaling is carried by a downlink physical layer control channel.

[0165] In one embodiment, the downlink physical layer control channel is a PDCCH.

[0166] In one embodiment, the downlink physical layer control channel is an sPDCCH.

[0167] In one embodiment, the second signaling carries a DCI.

[0168] In one embodiment, the second signaling carries a fast DCI.

[0169] In one embodiment, the UE performs blind detection in the second time resource pool to determine a time-frequency resource occupied by the second signaling.

[0170] In one embodiment, the UE determines whether the second signaling is transmitted in the second time resource pool by using a blind detection method.

[0171] In one embodiment, the blind detection refers to that the UE receives a signal on multiple candidate time-frequency resources and performs a decoding operation, and if the decoding is determined correct according to the check bit, the receiving is judged as successful, otherwise the receiving is judged as a failure.

[0172] In one embodiment, the frequency resource pool corresponding to the blind detection is configurable.

[0173] According to another embodiment of the present disclosure, the method comprises:

[0174] monitoring the first signaling in a third time resource pool;

[0175] wherein the first signaling is a dynamic signaling; the first signaling occupies one time resource block in the third time resource pool at most; the third time resource pool includes a positive integer number of the time resource block(s); a minimum time interval between time resource blocks in the third time resource pool is greater than a minimum time interval between time resource blocks in the second time resource pool.

[0176] In one embodiment, the advantages of the foregoing method are that reducing the signaling overhead of notifying the UE to perform the time resource of the operation, and increasing the dynamicity of the time resource scheduling.

[0177] In one embodiment, the third time resource pool is discontinuous in the time domain.

[0178] In one embodiment, the time resource block is discontinuous in the time domain.

[0179] In one embodiment, the time resource block is continuous in the time domain.

[0180] In one embodiment, the third time resource pool is a time resource pool common to the cell.

[0181] In one embodiment, the third time resource pool is a UE-specific time resource pool.

[0182] In one embodiment, the third time resource pool is a specific time resource pool of the first antenna port group.

[0183] In one embodiment, the first antenna port group is used to determine the third time resource pool.

[0184] In one embodiment, the first antenna virtualization vector is used for transmitting analog beamforming of the first signaling.

[0185] In one embodiment, the second antenna virtualization vector is used for receiving analog beamforming of the first signaling.

[0186] In one embodiment, the UE performs blind detection in the third time resource pool to determine a time-frequency resource occupied by the first signaling.

[0187] In one embodiment, the UE determines whether the first signaling is transmitted in the third time resource pool by using a blind detection method.

[0188] In one embodiment, the first signaling is on a common search space.

[0189] In one embodiment, the first signaling is in a specific search space of the first antenna port group.

[0190] In one embodiment, the first signaling is on the UE-specific search space.

[0191] In one embodiment, the third time resource pool is a subset of the second time resource pool.

[0192] The present disclosure discloses a method for multi-antenna transmission in a base station, comprising:

[0193] transmitting first radio signal; and

[0194] transmitting a first signaling;

[0195] wherein the first radio signal is transmitted by K antenna port groups; the antenna port group(s) includes a positive integer number of the antenna port(s); the first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; at least one first antenna virtualization vector, and second antenna virtualization vector is associated with the first antenna port group; the firs antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool;

the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; the K is a positive integer greater than 1.

[0196] In one embodiment, the first signaling is transmitted by the first antenna port group.

[0197] In one embodiment, the reference signal(s) transmitted by the first antenna port group with at least two different antenna port(s) has the same pattern in the time-frequency resource block(s).

[0198] In one embodiment, the first time resource pool is discontinuous in the time domain.

[0199] According to one aspect of the present disclosure, the method comprises:

[0200] transmitting a second signaling;

[0201] performing second radio signal in a first time resource sub-pool;

[0202] wherein the performing is transmitting; or the performing is receiving; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI, (a) transmitting antenna port(s) of the second radio signal.

[0203] In one embodiment, the second signaling is transmitted by the first antenna port group.

[0204] In one embodiment, the second signaling is transmitted by one antenna port in the first antenna port group.

[0205] In one embodiment, the first time resource sub-pool is discontinuous in the time domain.

[0206] According to one aspect of the present disclosure, the method comprises:

[0207] transmitting first information;

[0208] wherein the first information is used to determine the first antenna port group.

[0209] In one embodiment, the first information is a domain of the first signaling.

[0210] In one embodiment, the first information is transmitted before the first signaling

[0211] According to one aspect of the present disclosure, the method comprises:

[0212] receiving second information;

[0213] wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer.

[0214] In one embodiment, the K1 is equal to 1.

[0215] In one embodiment, the K1 is greater than 1.

[0216] In one embodiment, the second information is a CRI.

[0217] According to another embodiment of the present disclosure, the method comprises:

[0218] transmitting the second signaling in a second time resource pool;

[0219] wherein the second signaling occupies one time resource block in the second time resource pool at most; the second time resource pool includes a positive integer number of the time resource block(s).

[0220] In one embodiment, the second time resource pool is discontinuous in the time domain.

[0221] According to one aspect of the present disclosure, the method comprises:

[0222] transmitting the first signaling in a third time resource pool;

[0223] wherein the first signaling is a dynamic signaling; the first signaling occupies one time resource block in the third time resource pool at most; the third time resource pool includes a positive integer number of the time resource block(s); a minimum time interval between time resource blocks in the third time resource pool is greater than a minimum time interval between time resource blocks in the second time resource pool.

[0224] In one embodiment, the third time resource pool discontinuous in the time domain.

[0225] The present disclosure discloses a user equipment for multi-antenna transmission, comprising:

[0226] a first transceiver, receiving first radio signal; and

[0227] a second receiver, receiving a first signaling;

[0228] wherein the first radio signal is transmitted by K antenna port groups; the antenna port group(s) includes a positive integer number of the antenna port(s); the first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; at least one first antenna virtualization vector, and second antenna virtualization vector is associated with the first antenna port group; the firs antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; the K is a positive integer greater than 1.

[0229] According to one aspect of the present disclosure, the method comprises:

[0230] a third receiver, receiving a second signaling; and

[0231] a second transceiver, operating a second radio signal in a first time resource sub-pool;

[0232] wherein the operating is receiving; or the operating is transmitting; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; and the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI, (a) transmitting antenna port(s) of the second radio signal.

[0233] In one embodiment, the second receiver receives the first information. The first information is used to determine the first antenna port group.

[0234] In one embodiment, the first transceiver transmits the second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer.

[0235] In one embodiment, the third receiver further monitors the second signaling in a second time resource pool, wherein the second signaling occupies one time resource block in the second time resource pool at most; the second time resource pool includes a positive integer number of the time resource block(s).

[0236] In one embodiment, the first signaling is a dynamic signaling, and the second receiver monitors the first signaling in a third time resource pool. Wherein the first signaling occupies one time resource block in the third time resource pool at most; the third time resource pool includes a positive integer number of the time resource block(s); a minimum time interval between time resource blocks in the third time resource pool is greater than a minimum time interval between time resource blocks in the second time resource pool.

[0237] In one embodiment, the first time resource pool is discontinuous in the time domain.

[0238] In one embodiment, the first signaling is a semi-static signaling.

[0239] The present disclosure discloses a base station device for multi-antenna transmission, comprising:

[0240] a third transceiver, transmitting first radio signal;

[0241] a second transmitter, transmitting a first signaling;

[0242] wherein the first radio signal is transmitted by K antenna port groups; the antenna port group(s) includes a positive integer number of the antenna port(s); the first antenna port group is

one of the K antenna port groups; the first signaling is used to determine a first time resource pool; at least one first antenna virtualization vector, and second antenna virtualization vector is associated with the first antenna port group; the firs antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; the K is a positive integer greater than 1.

[0243] According to one aspect of the present disclosure, the method comprises:

[0244] third transmitter, transmitting a second signaling; and

[0245] a fourth transceiver, performing a second radio signal in a first time resource sub-pool;

[0246] wherein the performing is transmitting; or the performing is receiving; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI, (a) transmitting antenna port(s) of the second radio signal.

[0247] In one embodiment, the second transmitter transmits a first information. The first information is used to determine the first antenna port group.

[0248] In one embodiment, the third transceiver receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer.

[0249] In one embodiment, the third transmitter transmits the second signaling in a second time resource pool, wherein the second signaling occupies one time resource block in the second time resource pool at most; the second time resource pool includes a positive integer number of the time resource block(s).

[0250] In one embodiment, the first signaling is a dynamic signaling, and the second transmitter transmits the first signaling in a third time resource pool. Wherein the first signaling occupies one time resource block in the third time resource pool at most; the third time resource pool includes a positive integer number of the time resource block(s); a minimum time interval between time resource blocks in the third time resource pool is greater than a minimum time interval between time resource blocks in the second time resource pool.

[0251] In one embodiment, the first time resource pool is discontinuous in the time domain.

[0252] In one embodiment, the first signaling is a semi-static signaling.

[0253] Compared with traditional schemes, the present disclosure has the following advantages:

[0254] The overhead of wireless resource scheduling signaling is reduced by using beam information.

[0255] The joint indication of the time resources by the first signaling and the second signaling not only saves the signaling overhead, but also ensures the dynamic and timeliness of the signaling.

[0256] The gain of multiple antennas is utilized by using the first antenna virtualization vector and the second antenna virtualization vector.

[0257] The RF costs for multi-antenna systems is reduced by applying the first antenna virtualization vector and the second antenna virtualization vector to analog beamforming.

BRIEF DESCRIPTION OF THE DRAWINGS

[0258] Other features, objects, and advantages of the present disclosure will become more apparent from the detailed description of the accompanying drawings.

[0259] FIG. 1 shows a flowchart of wireless transmission according to one embodiment of the present disclosure;

[0260] FIG. 2 shows a flowchart of wireless transmission according to another one embodiment of the present disclosure;

[0261] FIG. 3 shows a flowchart of wireless transmission in accordance with yet another embodiment of the present disclosure;

[0262] FIG. 4 shows a schematic diagram of a first time resource pool and a first time resource sub-pool according to one embodiment of the present disclosure;

[0263] FIG. 5 shows a schematic diagram of a time-frequency resources occupied by a second radio signal according to one embodiment of the present disclosure;

[0264] FIG. 6 shows a schematic diagram of the first time resource sub-pool jointly determined by the first signaling and the second signaling according to one embodiment of the present disclosure;

[0265] FIG. 7 shows a schematic diagram of a time resource pool and a time resource block according to one embodiment of the present disclosure;

[0266] FIG. 8 shows a schematic diagram of the distribution of a second time resource pool and a third time resource pool in a time domain according to one embodiment of the present disclosure;

[0267] FIG. 9 shows schematic diagram of an antenna port group(s) corresponding to a time resource pool according to one embodiment of the present disclosure;

[0268] FIG. 10 shows a structural block diagram of a processing device for a UE according to one embodiment of the present disclosure;

[0269] FIG. 11 shows a structural block diagram of a processing device for a base station according to one embodiment of the present disclosure;

[0270] FIG. 12 shows flow chart of a first radio signal and first signaling according to one embodiment of the present disclosure;

[0271] FIG. 13 shows a schematic diagram of a network architecture according to one embodiment of the present disclosure;

[0272] FIG. 14 shows a schematic diagram of a wireless protocol architecture of a user plane and a control plane according to one embodiment of the present disclosure;

[0273] FIG. 15 shows a schematic diagram of a base station device and a given user equipment according to one embodiment of the present disclosure.

DESCRIPTION OF THE EMBODIMENTS

[0274] Embodiment 1

[0275] Embodiment 1 illustrates a flow chart of wireless transmission according to one embodiment of the present disclosure, as shown in FIG.1. In FIG.1, the base station N1 is a maintenance base station of the serving cell of the UE U2. In the figure, the step in the box identified as F1 and F 2 are optional, respectively.

[0276] The base station N1 transmits the first radio signal in step S11; receives the second information in step S12; transmits the first information in step S13,; and transmits the first signaling in step S14.

[0277] The UE U2 receives the first radio signal in step S21; transmits the second information in step S22; receives the first information in step S23; and receives the first signaling in step S24.

[0278] In Embodiment 1, the first radio signal is transmitted by K antenna port groups, the antenna port group(s) includes a positive integer number of the antenna port(s); a first antenna

port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; at least one first antenna virtualization vector, and second antenna virtualization vector is associated with the first antenna port group; the firs antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; the K is a positive integer greater than 1. The first information is used to determine the first antenna port group. The second information is used to determine K1 antenna port group(s), the K1 antenna port group(s) belong to the K antenna port groups. The first antenna port group is one of the K1 antenna port group(s). The K1 is a positive integer.

[0279] In n a sub-embodiment 1 of Embodiment 1, the first antenna virtualization vector and the second antenna virtualization vector are both associated with the first antenna port group.

[0280] In a sub-embodiment 2 of embodiment 1, the second information includes a CRI.

[0281] In a sub-embodiment 3 of Embodiment 1, the first information is carried by RRC signaling.

[0282] In a sub-embodiment 4 of Embodiment 1, the first information is DCI.

