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Application number: 62372919

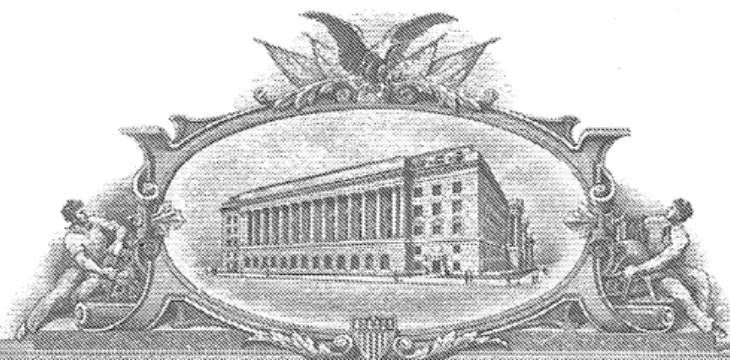
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THE UNITED STATES OF AMERICA

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UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

August 17, 2017

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: 62/372,919
FILING DATE: *August 10, 2016*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US62/372,919*



Certified by

Michelle K. Lee

Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	16P01405US00
		Application Number	
Title of Invention	RADIO TERMINAL AND BASE STATION		
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. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐ 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	
	Masato		FUJISHIRO		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Yokohama-shi		Country of Residence ⁱ	JP	
Mailing Address of Inventor:					
Address 1		c/o Kyocera Corporation			
Address 2		6 Takeda Tobadono-cho, Fushimiku			
City	Kyoto-shi, Kyoto		State/Province		
Postal Code	612-8501		Country ⁱ	JP	
Inventor	2				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Henry		CHANG		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	San Diego	State/Province	CA	Country of Residence ⁱ	US
Mailing Address of Inventor:					
Address 1		c/o Kyocera International, Inc. IP Department			
Address 2		8611 Balboa Ave			
City	San Diego		State/Province	CA	
Postal Code	92123		Country ⁱ	US	
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.					
Add					

Correspondence Information:

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	16P01405US00
		Application Number	
Title of Invention	RADIO TERMINAL AND BASE STATION		

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	32968		
Email Address		Add Email	Remove Email

Application Information:

Title of the Invention	RADIO TERMINAL AND BASE STATION		
Attorney Docket Number	16P01405US00	Small Entity Status Claimed	☐
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	13	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

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.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	32968		

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	16P01405US00
	Application Number	
Title of Invention	RADIO TERMINAL AND BASE STATION	

Domestic Benefit/National Stage Information:

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		Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button. Add			

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).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ^j (if applicable)	Remove
Additional Foreign Priority Data may be generated within this form by selecting the Add button. Add				

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.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	16P01405US00
		Application Number	
Title of Invention	RADIO TERMINAL AND BASE STATION		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

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.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

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)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ 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.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	16P01405US00
		Application Number	
Title of Invention	RADIO TERMINAL AND BASE STATION		

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	Kyocera Corporation		
Mailing Address Information For Applicant:			
Address 1	5 Takeda Tobadono-cho, Fushimiku		
Address 2			
City	Kyoto-shi, Kyoto	State/Province	
Country	JP	Postal Code	612-8501
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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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	16P01405US00
		Application Number	
Title of Invention	RADIO TERMINAL AND BASE STATION		

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				
If the Assignee or Non-Applicant Assignee is an Organization check here. ☐				
Prefix	Given Name	Middle Name	Family Name	Suffix
Mailing Address Information For Assignee including Non-Applicant Assignee:				
Address 1				
Address 2				
City		State/Province		
Country		Postal Code		
Phone Number		Fax Number		
Email Address				
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add				

Signature:					Remove
NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).					
This Application Data Sheet <u>must</u> be signed by a patent practitioner if one or more of the applicants is a juristic entity (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, all joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of all joint inventor-applicants.					
See 37 CFR 1.4(d) for the manner of making signatures and certifications.					
Signature	/Kathleen L. Connell/			Date (YYYY-MM-DD)	2016-08-10
First Name	Kathleen	Last Name	Connell	Registration Number	45344
Additional Signature may be generated within this form by selecting the Add button. Add					

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	16P01405US00
		Application Number	
Title of Invention	RADIO TERMINAL AND BASE STATION		

This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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 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.

Doc Code: **TR.PROV**

Document Description: Provisional Cover Sheet (SB16)

PTO/SB/16 (11-08)

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Provisional Application for Patent Cover Sheet

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

Inventor(s)

Inventor 1

Remove

Given Name	Middle Name	Family Name	City	State	Country j
Masato		FUJISHIRO	Yokohama-shi		JP

Inventor 2

Remove

Given Name	Middle Name	Family Name	City	State	Country j
Henry		CHANG	San Diego	CA	US

All Inventors Must Be Listed – Additional Inventor Information blocks may be generated within this form by selecting the **Add** button.

Add

Title of Invention

RADIO TERMINAL AND BASE STATION

Attorney Docket Number (if applicable)

16P01405US00

Correspondence Address

Direct all correspondence to (select one):

☒ The address corresponding to Customer Number

☐ Firm or Individual Name

Customer Number

32968

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

Yes, the invention was made by an agency of the United States Government. The U.S. Government agency name is:

Yes, the invention was under a contract with an agency of the United States Government. The name of the U.S. Government agency and Government contract number are:

Doc Code: **TR.PROV**

Document Description: Provisional Cover Sheet (SB16)

PTO/SB/16 (11-08)

Approved for use through 05/31/2015. CMB 0651-0032

U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

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Entity Status

Applicant asserts small entity status under 37 CFR 1.27 or applicant certifies micro entity status under 37 CFR 1.29

- ☐ Applicant asserts small entity status under 37 CFR 1.27
- ☐ Applicant certifies micro entity status under 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
- ☒ No

Warning

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

Signature

Please see 37 CFR 1.4(d) for the form of the signature.

Signature	Kathleen L. Connell/		Date (YYYY-MM-DD)	2016-08-10
First Name	Kathleen	Last Name	Connell	Registration Number (If appropriate)
				45344

This collection of information is required by 37 CFR 1.51. 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 8 hours 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. **This form can only be used when in conjunction with EFS-Web. If this form is mailed to the USPTO, it may cause delays in handling the provisional application.**

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 disclosure of these records is required by the Freedom of Information Act.
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 inspection 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.

[Document Name] Specification

[Title of Invention] RADIO TERMINAL AND BASE STATION

[Technical Field]

The present invention relates to a radio terminal and base station for a mobile communication system.

[Background Art]

In the Third Generation Partnership Project (3GPP), a project to standardize mobile communication systems, a Multimedia Broadcast Multicast Service (MBMS), which provides multicast and broadcast services to radio terminals, is being specified. There are two radio transmission methods for MBMS, being MBSFN (Multicast Broadcast Single Frequency Network) transmission and SC-PTM (Single Cell Point-To-Multipoint) transmission. Since the MBMS transmits the same data to a plurality of radio terminals by using the same radio resource, utilization efficiency of the radio resource can be enhanced.

Meanwhile, radio terminals for MTC (Machine Type Communication) and Internet of Things (IoT) services that perform communication without human intervention are being studied. Such a radio terminal is required to achieve cost reduction, coverage expansion, and low power consumption. Thus, in 3GPP, a category of a new radio terminal in which transmission/reception bandwidth is limited only to a part of a system transmission/reception band has specified. However, there is a problem in that there is currently no mechanism for a new category of radio terminal to efficiently receive multicast/broadcast services using MBMS.

[Summary of Invention]

A radio terminal according to a first feature is a radio terminal for a mobile communication system. The radio terminal is provided with: a transceiver configured to transmit and receive radio signals within a limit bandwidth narrower than a system transmission/reception band; and a control unit that uses the transceiver to perform radio communication with a base station. The control unit performs a process for receiving, from the base station, information required for receiving an MBMS service provided via the base station within the limit bandwidth.

A base station according to a second feature is a base station for a mobile communication system. The base station is provided with a control unit for transmitting, within a limit bandwidth narrower than the system transmission/reception bandwidth, information required for receiving an MBMS service provided via the base station to a radio terminal configured to transmit/receive a radio signal within the limit bandwidth.