[0283] In a sub-embodiment 5 of Embodiment 1, the K antenna port groups respectively correspond to K reference signal group(s).

[0284] In a sub-embodiment 6 of Embodiment 1, the first radio signal includes the K reference signal groups.

[0285] Embodiment 2

[0286] Embodiment 2 illustrates a flowchart of wireless transmission according to another one embodiment of the present disclosure, as shown in FIG.2. In FIG.2, the base station N3 is a maintenance base station of the serving cell of the user equipment U4.In Embodiment II, the N3 can reuse steps S11-S13 in FIG. 1 before step 31; the U4 can reuse steps S21-S23 in FIG.1 before step S41. In FIG. 2, the step in the box identified as F3 and F 4 are optional, respectively.

[0287] The base station N3 transmits a first signaling in step S31; transmits a second signaling in step S32; receives second radio signal in the first time resource sub-pool in step S33.

[0288] The UE U4 monitors a first signaling in the third time resource pool in step S41; receives the first signaling in step S42; monitors a second signaling in the second time resource pool in step S43; receives the second signaling in step S44; transmits the second radio signal in the first time resource sub-pool in step S45.

[0289] In a sub-embodiment 1 of Embodiment 2, the first signaling is a semi-static RRC signaling, including one or more RRC IEs (Information Element).

[0290] In a sub-embodiment 2 of Embodiment 2, the first signaling is a DCI carried by a PDCCH.

[0291] In a sub-embodiment 3 of Embodiment 2, the first signaling is for a terminal group, the terminal group includes a plurality of terminals, and the UE is one terminal in the terminal group.

[0292] In a sub-embodiment 4 of Embodiment 2, the first signaling is transmitted by the first antenna port group.

[0293] n a sub-embodiment 5 of Embodiment 2, the second signaling is a DCI carried by a PDCCH. The second signaling is for a terminal group, the terminal group includes a plurality of terminals, and the UE is one terminal in the terminal group. The second signaling is transmitted by the first antenna port group.

[0294] In a sub-embodiment 6 of Embodiment 2, the transmission period of the first signaling is greater than the transmission period of the second signaling.

[0295] Embodiment 3

[0296] Embodiment 3 illustrates a flowchart of wireless transmission in accordance with yet another embodiment of the present disclosure, as shown in FIG.3. In FIG.3, a base station N5 is a maintenance base station for a serving cell of the UE U6. In Embodiment 3, the N5 can reuse steps S11-S13 in FIG. 1 and steps S31-S32 in FIG. 2 prior to step 51; the U4 can reuse steps S21-S23 in FIG.1 and steps S41-S44 before in FIG.2 prior to step S61.

[0297] The base station N5 transmits the second radio signal in the first time resource sub-pool in step S51.

[0298] The UE U6 receives the second radio signal in the first time resource sup-pool in step S61.

[0299] Embodiment 4

[0300] Embodiment 4 illustrates a schematic diagram of a first time resource pool and a first time resource sub-pool, as shown in FIG. 4.

[0301] In Embodiment 4, the first time resource pool includes N1 time resources; the first signaling indicates the distribution of the first time resource pool in the time domain. The second radio signal is transmitted on the first time resource sub-pool. The first time resource sub-pool

includes N2 time resources #k1-#km in the N1 time resources. The second signaling indicates the number #k1-#km of the N2 time resources in the N1 time resources.

[0302] In a sub-embodiment 1 of Embodiment 4, the time resource is a subframe.

[0303] In a sub-embodiment 2 of Embodiment 4, the time resource is an OFDM symbol.

[0304] Embodiment 5

[0305] Embodiment 5 illustrates a schematic diagram of a time-frequency resources occupied by second radio signal, as shown in FIG.5. In FIG.5, the slash-filled block is the time-frequency resource occupied by the second radio signal.

[0306] In Embodiment 5, the second radio signal is transmitted on the time resource #k1-#km of the first time resource sub-pool. By the second signaling, the UE determines a first time resource sub-pool from the first time resource pool and determines the frequency domain resources occupied by the second radio signal, thereby determining the second time-frequency resource occupied by the second radio signal.

[0307] In a sub-embodiment 1 of Embodiment 5, the time resource is a subframe.

[0308] In a sub-embodiment 2 of embodiment 5, the time resource is an OFDM symbol.

[0309] In a sub-embodiment 3 of the embodiment 5, the time-frequency resource is a wireless resource block(s).

[0310] Embodiment 6

[0311] Embodiment 6 illustrates a schematic diagram of the first time resource sub-pool jointly determined by the first signaling and the second signaling, as shown in FIG.6. In FIG.6, the bold block is a subframe in the first time resource pool, and the slash-filled bold block is a subframe in the first time resource sub-pool.

[0312] In Embodiment 6, subframes #1-#8 are candidate subframes for transmitting a second radio signal, and the first signaling, by the form of bitmap, uses 10101010 to indicate that the first time resource pool is consisted of subframes # 1, # 3, # 5 and # 7, the second signaling, by the form of bitmap, uses 0101 to indicate that the subframe # 3 and # 7 in the first time resource pool {#1, #3, #5, #7} consiste of the first time sub-pool , which means the UE receives the second radio signal on the subframes # 3 and # 7.

[0313] In a sub-embodiment 1 of Embodiment 6, the first signaling is high layer signaling, and the second signaling is UE-specific DCI.

[0314] In a sub-embodiment 2 of Embodiment 6, the first signaling is a terminal group specific DCI, and the second signaling is UE-specific DCI.

[0315] Embodiment 7

[0316] Embodiment 7 illustrates a schematic diagram of a time resource pool and a time resource block, as shown in FIG. 7.

[0317] In Embodiment 7, one target time resource pool includes N time resource block(s), and the N time resource block(s) are discontinuous in the time domain. The time resource block #k is one of the N time resource block(s). The time resource block(s) #k includes M symbols in the target time resource pool. The M symbols in the target time resource pool are discontinuous in the time domain. The time interval between two time resource blocks is the time interval between the first symbols of the respective two time resource blocks.

[0318] In a sub-embodiment 1 of Embodiment 7, the target time resource pool is a second time resource pool, and the second signaling occupies one time resource block in the second time resource pool at most.

[0319] In a sub-embodiment 2 of Embodiment 7, the target time resource pool is a third time resource pool, and the first signaling occupies one time resource block in the third time resource pool at most.

[0320] In a sub-embodiment 3 of embodiment 7, the symbol is an OFDM symbol.

[0321] Embodiment 8

[0322] Embodiment 8 illustrates a schematic diagram of the distribution of the second time resource pool and the third time resource in the time domain, as shown in FIG.8. In FIG. 8, the horizontally filled blocks are time resource blocks in the second time resource pool, and the diagonally filled blocks are time resource blocks in the third time resource pool.

[0323] In Embodiment 8, the second signaling is transmitted on one time resource block in the second time resource pool, and the first signaling is transmitted on one time resource block in the third time resource pool. Between two time resource blocks of the third time resource pool may exist a plurality of time resource blocks of the second time resource pool.

[0324] In a sub-embodiment 1 in Embodiment 8, the second time resource pool and the third time resource pool are discontinuous in the time domain.

[0325] Embodiment 9

[0326] Embodiment 9 illustrates a schematic diagram of an antenna port group(s) corresponding to a time resource pool; as shown in FIG. 9.

[0327] In Embodiment 9, the first antenna port group is one of the K antenna port groups. The K antenna port groups respectively correspond to K different beam groups. The K antenna port groups respectively correspond to K time resource pools, and the first time resource pool is a time resource pool corresponding to the first antenna port group.

[0328] Embodiment 10

[0329] Embodiment 10 illustrates a structural block diagram of a processing device in a UE, as shown in FIG. 10.

[0330] In FIG.10, the UE 1000 is mainly composed of a first transceiver 1001, a second receiver 1002, a third receiver 1003, and a second transceiver 1004.

[0331] The first transceiver 1001 receives the first radio signal; the second receiver 1002 receives the first signaling; the third receiver 1003 receives the second signaling; and the second transceiver 1004 operates the second radio signal in the first time resource pool.

[0332] In the embodiment 10, the first radio signal is transmitted by K antenna port groups, and the antenna port group(s) includes a positive integer number of the antenna port(s). The K is a positive integer greater than 1. The first antenna port group is one of the K antenna port groups. The first signaling is used by the UE to determine the first time the resource pool. At least one of a first antenna virtualization vector and a second antenna virtualization vector is associated with the first antenna port group. The first antenna virtualization vector is an available antenna virtualization vector of the base station in the first time resource pool. The second antenna virtualization vector is an available antenna virtualization vector of the UE in the first time resource pool. The operation is receiving; or the operation is transmitting. The second signaling is used by the UE to determine the first time resource sub-pool from the first time resource pool, and the second signaling is further used by the UE to determine at least one of the occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI, (a) transmit antenna port of the second radio signal.

[0333] In a sub-embodiment 1 of the embodiment 10, the second receiver 1002 is further used by the UE to receive the first information. The first information is used to determine the first antenna port group.

[0334] In a sub-embodiment 2 of the embodiment 10, the first transceiver 1001 is further used by the UE to transmit the second information. The second information is used by the base station to determine K1 antenna port group(s), the K1 antenna port group(s) belong to the K antenna

port groups, and the first antenna port group is one of the K1 antenna port group(s). The K1 is a positive integer.

[0335] In a sub-embodiment 3 of embodiment 10, the third receiver 1003 is further used by the UE to monitor the second signaling in a second time resource pool.

[0336] In a sub-embodiment 4 of embodiment 10, the first signaling is a dynamic signaling, and the second receiver 1002 is further used by the UE to monitor the first signaling in a third time resource pool. The minimum time interval between time resource blocks in the third time resource pool is greater than the minimum time interval between time resource blocks in the second time resource pool.

[0337] In a sub-embodiment 5 of embodiment 10, the first time resource pool is discontinuous in the time domain.

[0338] In a sub-embodiment 6 of embodiment 10, the first signaling is a semi-static signaling.

[0339] In one embodiment, the second transceiver 1001 includes a transmitter/receiver 460, a MIMO detector 472, a receiving processor 452, an antenna 460, a controller/processor 490, and a memory 480 in Embodiment 15.

[0340] In one embodiment, the first transceiver 1001 includes a transmitting processor 455, a MIMO transmitting processor 471, a transmitter/receiver 460, and an antenna 460 in Embodiment 15.

[0341] In one embodiment, the second receiver 1002 includes a transmitter/receiver 460, a MIMO detector 472, a receiving processor 452, and an antenna 460 in Embodiment XV.

[0342] In one embodiment, the second receiver 1002 includes the controller/processor 490 in Embodiment 15.

[0343] In one embodiment, the third receiver 1003 includes the transmitter/receiver 460, the MIMO detector 472, the receiving processor 452, and the antenna 460 in Embodiment 15.

[0344] In one embodiment, the second transceiver 1004 includes the transmitter/receiver 460, the MIMO detector 472, the receiving processor 452, the antenna 460, the controller/processor 490, and the memory 480 in Embodiment 15.

[0345] In one embodiment, the second transceiver 1004 includes a transmitting processor 455, a MIMO transmitting processor 471, a transmitter/receiver 460, a controller/processor 490, a data source 467, and an antenna 460 in Embodiment 15.

[0346] Embodiment 11

[0347] Embodiment 11 illustrates a structural block diagram of a processing device in the base station equipment; as shown in FIG. 11.

[0348] FIG.11, the base station 1100 is mainly composed of a third transceiver 1101, a second transmitter 1102, a third transmitter 1103, and a fourth transceiver 1104.

[0349] The third transceiver 1101 transmits first radio signal; the second transmitter 1102 transmits a first signaling; the third transmitter 1103 transmits a second signaling; and the fourth transceiver 1104 performs second radio signal in a first time resource sub-pool.

[0350] In Embodiment 11, the first radio signal is transmitted by K antenna port groups, and the antenna port group(s) includes a positive integer number of the antenna port(s). The K is a positive integer greater than 1. The first antenna port group is one of the K antenna port groups. The first signaling is used by the UE to determine the first time the resource pool. At least one first antenna virtualization vector, and the second antenna virtualization vector is associated with the first antenna port group. The first antenna virtualization vector is an available antenna virtualization vector of the base station in the first time resource pool. The second antenna virtualization vector is an available antenna virtualization vector of a target receiver of the first signaling in the first time resource pool. The K is a positive integer greater than 1. The performing is receiving; or the performing is transmitting. The second signaling is used by the UE to determine the first time resource sub-pool from the first time resource pool, and the second signaling is further used by the UE to determine at least one of the occupied frequency domain resources, a MCS, a HARQ process number, a RV, a NDI, (a) transmit antenna port of the second radio signal.

[0351] In a sub-embodiment 1 of Embodiment 11, the second transmitter 1102 is further used by the base station to transmit first information. Herein, the first information is used by the UE to determine the first antenna port group.

[0352] In a sub-embodiment 2 of the embodiment 11, the third transceiver 1101 is further used by the base station to receive the second information. Herein, the second information is used by the base station to determine K1 antenna port group(s), the K1 antenna port group(s) belong to the K antenna port groups, and the first antenna port group is one of the K1 antenna port group(s). The K1 is a positive integer.

[0353] In a sub-embodiment 3 of Embodiment 11, the third transmitter 1103 is further used by the base station to transmit the second signaling in a second time resource pool.

[0354] In a sub-embodiment 4 of Embodiment 11, the first signaling is a dynamic signaling, and the second transmitter 1102 is further used by the base station to transmit the first signaling

in a third time resource pool. The minimum time interval between time resource blocks in the third time resource pool is greater than the minimum time interval between time resource blocks in the second time resource pool.

[0355] In a sub-embodiment 5 of embodiment 11, the first time resource pool is discontinuous in the time domain.

[0356] In a sub-embodiment 6 of Embodiment 11, the first signaling is a semi-static signaling.

[0357] In one embodiment, the third transceiver 1101 includes a transmitting processor 415, a MIMO transmitting processor 441, a transmitter/receiver 416, and an antenna 420 in Embodiment 15.

[0358] In one embodiment, the third transceiver 1101 includes an antenna 420, a transmitter/receiver 416, a MIMO detector 442, and a receiving processor 412 in Embodiment 15.

[0359] In one embodiment, the second transmitter 1102 includes a transmitting processor 415, a MIMO transmitting processor 441, a transmitter/receiver 416, and an antenna 420 in Embodiment 15.

[0360] In one embodiment, the second transmitter 1102 includes the controller/processor 440 of Embodiment 15.

[0361] In one embodiment, the third transmitter 1103 includes a transmitting processor 415, a MIMO transmitting processor 441, a transmitter/receiver 416, and an antenna 420 in Embodiment 15.

[0362] In one embodiment, the fourth transceiver 1104 includes the controller/processor 440, the transmitting processor 415, the MIMO transmitting processor 441, the transmitter/receiver 416, and the antenna 420 in Embodiment 15.

[0363] In one embodiment, the fourth transceiver 1104 includes an antenna 420, a transmitter/receiver 416, a MIMO detector 442, a receiving processor 412, a controller/processor 440, and a memory 430 in Embodiment 15.

[0364] Embodiment 12

[0365] Embodiment 12 illustrates a flow chart of the first radio signal and the first signaling, as shown in FIG.12. In FIG.12, each box represents a step. In Embodiment 12, the user equipment (UE) in the present disclosure sequentially receives a first radio signal and a first signaling; wherein the first radio signal is transmitted by the K antenna port groups; the antenna port group(s) includes a positive integer number of the antenna port(s); the first antenna port

group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool. At least one first antenna virtualization vector, and the second antenna virtualization vector is associated with the first antenna port group. The first antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; the K is a positive integer greater than 1.

[0366] In one embodiment, the first radio signal is K reference signal(s) groups respectively transmitted by the K antenna port groups. The first reference signal group(s) is(are) reference signal group(s) transmitted by the first antenna port group in the K reference signal group(s). The first antenna virtualization vector is used to form an analog transmitting beam for transmitting the first reference signal group, and the second antenna virtualization vector is used to form an analog receiving beam for receiving the first reference signal group(s).

[0367] In one embodiment, the first signaling is a semi-static signaling.

[0368] In one embodiment, the first time resource pool is used to transmit physical layer control signaling.

[0369] In one embodiment, the first signaling is a dynamic signaling.

[0370] In one embodiment, the first time resource pool is used to transmit high layer signaling or data.

[0371] In one embodiment, the first antenna virtualization vector is used to form a wireless channel corresponding to the first antenna port group.

[0372] In one embodiment, the second antenna virtualization vector is used to form a wireless channel corresponding to the first antenna port group.

[0373] In one embodiment, the second antenna virtualization vector is a spatial Receive(Rx) parameter used by the UE to receive a radio signal in the first time resource pool.

[0374] Embodiment 13

[0375] Embodiment 13 illustrates a schematic diagram of network architecture, as shown in FIG. 13.

[0376] FIG. 13 describes a system network structure 200 of NR 5G, long-term evolution (LTE) and long-term evolution advanced (LTE-A). The network architecture 200 of NR 5G or LTE may be referred to as an evolve packet system (EPS) 200 or some other suitable terminology. The EPS 200 may include one or more UEs 201, NG- radio access network (RAN) 202, 5G- core

network (CN)/ evolved packet core (EPC) 210, Home Subscriber Server (HSS)220 and the internet service 230. EPS may be interconnected with other access networks, but for the sake of simplicity, these entities/interfaces are not shown. As shown in figure, the EPS provides the packet switching services. Those skilled in the art would readily appreciate that the various concepts presented throughout this disclosure can be extended to networks or other cellular networks that provide circuit switched services. The NG-RAN includes an NR Node B (gNB) 203 and other gNBs 204.The gNB 203 provides user and control plane protocol termination for the UE 201.The gNB 203 can be connected to other gNBs 204 via an Xn interface (eg, a backhaul).The gNB 203 may also be referred to as a base station, a base transceiver station, a wireless base station, a wireless transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), a transmission and reception point (TRP), or some other suitable terminology. The gNB 203 provides the UE201 with an access point to the 5G-CN/EPC 210. In the embodiment, the UE201 includes cellular telephones, smart phones, Session Initiation Protocol (SIP) phones, laptop computers, personal digital assistants (PDAs), satellite wirelesses, non-terrestrial base station communications, satellite mobile communications, global positioning systems, multimedia devices, video devices, digital audio player (e.g. MP3 players), cameras, game consoles, drones, aircrafts, narrowband physical network devices, machine type communication devices, land vehicles, cars, wearable devices, or any other similar to functional devices. A person skilled in the art may also refer to UE 201 as a mobile station, a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a wireless communication device, a remote device, a mobile subscriber station, an access terminal, a mobile terminal, a wireless terminal, remote terminal, handset, user agent, mobile client, client or some other suitable term. The gNB 203 is connected to the 5G-CN/EPC 210 through an S1/NG interface. 5G-CN/EPC 210 includes MME/AMF/UPF 211, other Mobility Management Entity (MME)/ Authentication Management Field (AMF) / User Plane Function (UPF) 214 An Service Gateway (S-GW) 212 and a Packet Date Network Gateway (P-GW) 213. The MME/AMF/UPF 211 is a control node that handles signaling between the UE 201 and the 5G-CN/EPC 210. In general, MME/AMF/UPF 211 provides bearer and connection management. All User Internet Protocol (IP) packets are transmitted through the S-GW 212, and the S-GW 212 itself is connected to the P-GW 213. The P-GW 213 provides UE IP address allocation as well as other functions. The P-GW 213 is connected to the internet service 230. The internet service 230 includes an operator-compatible internet protocol service, and may specifically include the Internet, an intranet, an IP Multimedia Subsystem (IMS), and a PS streaming service (PSS).

[0377] In one embodiment, the UE 201 corresponds to the UE in this disclosure.

[0378] In one embodiment, the gNB203 corresponds to the base station in this disclosure.

[0379] In one embodiment, the UE 201 supports multi-antenna transmission.

[0380] In one embodiment, the gNB 203 supports multi-antenna transmission.

[0381] Embodiment 14

[0382] Embodiment 14 illustrates a schematic diagram of a radio protocol architecture of a user plane and a control plane, as shown in FIG.14.

[0383] FIG. 14 is a schematic diagram illustrating a radio protocol architecture of a user plane and a control plane. In FIG. 3, the radio protocol architecture for a UE and a gNB is represented by three layers, which are a layer 1, a layer 2 and a layer 3, respectively. The layer 1 (L1) is the lowest layer and performs signal processing functions of various PHY layers. The L1 is called PHY 301 in the present disclosure. The layer 2 (L2) 305 is above the PHY 301, and is in charge of the link between the UE and the gNB via the PHY 301. In the user plane, L2 305 comprises a Medium Access Control (MAC) sublayer 302, a Radio Link Control (RLC) sublayer 303 and a Packet Data Convergence Protocol (PDCP) sublayer 304. All the three sublayers terminate at the gNBs of the network side. Although not described in FIG. 3, the UE may comprise several protocol layers above the L2 305, such as a network layer (i.e., IP layer) terminated at a P-GW 213 of the network side and an application layer terminated at the other side of the connection (i.e., a peer UE, a server, etc.). The PDCP sublayer 304 provides multiplexing among variable radio bearers and logical channels. The PDCP sublayer 304 also provides a header compression for a higher-layer packet so as to reduce a radio transmission overhead. The PDCP sublayer 304 provides security by encrypting a packet and provides support for UE handover between gNBs. The RLC sublayer 303 provides segmentation and reassembling of a higher-layer packet, retransmission of a lost packet, and reordering of a packet so as to compensate the disordered receiving caused by Hybrid Automatic Repeat reQuest (HARQ). The MAC sublayer 302 provides multiplexing between a logical channel and a transport channel. The MAC sublayer 302 is also responsible for allocating between UEs various radio resources (i.e., resource block) in a cell. The MAC sublayer 302 is also in charge of HARQ operation. In the control plane, the radio protocol architecture of the UE and the gNB is almost the same as the radio protocol architecture in the user plane on the PHY 301 and the L2 305, but there is no header compression for the control plane. The control plane also comprises a Radio Resource Control (RRC) sublayer 306 in the layer 3 (L3). The RRC sublayer 306 is responsible for acquiring radio resources (i.e., radio bearer) and configuring the lower layer using an RRC signaling between the gNB and the UE.

[0384] In one embodiment, the radio protocol architecture of FIG. 14 is applicable to the user equipment in this disclosure.

[0385] In one embodiment, the radio protocol architecture of FIG. 14 is applicable to the base station in this disclosure.

[0386] In one embodiment, the first radio signal in the present disclosure is generated by the PHY 301.

[0387] In one embodiment, the first control signal in the present disclosure is generated by the PHY 301.

[0388] In one embodiment, the second radio signal in the present disclosure is generated by the PHY 301.

[0389] In one embodiment, the first reference signal in the present disclosure is generated by the PHY 301.

[0390] In one embodiment, the second reference signal in the present disclosure is generated by the PHY 301.

[0391] In one embodiment, the first signaling in the present disclosure is generated by the PHY 301.

[0392] Embodiment 15

[0393] Embodiment 15 illustrates a base station device and a given UE, as shown in FIG.15. The FIG.15 is a block diagram of a gNB 410 in communication with a UE 450 in an access network.

[0394] A base station device (410) comprises a controller/processor 440, a scheduler 443, a memory 430, a receiving processor 412, a transmitting processor 415, a MIMO transmitting processor 441, a MIMO detector 442, and a transmitter/receiver 416, and an antenna 420.

[0395] A user equipment (UE 450) comprises a controller/processor 490, a memory 480, a data source 467, a transmitting processor 455, a receiving processor 452, a MIMO transmitting processor 471, a MIMO detector 472, a transmitter/receiver 456, and an antenna 460.

[0396] In the downlink transmission (DL), the processing related to the base station (410) comprises:

[0397] A higher layer packet is provided to the controller/processor 440, the controller/processor440 provides header compression, encryption, packet segmentation and reordering, and multiplexing and demultiplexing between logical and transport channels so as to

implement L2 layer protocols used for the user plane and the control plane, the higher layer packet may include data or control information, such as a downlink shared channel (DL-SCH);

[0398] the controller/processor440 may be connected with a memory 430 that stores program codes and data, the memory 430 may be a computer-readable medium;

[0399] the controller/processor 440, which notifies the scheduler 443 of transmission requests, the scheduler 443 is configured for scheduling the air interface resource(s) corresponding to the transmission requests, and notifying the controller/processor 440 of the scheduling result;

[0400] the controller/processor 440transmits to the transmitting processor 415 control information for uplink transmission acquired from operation on uplink reception by the receiving processor 412;

[0401] the transmitting processor 415, which receives the output bit stream from the controller/processor 440, and implements various signal transmission processing functions for the L1 layer (i.e. physical layer), including encoding, interleaving, scrambling, modulation, power control/allocation and physical layer control signaling (i.e., PBCH, PDCCH,PHICH,PCFICH, a reference signal) generation, etc.;

[0402] the MIMO transmitting processor 441, which performs spatial processing on data symbols, control symbols or reference signal symbols (such as multi-antenna pre-coding, digital beamforming) and outputs a baseband signal to the transmitter 416;

[0403] the MIMO transmitting processor 441, which outputs an analog transmitting beamforming vector to the transmitter 416;

[0404] the transmitter 416, which is configured for converting a baseband signals provided by the MIMO transmitting processor 441 into a radio frequency signal to be transmitted via the antenna 420; each transmitter 416 performs sampling processing on respective input symbol streams (e.g. digital to analog conversion, amplification, filtering, upconversion, etc.) to get respective sampled signal streams; each transmitter 416 further processes respective sampled stream to obtain a downlink signal; the analog transmitting beamforming is processed in the transmitter 416.