[Brief Description of Drawings]

[FIG. 1] A diagram illustrating a configuration of an LTE system according to an embodiment.

[FIG. 2] A diagram illustrating a network configuration according to MBMS according to the embodiment.

[FIG. 3] A diagram illustrating a configuration of a UE (radio terminal) according to the embodiment.

[FIG. 4] A diagram illustrating a configuration of an eNB (base station) according to the embodiment.

[FIG. 5] A diagram illustrating a protocol stack of a radio interface in an LTE system according to the embodiment.

[FIG. 6] A diagram illustrating a configuration of a downlink channel of an LTE system according to the embodiment.

[FIG. 7] A diagram illustrating a configuration of a radio frame of an LTE system according to the embodiment.

[FIG. 8] A diagram illustrating relationships between a hyperframe, a radio frame, and a subframe according to the embodiment.

[FIG. 9] A diagram illustrating a downlink physical channel for a category M1 according to the embodiment.

[FIG. 10] A diagram illustrating an example of an operation where the UE according to the embodiment performs SC-PTM reception.

[FIG. 11] A diagram illustrating a Direct Indication according to the embodiment.

[FIG. 12] A diagram illustrating an SIB20 according to the embodiment.

[FIG. 13] A diagram illustrating SCPTM setting information (SCPTM Configuration) in the SC-MCCH according to the embodiment.

[FIG. 14] A diagram illustrating a provisioning start time expressed by an H-SFN according to the embodiment.

[FIG. 15] A diagram illustrating repeating count information according to the embodiment.
[Embodiments of Invention]
(Mobile Communication System)

A configuration of a mobile communication system according to an embodiment will be described. A mobile communication system according to the embodiment is an LTE (Long Term Evolution) system having specifications developed in 3GPP. FIG. 1 is a diagram illustrating a configuration of an LTE system according to the embodiment. FIG. 2 is a diagram illustrating a network configuration according to MBMS.

As illustrated in FIG. 1, an LTE system is provided with a radio terminal (UE: User Equipment) 100, a radio access network (E-UTRAN: Evolved-UMTS Terrestrial Radio Access Network) 10, and a core network (EPC: Evolved Packet Core) 20. The E-UTRAN 10 and the EPC 20 constitute a network of the LTE system.

The UE 100 is a mobile communication device. The UE 100 performs radio communication with an eNB 200 managing a cell (serving cell) in which the itself is present.

The E-UTRAN 10 includes a base station (eNB: evolved Node-B) 200. The eNB 200 are mutually connected via an X2 interface. The eNB 200 manages one or a plurality of cells and performs radio communication with the UE 100 having established a connection with its own cell. The eNB 200 has a radio resource management (RRM) function, a routing function of user data (hereinafter simply referred to as "data"), a measurement control function for mobility control and scheduling, and the like. "Cell" is used as a term indicating the minimum unit of a radio communication area. "Cell" is also used to describe a function or a resource that performs radio communication with the UE 100.

The EPC 20 includes a mobility management entity (MME) and a serving gateway (S-GW) 300. The MME performs various mobility controls and the like for the UE 100. The S-GW performs data transfer control. The MME/S-GW 300 is connected to the eNB 200 via the S1 interface.

Next, a network entity for MBMS will be described. The E-UTRAN 10 includes an MCE (Multi-Cell/Multicast Coordinating Entity) 11. The MCE 11 is connected to the eNB 200 via an M2 interface and is connected to the MME 300 via an M3 interface (see FIG. 2). The MCE 11 performs MBSFN radio resource management, allocation, and the like. Specifically, the MCE 11 performs scheduling of MBSFN transmission. In contrast, scheduling of SC-PTM transmission is performed by eNB 200.

The EPC 20 includes an MBMS GW (MBMS Gateway) 21. The MBMS GW 21 is connected to the eNB 200 through an M1 interface, connected to the MME 300 through an Sm interface, and connected to the BM-SC 22 through SG-mb and SGi-mb interfaces (see FIG. 2). The MBMS GW 21 performs IP multicast data transmission, session control, and the like with respect to the eNB 200.