[0405] In the DL transmission, the processing related to the user equipment (450) comprises:

[0406] the receiver 456 is configured for converting the radio frequency signal received through the antenna 460 into a baseband signal and providing it to the MIMO detector 472; the analog receiving beamforming is processed in the receiver 456;

[0407] the MIMO detector 472 is configured to perform MIMO detection on a signal received from the receiver 456, and provide the baseband signal subjected to the MIMO detection to the receiving processor 452;

[0408] the receiving processor 452 extracts parameter relevant to the analog receiving beamforming to be output to the MIMO detector 472, and the MIMO detector 472 outputs the analog receive beamforming vector to the receiver 456;

[0409] the receiving processor 452, which implements various signal receiving processing functions for the L1 layer (i.e. physical layer) , including decoding, deinterleaving, descrambling, demodulation and physical layer control signaling extraction, etc.;

[0410] the controller/processor 490 receives the bit stream output by the receive processor 452, provides header decompression, decryption, packet segmentation and reordering, and multiplexing and demultiplexing between a logical channel and a transport channel to implement L2 layer protocol for user plane and control plane;

[0411] the controller/processor 490 is associated with a memory 480 that stores program codes and data, and the memory 480 may be a computer-readable medium;

[0412] the controller/processor 490 transmits to the receiving processor 452 the control information for downlink reception obtained from uplink transmission processing by the transmitting processor 455.

[0413] The first control signal in the present disclosure is generated by the transmitting processor 415.The MIMO transmitting processor 441 performs multi-antenna precoding on a baseband signal associated with the first control signal output by the transmitting processor 415. The transmitter 416 converts a baseband signal provided by the MIMO transmitting processor 441 into a radio frequency signal, performs analog transmit beamforming, and transmits the radio frequency signal via antenna 420.The receiver 456 then receives the radio frequency signal through the antenna 460, perform analog receive beamforming, obtain a radio frequency signal related to the first control signal, and convert the radio frequency signal into a baseband signal to be supplied to the MIMO detector 472.The MIMO detector 472 performs MIMO detection on the signal received from the receiver 456.The receiving processor 452 processes the baseband signal output by the MIMO detector 472 to obtain the first control signal.

[0414] The first radio signal in the present disclosure is generated by the transmitting processor 415.The MIMO transmitting processor 441 performs multi-antenna precoding on a baseband signal associated with the first radio signal output by the transmitting processor 415.The transmitter 416 converts the baseband signal provided by MIMO transmit processor 441

into a radio frequency signal, performs analog transmitting beamforming, and transmits the radio frequency signal via antenna 420.The receiver 456 will receive the radio frequency signal through the antenna 460, perform analog receive beamforming, obtain a radio frequency signal related to the first radio signal, and convert the radio frequency signal into a baseband signal to be supplied to the MIMO detector 472.The MIMO detector 472 performs MIMO detection on the signal received from the receiver 456.The receiving processor 452 performs channel detection on the baseband signal output from the MIMO detector 472.

[0415] The first signaling in the present disclosure is generated by the transmitting processor 415 and output to the controller/processor 440 or is directly generated by the transmitting processor 415.The MIMO transmitting processor 441 performs multi-antenna precoding on a baseband signal relevant to the first signaling output by the transmitting processor 415. The transmitter 416 converts the baseband signal provided by MIMO transmitting processor 441 into a radio frequency signal, performs analog transmit beamforming, and transmits the radio frequency signal via antenna 420.The receiver 456 will receive the radio frequency signal through the antenna 460, perform analog receive beamforming, obtain a radio frequency signal related to the first signaling, and convert the radio frequency signal into a baseband signal to be provided to the MIMO detector 472.The MIMO detector 472 performs MIMO detection on the signal received from the receiver 456.The receiving processor 452 processes the baseband signal output by the MIMO detector 472 to obtain the first signaling.

[0416] The second signaling in this disclosure is generated by the transmitting processor 415.The MIMO transmitting processor 441 performs multi-antenna precoding on a baseband signal relevant to the first signaling output by the transmission processor 415. The transmitter 416 converts the baseband signal provided by MIMO transmitting processor 441 into a radio frequency signal, performs analog transmit beamforming, and transmits the radio frequency signal via antenna 420.The receiver 456 will receive the radio frequency signal through the antenna 460, perform analog receive beamforming, obtain a radio frequency signal related to the first signaling, and convert the radio frequency signal into a baseband signal to be supplied to the MIMO detector 472.The MIMO detector 472 performs MIMO detection on the signal received from the receiver 456.The receiving processor 452 processes the baseband signal outputted by the MIMO detector 472 to obtain the first signaling.

[0417] The first information in the present disclosure is generated by the controller/processor 440 and output to the transmit processor 415 or is directly generated by the transmit processor 415. The MIMO transmitting processor 441 performs multi-antenna precoding on a baseband signal relevant to the first signaling output by the transmitting processor 415. The transmitter 416

converts the baseband signal provided by MIMO transmitting processor 441 into a radio frequency signal, performs analog transmit beamforming, and transmits the radio frequency signal via antenna 420.The receiver 456 will receive the radio frequency signal through the antenna 460, perform analog receive beamforming, obtain a radio frequency signal related to the first signaling, and convert the radio frequency signal into a baseband signal to be provided to the MIMO detector 472.The MIMO detector 472 performs MIMO detection on the signal received from the receiver 456.The receiving processor 452 processes the baseband signal outputted by the MIMO detector 472 to obtain the first information.

[0418] In uplink (UL) transmission, the processing related to the user equipment (UE450) comprises:

[0419] the data source 467 provides a higher layer packet to controller/processor 490. The controller/processor 490 implements header compression, encryption, packet segmentation and reordering, and multiplexing and demultiplexing between the logical and transport channels, and implements an L2 layer protocol for the user plane and the control plane; the higher layer packet includes data or control information, such as an Uplink Shared Channel (UL-SCH);

[0420] the controller/processor 490 can be associated with the memory 480 that stores program codes and data .The memory 480 can be a computer readable medium;

[0421] the controller/processor 490 transmits to the transmitting processor 455 the control information for uplink transmission obtained from processing on downlink reception by the receiving processor 452;

[0422] the transmitting processor 455 receives the output bit stream of controller/processor 490 and implements various signal reception processing functions for the L1 layer (i.e. physical layer) , including encoding, interleaving, scrambling, modulation, power control/allocation and physical layer signaling （i.e., PUCCH, Sounding Reference Signal generation (SRS), a detection reference signal） , etc.;

[0423] the MIMO transmitting processor 471 performs spatial processing on data symbols, control symbols or reference signal symbols (such as multi-antenna pre-coding, digital beamforming) and outputs a baseband signal to the transmitter 456;

[0424] the MIMO transmitting processor 471 outputs an analog transmitting beamforming vector to the transmitter 457;

[0425] The transmitter 456 is configured to convert a baseband signals provided by MIMO transmitting processor 471 into a radio frequency signal and transmit the radio frequency signal

via the antenna 460; each transmitter 456 samples respective input symbol stream to obtain respective sampled signal stream. Each transmitter 456 further processes the respective sampled streams (such as digital-to-analog conversion, amplification, filtering, up-conversion, etc.) to obtain an uplink signal. The analog transmitting beamforming is processed in the transmitter 456.

[0426] In the uplink (UL) transmission, the processing related to the base station device (410) comprises:

[0427] the receiver 416 is configured to convert the radio frequency signal received by the antenna 420 into a baseband signal and provide the baseband signal to the MIMO detector 442; the analog receiving beamforming is processed in the receiver 416;

[0428] the MIMO detector 442 is configured to perform MIMO detection on the signal received from the receiver 416, and provide the receiving processor 442 with the MIMO-detected symbol;

[0429] the MIMO detector 442 outputs an analog receiving beamforming vector to the receiver 416;

[0430] the receiving processor 412 implements various signal receiving processing functions for the L1 layer (i.e. the physical layer), including decoding, deinterleaving, descrambling, demodulation, and physical layer control signaling extraction, and the like;

[0431] the controller/processor 440 receives the bit stream outputted by the receiving processor 412, and provides header decompression, decryption, packet segmentation, reordering, and multiplexing and demultiplexing between the logical and transport channels so as to implement L2 layer protocol of user plane and control plane;

[0432] the controller/processor 440 can be associated with memory 430 that stores program codes and data .The memory 430 can be a computer readable medium;

[0433] the controller/processor 440 transmits the control information of the uplink transmission obtained from processing the downlink transmission by the transmission processor 415 to the receiving processor 412;

[0434] The second information in the present disclosure is generated by the transmit processor 455.The MIMO transmitting processor 471 performs multi-antenna precoding on a baseband signal relevant to the second information output by the transmitting processor 455. The transmitter 456 converts the baseband signal provided by the MIMO transmitting processor 471 into a radio frequency signal, performs analog transmitting beamforming, and transmits the radio

frequency signal via antenna 460.The receiver 416 will receive the radio frequency signal through the antenna 420, perform analog receive beamforming, obtain a radio frequency signal related to the second information, and convert the radio frequency signal into a baseband signal for supply to the MIMO detector 442.The MIMO detector 442 performs MIMO detection on the signal received from the receiver 416.The receiving processor 412 processes the baseband signal outputted by the MIMO detector 442 to obtain the second information.

[0435] In one embodiment, the UE 450 comprises: at least one processor and at least one memory, the at least one memory further comprising computer program codes; the at least one memory and the computer program code are configured to work in collaboration with the processor, the UE 450 at least: receives a first radio signal and a first signaling. The first radio signal is transmitted by K antenna port groups; the antenna port group(s) includes a positive integer number of the antenna port(s); the first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; at least one first antenna virtualization vector, and second antenna virtualization vector is associated with the first antenna port group; the first antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; the K is a positive integer greater than 1.

[0436] In one embodiment, the UE 450 comprises a memory storing a computer readable instruction program, which generates an action when executed by at least one processor, and the action comprises: receiving first radio signal and a first signaling. The first radio signal is transmitted by K antenna port groups; the antenna port group(s) includes a positive integer number of the antenna port(s); the first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; at least one of first antenna virtualization vector, and second antenna virtualization vector is associated with the first antenna port group; the first antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; the K is a positive integer greater than 1.

[0437] In one embodiment, the gNB 410 device comprises: at least one processor and at least one memory, the at least one memory comprises computer program codes; the at least one memory and the computer program code are configured to work in collaboration with at least one processor. The gNB410 at least: transmits a first radio signal; and transmits a first signaling. The first radio signal is transmitted by K antenna port groups, the antenna port group(s) includes

a positive integer number of the antenna port(s); and the first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; at least one first antenna virtualization vector, and second antenna virtualization vector is associated with the first antenna port group; the first antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; the K is a positive integer greater than 1.

[0438] In one embodiment, the gNB 410 comprises: a memory storing a computer readable instruction program, which generates an action when executed by at least one processor, and the action comprises: transmitting first radio signal, transmitting the first signaling. The first radio signal is transmitted by K antenna port groups, the antenna port group(s) includes a positive integer number of the antenna port(s); and the first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; at least one first antenna virtualization vector, and second antenna virtualization vector is associated with the first antenna port group; the first antenna virtualization vector is an antenna virtualization vector available to a transmitter of the first signaling in the first time resource pool; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; the K is a positive integer greater than 1.

[0439] In one embodiment, the UE 450 corresponds to the UE in the present disclosure.

[0440] In one embodiment, the gNB 410 corresponds to the base station in the present disclosure.

[0441] In one embodiment, the transmitting processor 415, the MIMO transmitter 441 and the transmitter/receiver 416 are used to transmit the first radio signal in the present disclosure.

[0442] In one embodiment, the receiver 456, the MIMO detector 472, and the receiving processor 452 are configured to receive the first radio signal in the present disclosure.

[0443] In one embodiment, the transmitting processor 415, the MIMO transmitter 441 and the transmitter/receiver 416 are used to transmit the first signaling in the present disclosure.

[0444] In one embodiment, the controller/processor 440 is configured to transmit the first signaling in the present disclosure.

[0445] In one embodiment, the transmitter/receiver 456, the MIMO detector 472, and the receiving processor 452 are configured to receive the first signaling in the present disclosure.

[0446] In one embodiment, the controller/processor 490 is configured to receive the first signaling in the present disclosure.

[0447] In one embodiment, the transmitting processor 415, the MIMO transmitter 441 and the transmitter/receiver 416 are used to transmit the second signaling in the present disclosure.

[0448] In one embodiment, the transmitter/receiver 456, the MIMO detector 472, and the receiving processor 452 are configured to receive the second signaling in the present disclosure.

[0449] In one embodiment, the transmitting processor 415, the MIMO transmitter 441 and the transmitter/receiver 416 are used to transmit the first information in the present disclosure.

[0450] In one embodiment, the controller/processor 440 is configured to transmit the first information in the present disclosure.

[0451] In one embodiment, the transmitter/receiver 456, the MIMO detector 472, and the receiving processor 452 are used to receive the first information in the present disclosure.

[0452] In one embodiment, the controller/processor 490 is configured to receive the first information in the present disclosure.

[0453] In one embodiment, the transmitting processor 455, the MIMO transmitter 471, and the transmitter 456 are used to transmit the second information in the present disclosure.

[0454] In one embodiment, the receiver 416, the MIMO detector 442, and the receiving processor 412 are configured to receive the second information in the present disclosure.

[0455] The ordinary skill in the art may understand that all or part of steps in the above method may be implemented by instructing related hardware through a program. The program may be stored in a computer readable storage medium, for example Read-Only-Memory (ROM), hard disk or compact disc, etc. Optionally, all or part of steps in the above embodiments also may be implemented by one or more integrated circuits. Correspondingly, each module unit in the above embodiment may be implemented in the form of hardware, or in the form of software function modules. The present disclosure is not limited to any combination of hardware and software in specific forms. The UE and terminal in the present disclosure include but are not limited to unmanned aerial vehicles, communication modules on unmanned aerial vehicles, telecontrolled aircrafts, aircrafts, diminutive airplanes, mobile phones, tablet computers, notebooks, vehicle-mounted communication equipment, wireless sensor, network cards, terminals for Internet of Things (IOT), RFID terminals, NB-IOT terminals, Machine Type Communication (MTC) terminals, enhanced MTC (eMTC) terminals, data cards, low-cost mobile phones, low-cost tablet computers, etc. The base station in the present disclosure includes but is not

limited to macro-cellular base stations, micro-cellular base stations, home base stations, relay base station, gNB (NR node B), Transmitter Receiver Point (TRP), and other radio communication equipment.

[0456] The above are merely the preferred embodiments of the present disclosure and are not intended to limit the scope of protection of the present disclosure. Any modification, equivalent substitute and improvement made within the spirit and principle of the present disclosure are intended to be included within the scope of protection of the present disclosure.

CLAIMS

WHAT IS CLAIMED IS:

1. A method for multi-antenna transmission in a user equipment, comprising:

receiving a first radio signal; and

receiving a first signaling;

wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

2. The method of claim 1, further comprising:

receiving a second signaling; and

operating a second radio signal in a first time resource sub-pool;

wherein the operating is receiving, or the operating is transmitting; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; and the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI and (a) transmitting antenna port(s) of the second radio signal.

3. The method of claim 1, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, comprising:

receiving first information, wherein the first information is used to determine the first antenna port group.

4. The method of claim 1, further comprising:

transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, transmitting second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

5. The method of claim 1, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

6. A method for multi-antenna transmitting in a base station, comprising:

transmitting a first radio signal; and

transmitting a first signaling;

wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

7. The method of claim 6, further comprising:

transmitting a second signaling; and

performing a second radio signal in a first time resource sub-pool;

wherein the performing is transmitting, or the performing is receiving; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, an MCS, a HARQ process number, an RV, an NDI and (a) transmitting antenna port(s) of the second radio signal.

8. The method of claim 6, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, comprising:

transmitting first information, wherein the first information is used to determine the first antenna port group.

9. The method of claim 6, further comprising:

receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, receiving second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

10. The method of claim 6, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

11. A user equipment (UE) for multi-antenna transmission, comprising:

a first transceiver, receiving a first radio signal; and

a second receiver, receiving a first signaling;

wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

12. The UE of claim 11, comprising:

a third receiver, receiving a second signaling; and

a second transceiver, operating a second radio signal in a first time resource sub-pool;

wherein the operating is receiving, or the operating is transmitting; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; and the second signaling is used to determine at least one of occupied frequency domain resources, a MCS, a HARQ process number, a RV, a NDI and (a) transmitting antenna port(s) of the second radio signal.

13. The UE of claim 11, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, the second receiver further receives first information, wherein the first information is used to determine the first antenna port group.

14. The UE of claim 11, wherein:

the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, the first transceiver further transmits second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

15. The UE of claim 11, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

16. A base station equipment for multi-antenna transmission, comprising:

a third transceiver, transmitting a first radio signal; and

a second transmitter, transmitting a first signaling;

wherein the first radio signal is transmitted by K antenna port groups; the antenna port group includes a positive integer number of antenna port(s); a first antenna port group is one of the K antenna port groups; the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to a target receiver of the first signaling in the first time resource pool; and the K is a positive integer greater than 1; the first radio signal includes one or more of PSS (Primary Synchronization Signal), SSS (Secondary Synchronization Signal), MIB (Master Information Block)/SIB (System Information Block) or CSI-RS (Channel State Information Reference signal); the first signaling is a downlink signaling.

17. The base station equipment of claim 16, further comprising:

a third transmitter, transmitting a second signaling; and

a fourth transceiver, performing a second radio signal in a first time resource sub-pool;

wherein the performing is transmitting, or the performing is receiving; the second signaling is used to determine the first time resource sub-pool from the first time resource pool; the second signaling is used to determine at least one of occupied frequency domain resources, a MCS, a HARQ process number, a RV, a NDI and (a) transmitting antenna port(s) of the second radio signal.

18. The base station equipment of claim 16, wherein the first signaling indicates the first antenna port group from the K antenna port group(s);

or, the second transmitter further transmits first information, wherein the first information is used to determine the first antenna port group.

19. The base station equipment of claim 16, wherein:

the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer;

or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information includes a CRI(CRIs) (CSI-RS Resource Indicator), and the CRI(s) indicates(indicate) the CSI-RS resource(s) corresponding to the K1 antenna port group(s) from the CSI-RS resources corresponding to the K antenna port groups;

or, the third transceiver further receives second information, wherein the second information is used to determine K1 antenna port group(s); the K1 antenna port group(s) belong(s) to the K antenna port groups; the first antenna port group is one of the K1 antenna port group(s); the K1 is a positive integer; the second information is a RACH preamble, and at least one of the sequence of the RACH preamble or the time-frequency resource occupied by the RACH preamble is used to determine the first antenna port group.

20. The base station equipment of claim 16, wherein the first time resource pool is discontinuous in time domain; or the first signaling is a semi-static signaling; or the first signaling is a high layer signaling; or the first signaling is a physical layer signaling; or the first signaling includes one or more RRC IEs; or the first signaling is carried by a PDCCH; or the first signaling is transmitted on a PBCH; or the first signaling is cell-common; or the first signaling is for the UE.

ABSTRACT

The present disclosure discloses a method and device for multi-antenna transmission in UE and base station. The user equipment receives a first radio signal at first, then receives a first signaling. The first radio signal is transmitted by K antenna port groups, and the first signaling is used to determine a first time resource pool; a second antenna virtualization vector is associated with the first antenna port group; the second antenna virtualization vector is an antenna virtualization vector available to the user equipment in the first time resource pool. The invention effectively reduces signaling overhead of wireless resource dynamic scheduling of a massive MIMO system.

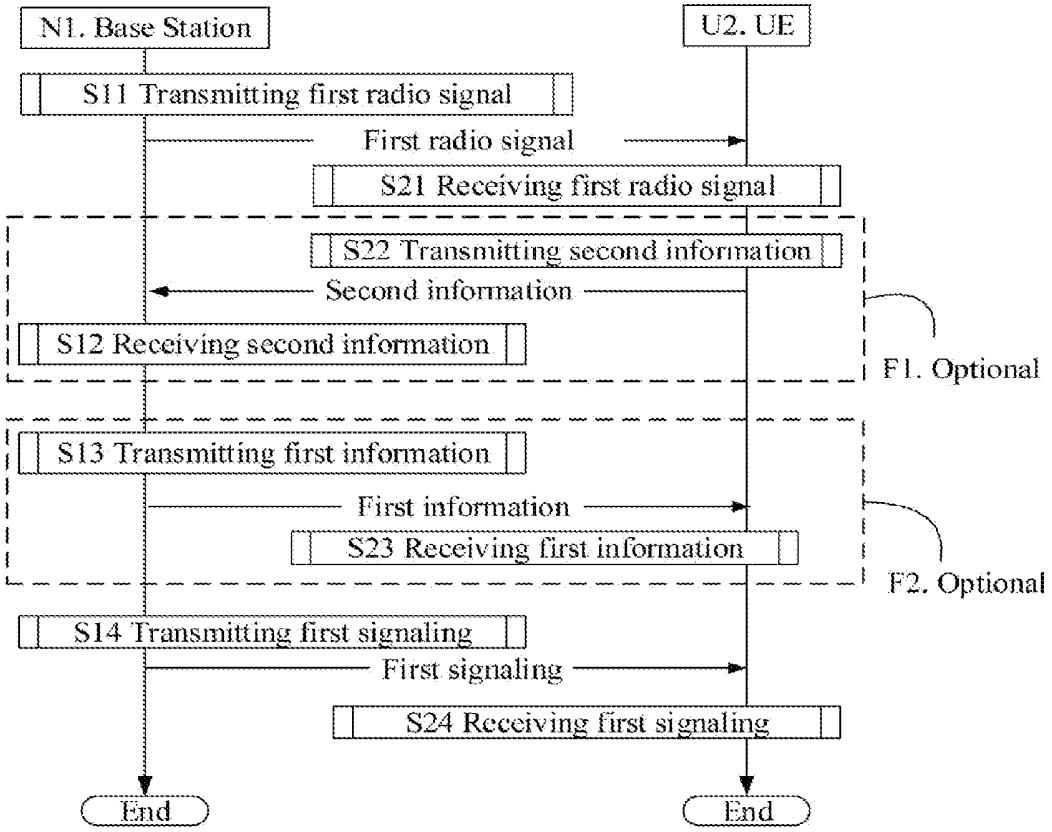

N1. Base Station
U2. UE
S11 Transmitting first radio signal
First radio signal
S21 Receiving first radio signal
S22 Transmitting second information
Second information
S12 Receiving second information
F1. Optional
S13 Transmitting first information
First information
S23 Receiving first information
F2. Optional
S14 Transmitting first signaling
First signaling
S24 Receiving first signaling
End
End

Fig. 1

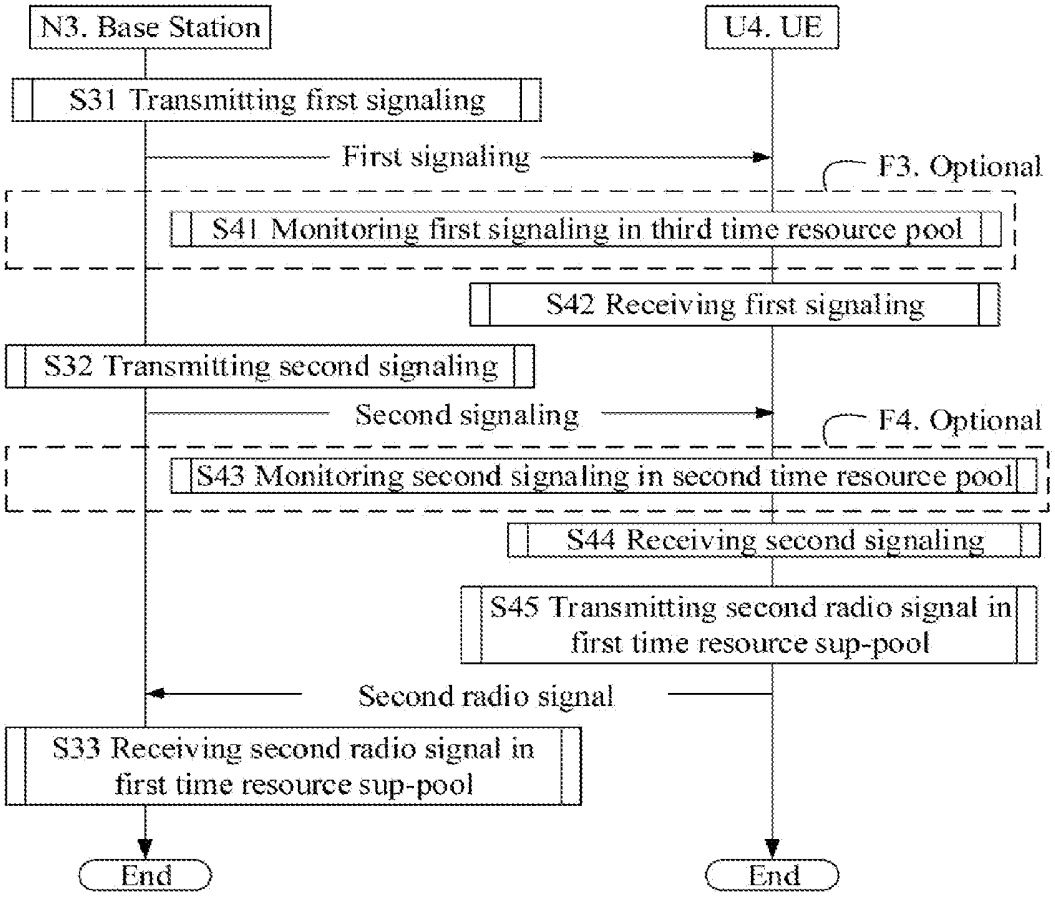

N3. Base Station
U4. UE
S31 Transmitting first signaling
First signaling
F3. Optional
S41 Monitoring first signaling in third time resource pool
S42 Receiving first signaling
S32 Transmitting second signaling
Second signaling
F4. Optional
S43 Monitoring second signaling in second time resource pool
S44 Receiving second signaling
S45 Transmitting second radio signal in first time resource sup-pool
Second radio signal
S33 Receiving second radio signal in first time resource sup-pool
End
End