The EPC 20 also includes a BM-SC (Broadcast Multicast Service Center) 22. The BM-SC 22 is connected to the MBMS GW 21 via the SG-mb and SGi-mb interfaces, and is connected to the P-GW 23 via the SGi interface (see FIG. 2). The BM-SC 22 manages and assigns a Temporary Mobile Group Identity (TMGI).

Furthermore, a GCS AS (Group Communication Service Application Server) 31 is provided in a network (that is, the Internet) external to the EPC 20. The GCS AS 31 is an application server for group communication. The GCS AS 31 is connected to the BM-SC 22 via MB2-U and MB2-C interfaces and is connected to the P-GW 23 via the SGi interface. The GCS AS 31 performs group management, data distribution, and the like in group communication.

FIG. 3 is a diagram illustrating a configuration of the UE 100 (radio terminal) according to the embodiment. As illustrated in FIG. 3, the UE 100 is provided with a reception unit 110, a transmission unit 120, and a control unit 130.

The reception unit 110 performs various reception under the control of the control unit 130. The reception unit 110 includes an antenna and a receiver. The receiver converts a radio signal received by the antenna into a baseband signal (reception signal) and outputs such to the control unit 130.

The transmission unit 120 performs various transmissions under the control of a control unit 130. The transmission unit 120 includes an antenna and a transmitter. The transmitter converts a baseband signal (transmission signal) outputted by the control unit 130 into a radio signal and transmits the such from the antenna.

The control unit 130 performs various control in the UE 100. The control unit 130 includes a processor and a memory. The memory stores a program executed by the processor and information used for processing by the processor. The processor includes a baseband processor that modulates and demodulates a baseband signal and encodes and decodes the baseband signal, and a central processing unit (CPU) that executes the program stored in the memory and performs various processes. The processor may include a codec for encoding/decoding an audio/video signal. The processor executes various processes described below.

FIG. 4 is a diagram illustrating a configuration of the eNB 200 (base station) according to the embodiment. As illustrated in FIG. 4, the eNB 200 is provided with a transmission unit 210, a reception unit 220, a control unit 230, and a backhaul communication unit 240.

The transmission unit 210 performs various transmission under the control of the control unit 230. The transmission unit 210 includes an antenna and a transmitter. The transmitter converts a baseband signal (transmission signal) outputted by the control unit 230 into a radio signal and transmits the such from the antenna.

The reception unit 220 performs various reception under the control of the control unit 230. The receiver 220 includes an antenna and a receiver. The receiver converts a radio signal received by the antenna into a baseband signal (reception signal) and outputs such to the control unit 230.

The control unit 230 performs various control in the eNB 200. The control unit 230 includes a processor and a memory. The memory stores a program executed by the processor and information used for processing by the processor. The processor includes a baseband processor that modulates and demodulates a baseband signal and encodes and decodes the baseband signal,

and a CPU that executes the program stored in the memory and performs various processes. The processor executes various processes described below.

A backhaul communication unit 240 is connected to an adjacent eNB via an X2 interface, and is connected to an MME/S-GW 300 via an S1 interface. The backhaul communication unit 240 is used for communication performed on the X2 interface, communication performed on the S1 interface, and the like.

FIG. 5 is a diagram illustrating a protocol stack of a radio interface in an LTE system. As illustrated in FIG. 5, a radio interface protocol is divided into a first layer to a third layer of an OSI reference model. The first layer is a physical (PHY) layer. The second layer includes a medium access control (MAC) layer, a radio link control (RLC) layer, and a packet data convergence protocol (PDCP) layer. The third layer includes a radio resource control (RRC) layer.

The physical layer performs encoding/decoding, modulation/demodulation, antenna mapping/demapping, and resource mapping/demapping. Data and a control signal are transmitted between the physical layer of the UE 100 and the physical layer of the eNB 200 via a physical channel.

The MAC layer performs priority control of data, retransmission processing via HARQ (Hybrid ARQ), and the like. Data and a control signal are transmitted between the MAC layer of the UE 100 and the MAC layer of the eNB 200 via a transport channel. The MAC layer of the eNB 200 includes a scheduler which determines a transport format (transport block size, modulation/encoding system (MCS)) of uplink and downlink and an allocation resource block to the UE 100.