Fig. 2

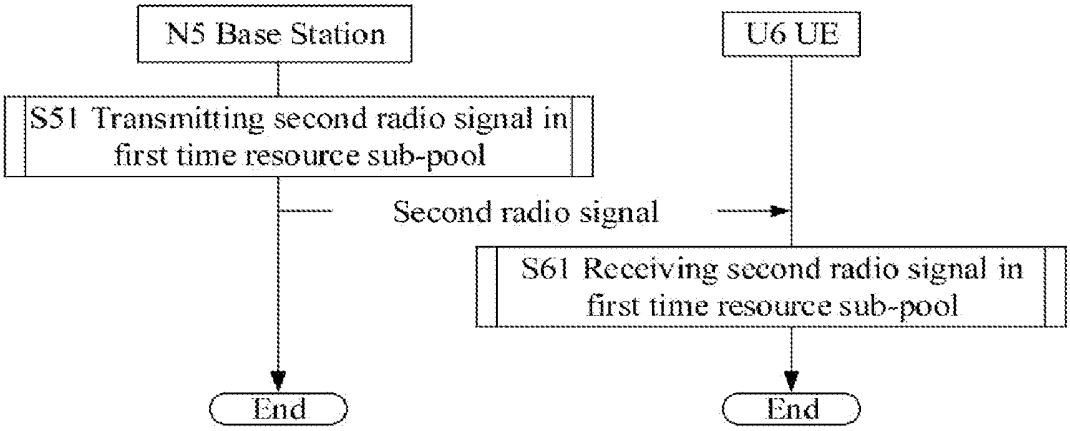

N5 Base Station
U6 UE
S51 Transmitting second radio signal in first time resource sub-pool
Second radio signal
S61 Receiving second radio signal in first time resource sub-pool
End
End

Fig. 3

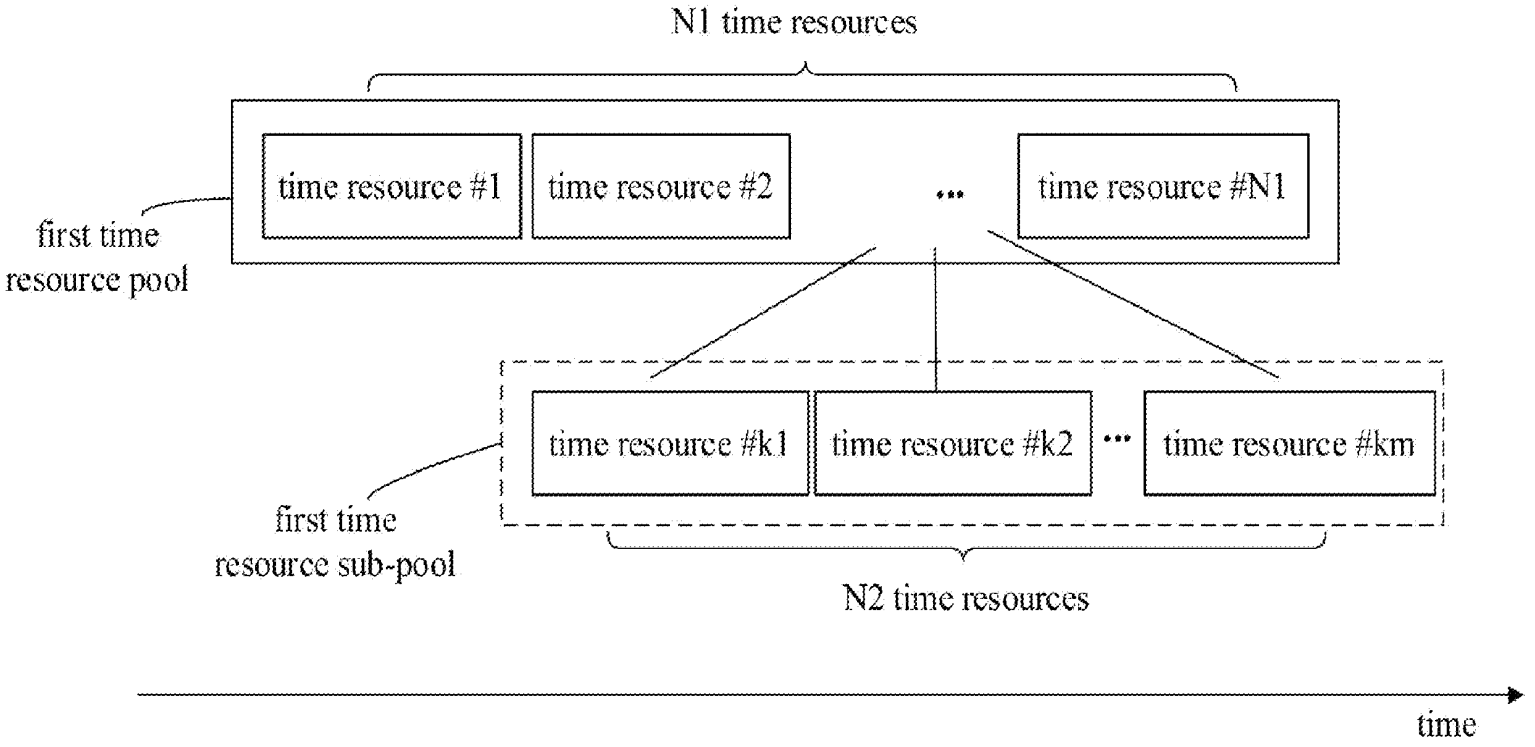

N1 time resources
time resource #1
time resource #2
...
time resource #N1
first time resource pool
time resource #k1
time resource #k2
...
time resource #km
first time resource sub-pool
N2 time resources
time

Fig. 4

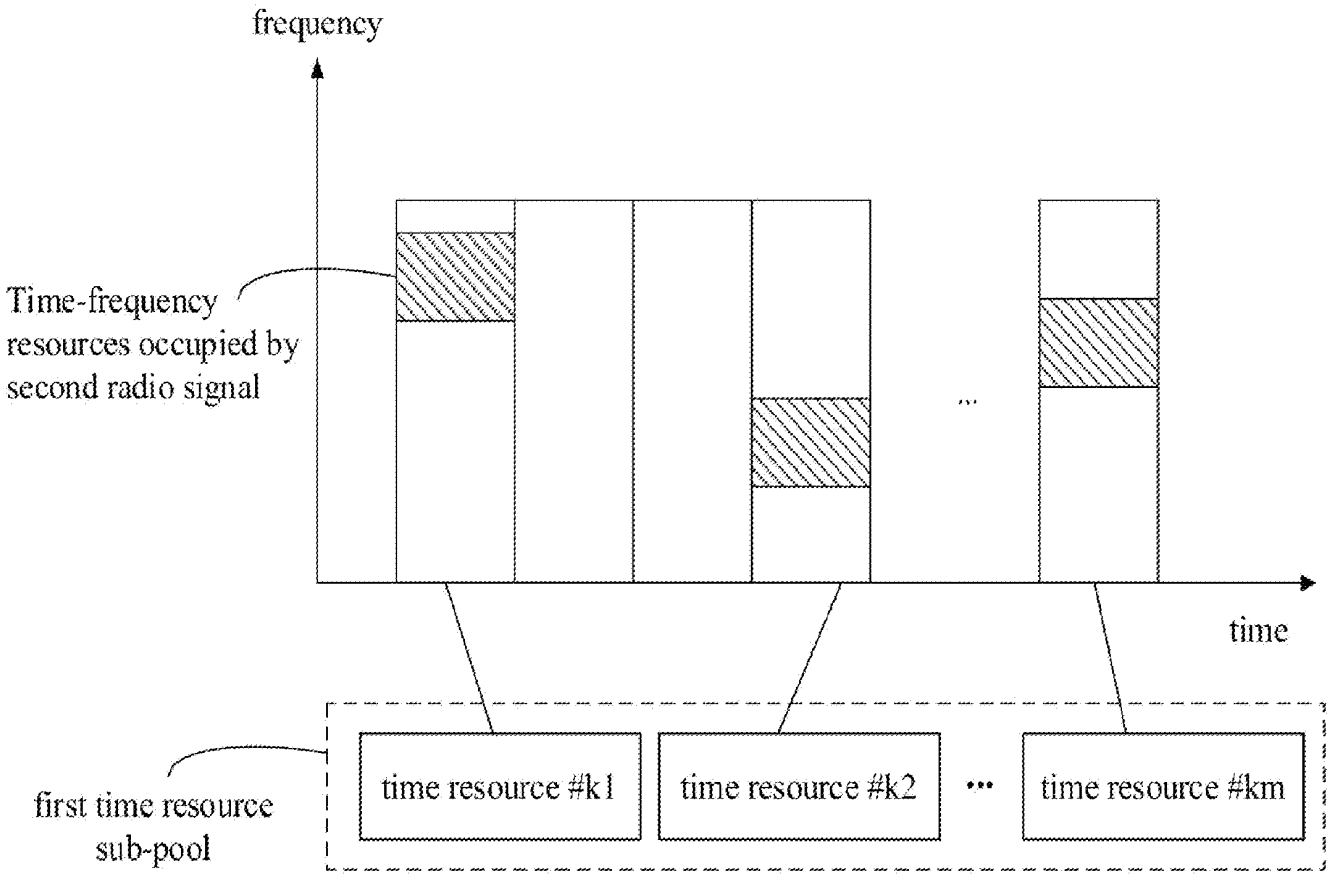

frequency
Time-frequency resources occupied by second radio signal
...
time
first time resource sub-pool
time resource #k1
time resource #k2
...
time resource #km

Fig. 5

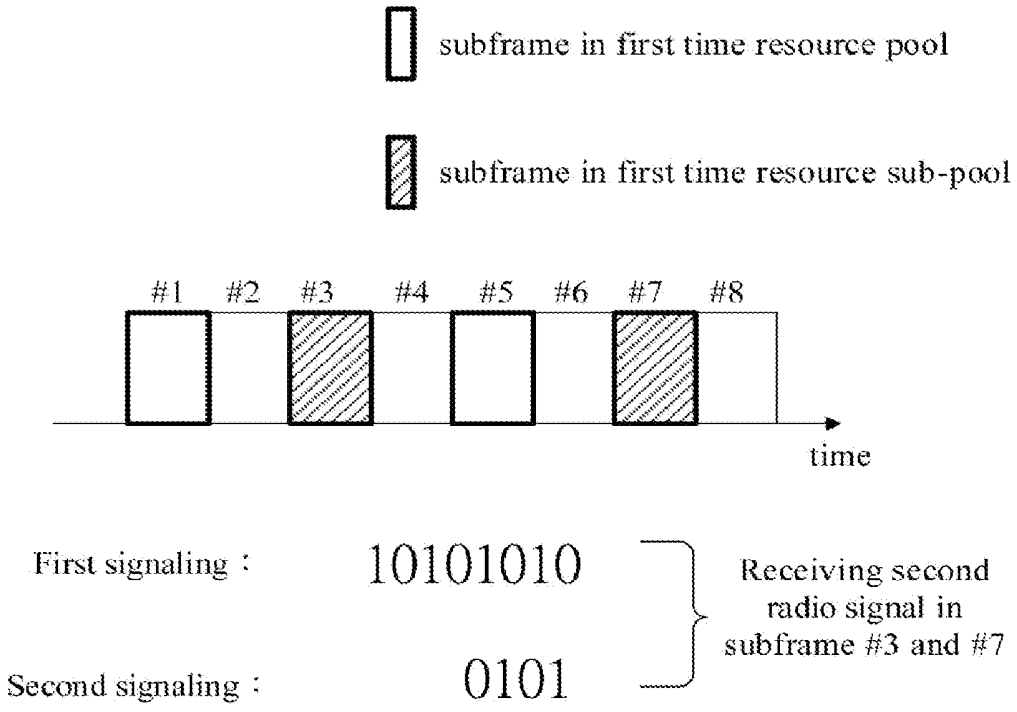

subframe in first time resource pool
subframe in first time resource sub-pool
#1
#2
#3
#4
#5
#6
#7
#8
time
First signaling：
10101010
Second signaling：
0101
Receiving second radio signal in subframe #3 and #7

Fig. 6

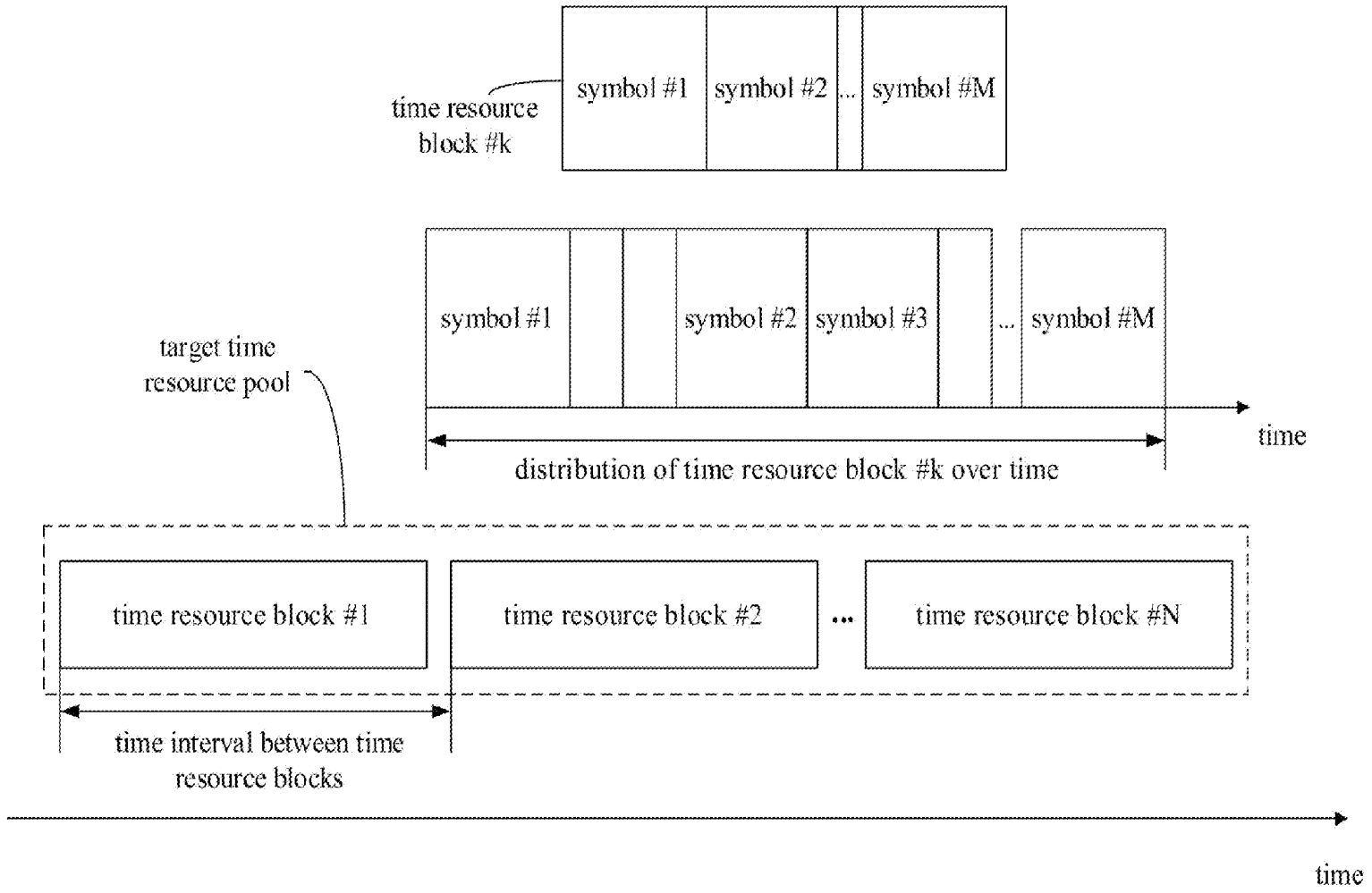

time resource block #k
symbol #1
symbol #2
...
symbol #M
target time resource pool
symbol #1
symbol #2
symbol #3
...
symbol #M
time
distribution of time resource block #k over time
time resource block #1
time resource block #2
...
time resource block #N
time interval between time resource blocks
time

Fig. 7

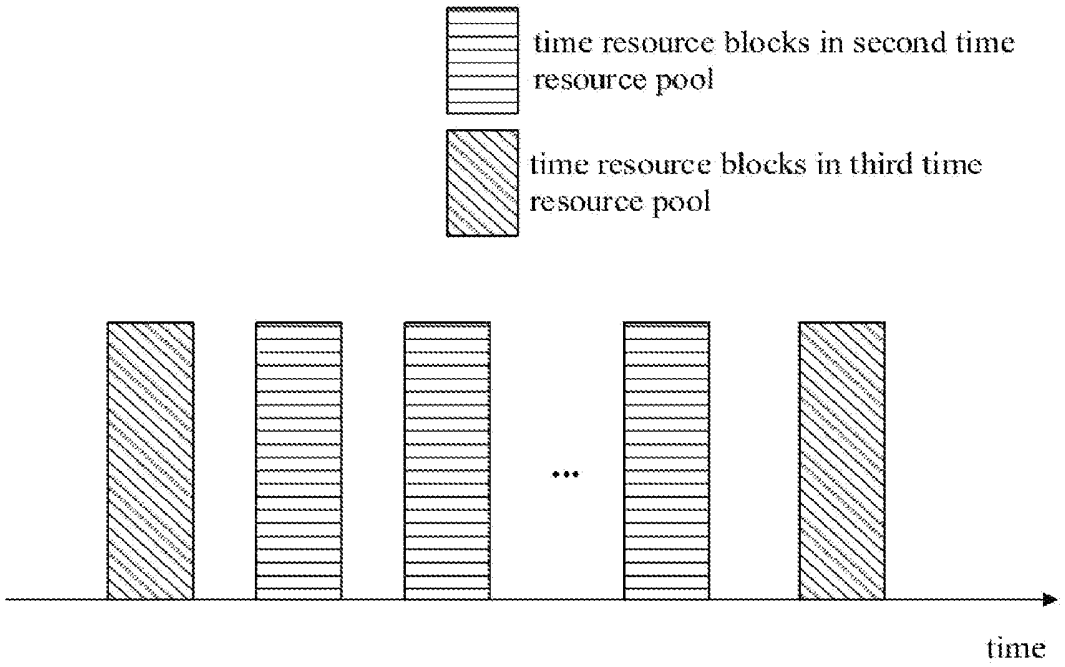

time resource blocks in second time resource pool
time resource blocks in third time resource pool
...
time

Fig. 8

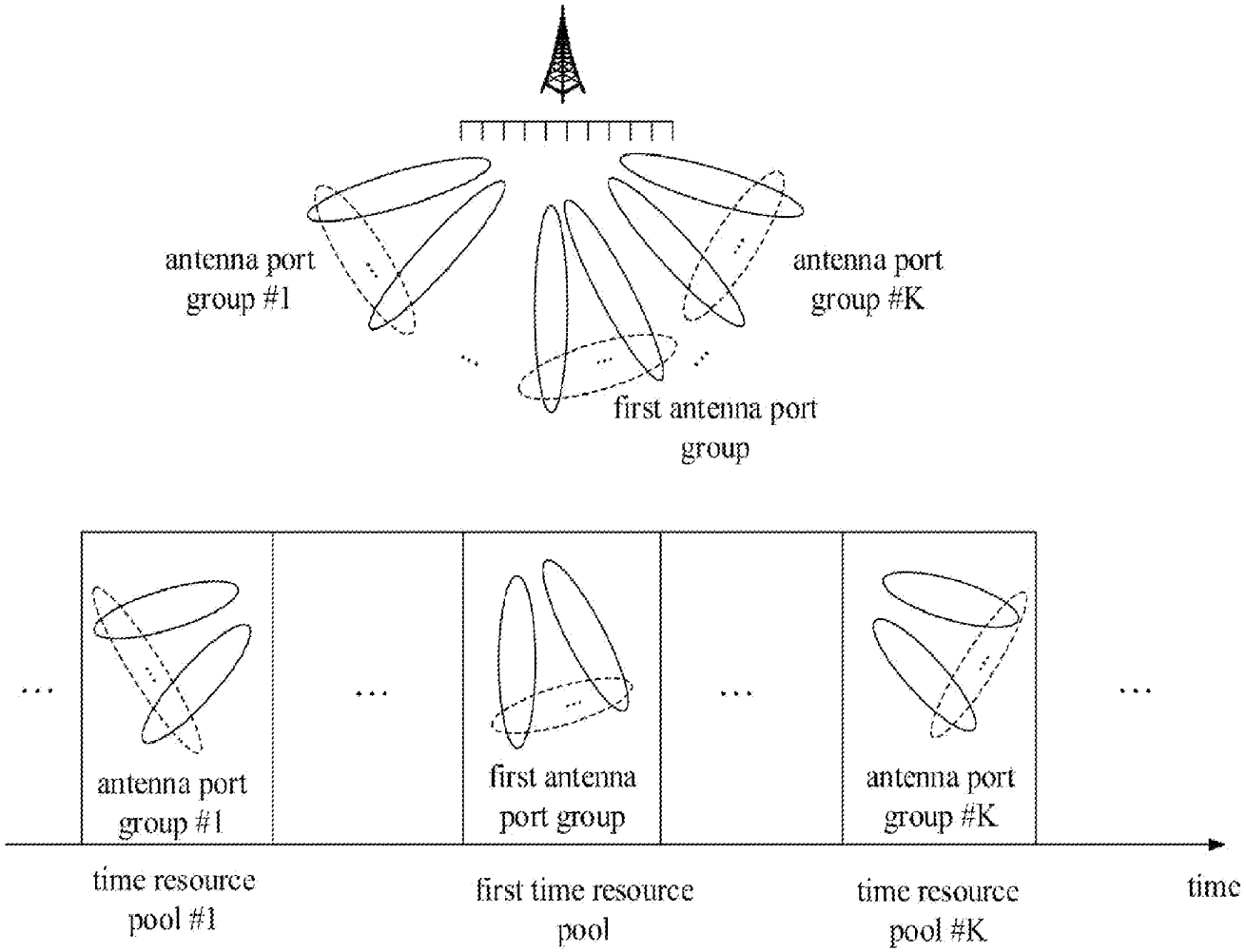

antenna port group #1
antenna port group #K
first antenna port group
antenna port group #1
first antenna port group
antenna port group #K
time resource pool #1
first time resource pool
time resource pool #K
time