The RLC layer transmits data to the RLC layer of the receiving side by using the functions of the MAC layer and the physical layer. Data and a control signal are transmitted between the RLC layer of the UE 100 and the RLC layer of the eNB 200 via a logical channel.

The PDCP layer performs header compression/decompression and encryption/decryption.

The RRC layer is defined only in a control plane handling a control signal. Messages (RRC messages) for various settings are transmitted between the RRC layer of the UE 100 and the RRC layer of the eNB 200. The RRC layer controls the logical channel, the transport channel, and the physical channel according to establishment, re-establishment, and release of a radio bearer. When there is a connection (RRC connection) between the RRC of the UE 100 and the RRC of the eNB 200, the UE 100 is in an RRC connected mode, and when not, the UE 100 is in an RRC idle mode.

A NAS (Non-Access Stratum) layer positioned above the RRC layer performs session management, mobility management, and the like.

FIG. 6 is a diagram illustrating a configuration of a downlink channel of the LTE system. FIG. 6(a) illustrates a mapping between a logical channel (Downlink Logical Channel) and a transport channel (Downlink Transport Channel).

As illustrated in FIG. 6(a), a PCCH (Paging Control Channel) is a logical channel for notifying paging information and system information change. The PCCH is mapped to a PCH (Paging Channel) which is a transport channel.

A BCCH (Broadcast Control Channel) is a logical channel for system information. The BCCH is mapped to a BCH (Broadcast Control Channel) and a DL-SCH (Downlink Shared Channel), which are transport channels.

A CCCH (Common Control Channel) is a logical channel for transmission control information between the UE 100 and the eNB 200. The CCCH is used when the UE 100 does not have an RRC connection with the network. The CCCH is mapped to the DL-SCH.

A DCCH (Dedicated Control Channel) is a logical channel for transmitting individual control information between the UE 100 and a network. The DCCH is used when the UE 100 has an RRC connection. The DCCH is mapped to the DL-SCH.

A DTCH (Dedicated Traffic Channel) is an individual logical channel for data transmission. The DTCH is mapped to the DL-SCH.

An SC-MTCH (Single Cell Multicast Traffic Channel) is a logical channel for SC-PTM transmission. The SC-MTCH is a one-to-many channel (point-to-multipoint downlink channel) for transmitting data from the network to the UE 100 using SC-PTM transmission.

A single cell multicast control channel (SC-MCCH) is a logical channel for SC-PTM transmission. The SC-MTCH is a one-to-many channel (point-to-multipoint downlink channel) for transmitting SC-MTCH control information for one or a plurality of MBMSs from the network to the UE 100. The SC-MCCH is used for the UE 100, which receives or is interested in receiving an MBMS using the SC-PTM. Moreover, only one SC-MCCH is present in one cell.

An MCCH (Multicast Control Channel) is a logical channel for MBSFN transmission. The MCCH is used for transmitting MBMS control information for the MTCH from the network to the UE 100. The MCCH is mapped to an MCH (Multicast Channel) which is a transport channel.

The MTCH (Multicast Traffic Channel) is a logical channel for MBSFN transmission. The MTCH is mapped to the MCH.

FIG. 6(b) illustrates a mapping between a transport channel (Downlink Transport Channel) and a physical channel (Downlink Physical Channel).

As illustrated in FIG. 6(b), the BCH is mapped to a physical broadcast channel (PBCH).

The MCH is mapped to a physical multicast channel (PMCH). The MCH supports MBSFN transmission by a plurality of cells.

The PCH and the DL-SCH are mapped to a physical downlink shared channel (PDSCH). The DL-SCH supports HARQ, link adaptation, and dynamic resource allocation.

The PDCCH transports resource allocation information of the PDSCH (DL-SCH, PCH) and DL-SCH information or the like related to the HARQ. The PDCCH also carries an uplink scheduling grant.

FIG. 7 is a diagram illustrating a configuration of a radio frame of the LTE system. In the LTE system, OFDMA (Orthogonal Frequency Division Multiple Access) is applied to downlink, and SC-FDMA (Single Carrier Frequency Division Multiple Access) is applied to uplink.