Fig. 9

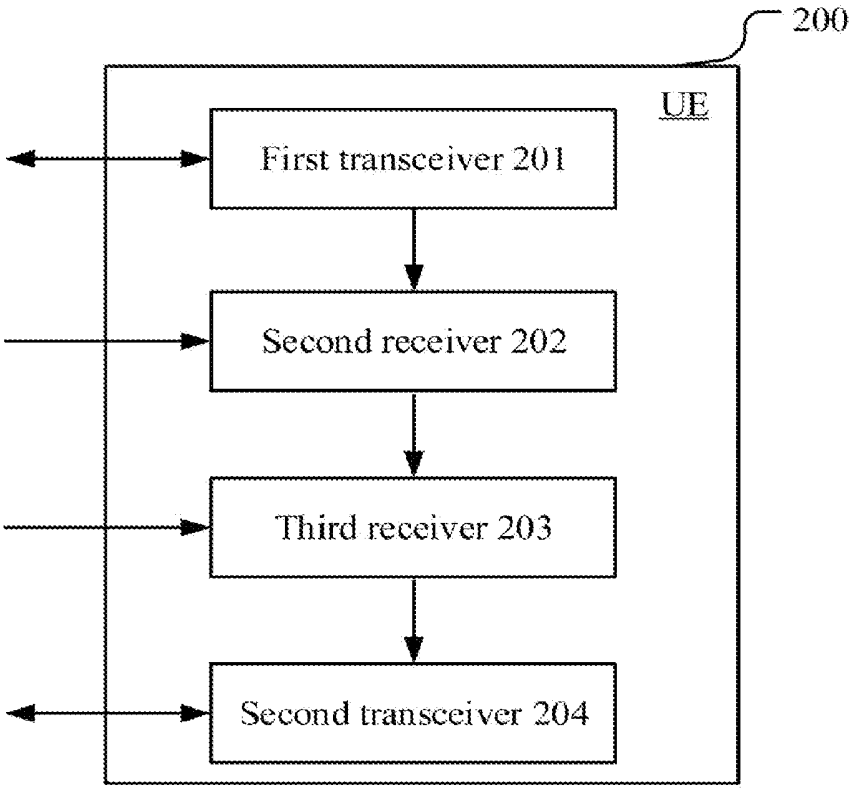

200
UE
First transceiver 201
Second receiver 202
Third receiver 203
Second transceiver 204

Fig. 10

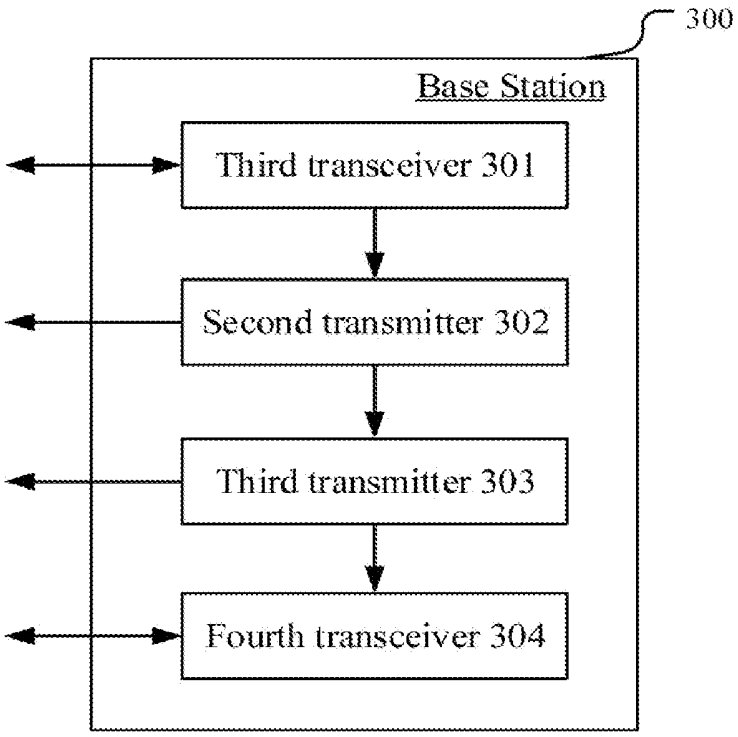

300
Base Station
Third transceiver 301
Second transmitter 302
Third transmitter 303
Fourth transceiver 304

Fig. 11

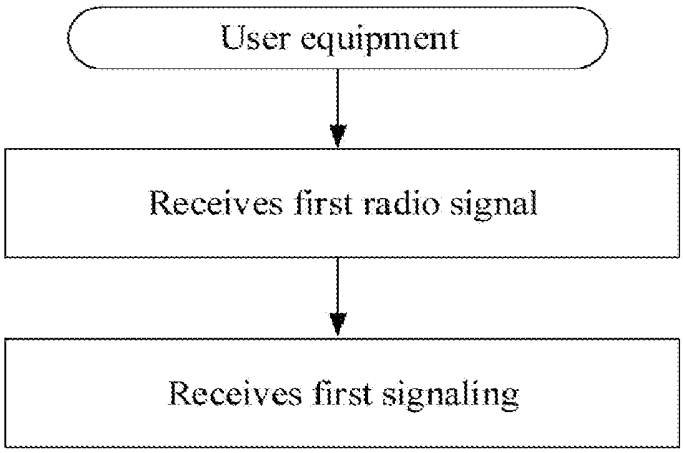

User equipment
Receives first radio signal
Receives first signaling

Fig. 12

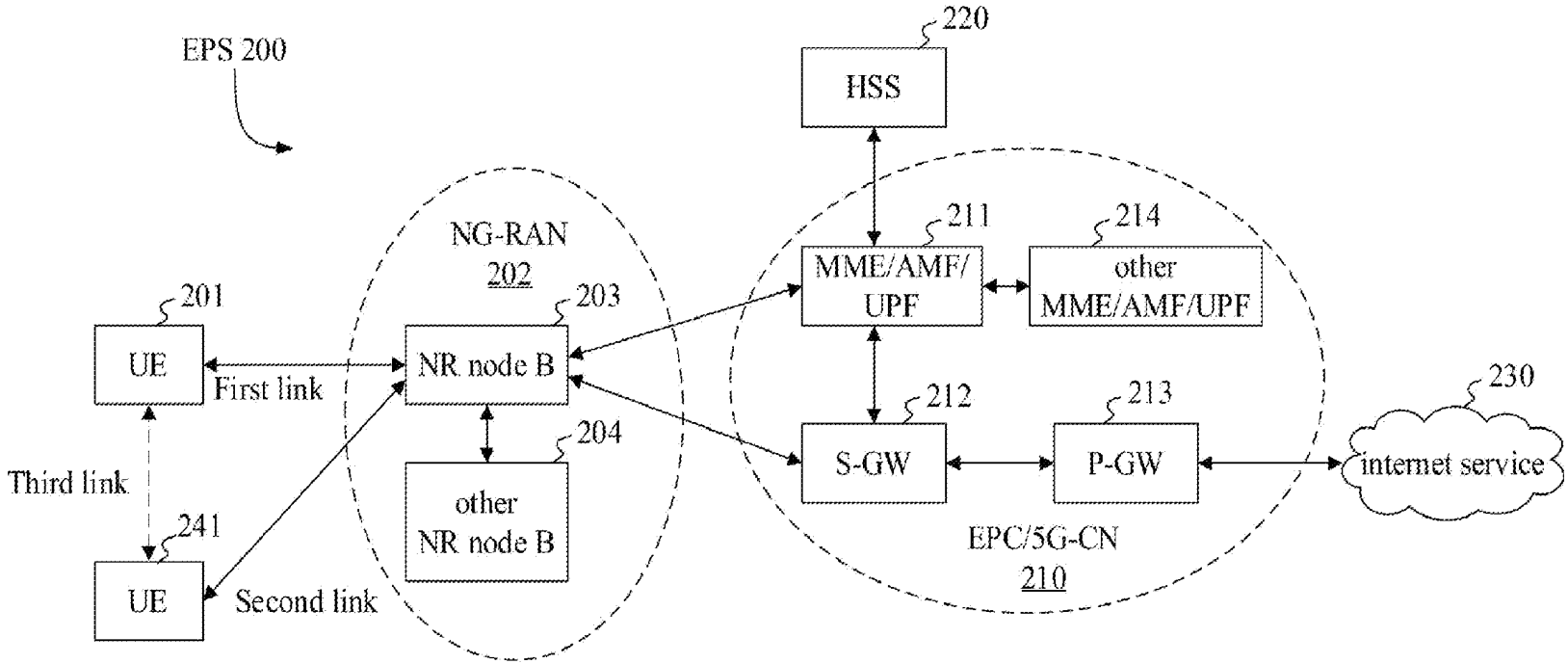

EPS 200
220
HSS
NG-RAN
202
211
214
MME/AMF/
UPF
other
MME/AMF/UPF
201
203
UE
First link
NR node B
230
212
213
204
Third link
S-GW
P-GW
internet service
other
NR node B
241
EPC/5G-CN
210
UE
Second link

Fig. 13

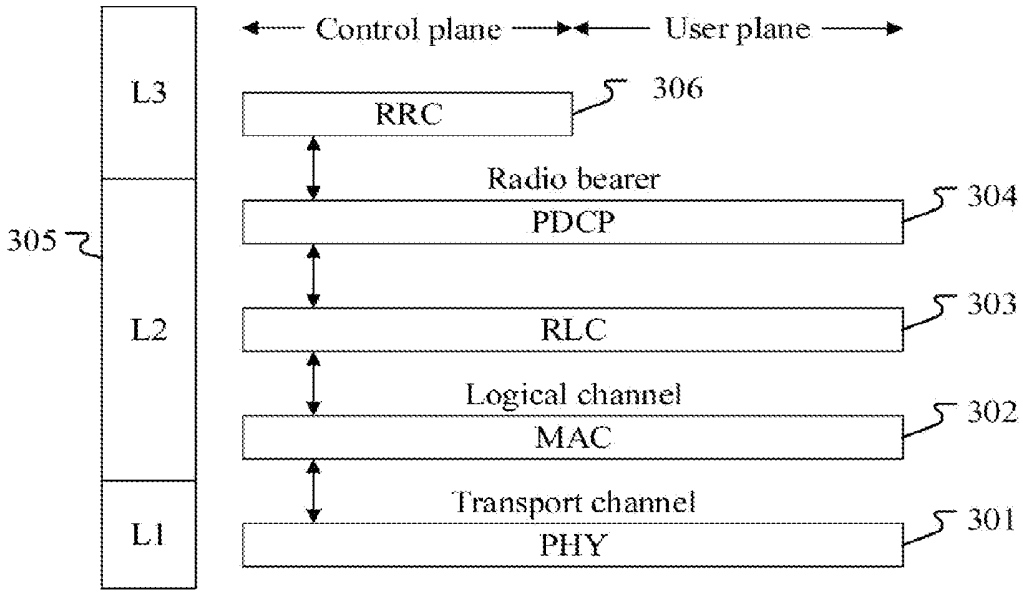

Control plane
User plane
L3
L2
L1
305
RRC
306
Radio bearer
PDCP
304
RLC
303
Logical channel
MAC
302
Transport channel
PHY
301

Fig. 14

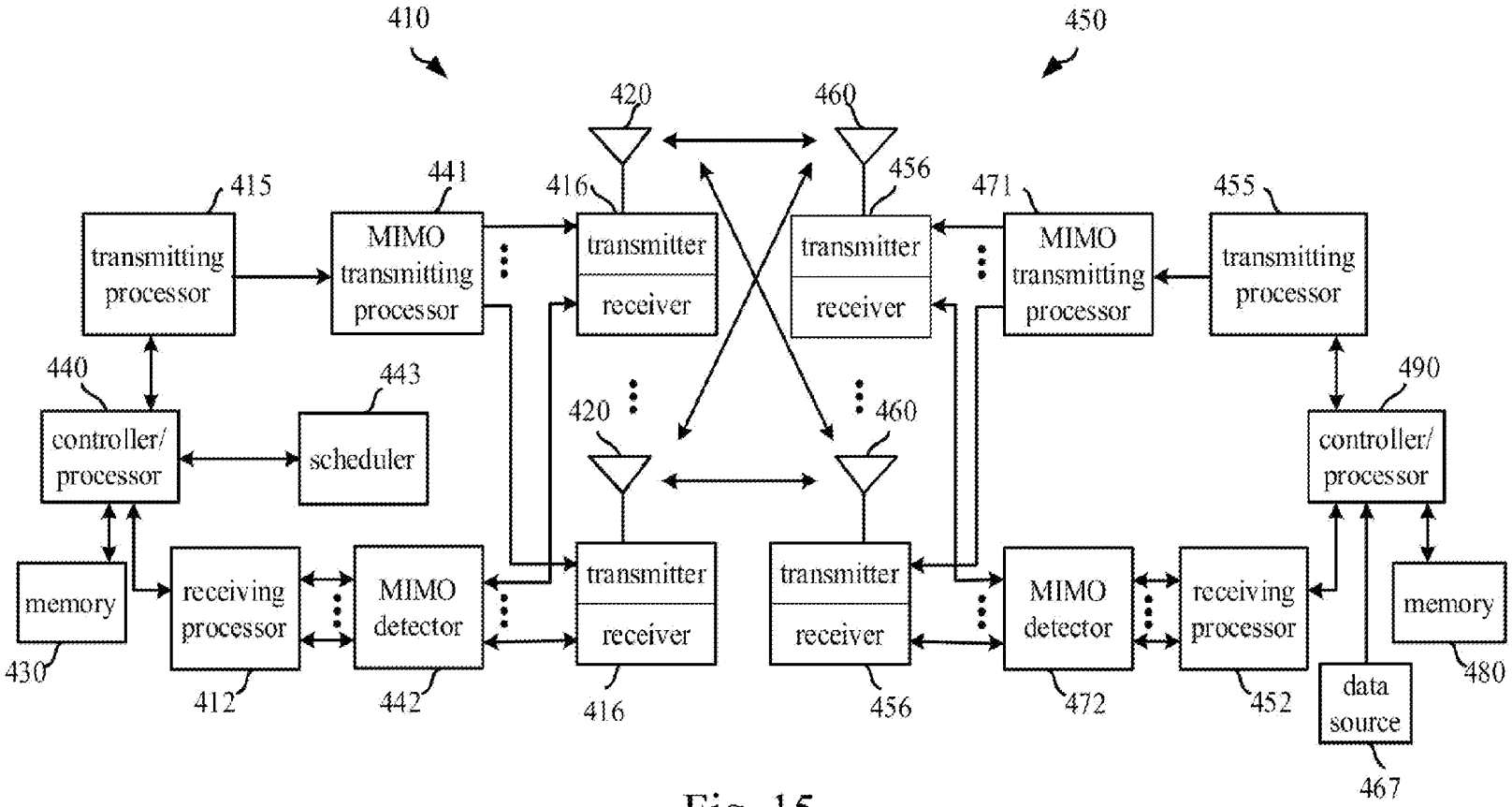

410
450
420
460
415
441
416
456
471
455
transmitting processor
MIMO transmitting processor
transmitter
receiver
transmitter
receiver
MIMO transmitting processor
transmitting processor
440
443
420
460
490
controller/ processor
scheduler
controller/ processor
memory
receiving processor
MIMO detector
transmitter
receiver
transmitter
receiver
MIMO detector
receiving processor
memory
data source
430
412
442
416
456
472
452
480
467

Fig. 15

PTO/AIA/01 (06-12)
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	Method and Device for Multi-Antenna Transmission in UE and Base Station

As the below named inventor, I hereby declare that:

This declaration is directed to:

- ☐ The attached application, or
- ☑ United States application or PCT international application number PCT/CN2017/112033 filed on November 21, 2017.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

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LEGAL NAME OF INVENTOR

Inventor: XiaoBo ZHANG Date (Optional): May.30 2019

Signature: XiaoBo ZHANG

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/SB/AIA01 form for each additional inventor.

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Application Number	
Filing Date	
First Named Inventor	Xiaobo ZHANG
Title	Method and Device for Multi-Antenna Transmission in User Equipment (UE) and Base Station
Art Unit	
Examiner Name	
Attorney Docket Number	ZL0205-0002-PCT-US-CON2

SIGNATURE of Applicant or Patent Practitioner

Signature	/Jialin Zhong/	Date (Optional)	
Name	Jialin Zhong	Registration Number	62937
Title (if Applicant is a juristic entity)	Registered Patent Attorney		
Applicant Name (if Applicant is a juristic entity)	APEX BEAM TECHNOLOGIES LLC		

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