As illustrated in FIG. 7, the radio frame is configured from ten subframes aligned in the time direction. Each subframe is configured from two slots arranged in the time direction. The length of each subframe is 1 ms, and the length of each slot is 0.5 ms. Each subframe includes a plurality of resource blocks (RB) in the frequency direction and includes a plurality of symbols in the time direction. Each resource block includes a plurality of subcarriers in the frequency direction. One resource element (RE) is configured from one symbol and one subcarrier. Among the radio resources (time/frequency resources) allocated to the UE 100, the frequency resource can be specified by a resource block, and the time resource can be specified by a subframe (or a slot).

In a downlink, the section of the leading few symbols of each subframe is a region used mainly as a PDCCH for transmitting a downlink control signal. Furthermore, the remaining portion of each subframe is an area that can be used as a PDSCH for mainly transmitting downlink data. Furthermore, in the downlink, an MBSFN subframe that is a subframe for MBSFN transmission may be set.

In an uplink, both ends in the frequency direction in each subframe are regions used mainly as PUCCH for transmitting an uplink control signal. The remaining portion in each subframe is an area that can be used as a PUSCH for mainly transmitting uplink data.

In the LTE system, Discontinuous Reception (DRX) may be set in the UE 100 to reduce power consumption. In a DRX operation, the UE 100 in the RRC idle mode monitors a paging message in a paging reception occasion (Paging Occasion) generated at a predetermined time interval (DRX cycle).

In the DRX operation, the UE 100 intermittently monitors the PDCCH to receive paging. The UE 100 decodes the PDCCH by using a paging radio network temporary identifier (P-RNTI) to acquire allocation information of a paging channel. The UE 100 acquires a paging message on the basis of the allocation information. A PDCCH monitoring timing in the UE 100 is determined based on an identifier (IMSI: International Mobile Subscriber Identity) of the UE 100.

The PDCCH monitoring timing (PDCCH monitoring subframe) in the DRX operation is referred to as a Paging Occasion (PO). The PO corresponds to a paging receiving occasion.

The UE 100 and the eNB 200 calculate the Paging Occasion (PO) and the Paging Frame (PF), which is a radio frame that can include the Paging Occasion, as shown below.

A system frame number (SFN) of the PF is obtained from the following formula (1).

$$\text{SFN mod } T = (T \text{ div } N) * (\text{UE_ID mod } N) \dots (1)$$

Here, T is the DRX cycle of the UE 100 for monitoring paging and is expressed in a number of radio frames. Furthermore, T is the smaller between a default DRX value broadcast by the eNB 200 via a system information block (SIB) and a UE-specific DRX value set in the UE 100 by the NAS message. Note that when a UE-specific DRX value is not set, the UE 100 applies a default DRX value. In addition, N is the smaller value between T and nB. nB is a value selected from 4T, 2T, T, T/2, T/4, T/8, T/16, and T/32. UE_ID is the value determined by "IMSI mod 1024."

Among the PFs obtained in this manner, an index i_s is obtained by the following formula (2), and a subframe number of the PO corresponding to the index i_s is obtained.

$$i_s = \text{floor}(\text{UE_ID}/N) \text{ mod } N_s \dots (2)$$

Here, N_s is the larger value between 1 and nB/T .

Next, an extended DRX (extended DRX) will be described. In the extended DRX, a hyperframe is used to support a very long DRX cycle.

FIG. 8 is a diagram illustrating a relationship between a hyperframe, a radio frame, and a subframe. As illustrated in FIG. 8, the hyperframe is identified by an H-SFN (Hyper System Frame Number). The H-SFN is reported from a cell. The radio frame is identified by a system frame number (SFN). The subframe is identified by the subframe number. One hyperframe is configured from 1024 radio frames. System frame numbers from No. 0 to No. 1023 are assigned to the 1024 radio frames. Furthermore, 1 radio frame is configured from 10 subframes. Subframe numbers from No. 0 to No. 9 are assigned to the 10 subframes.

The UE 100 for which the extended DRX cycle is set performs extended DRX operation when the cell indicates, via system information, support for extended DRX. The UE 100 monitors the PO described above in a periodic paging window set in its own UE. The paging window is UE-specific. The paging window is defined by a paging hyperframe (PH), a start point (PW_start) in the PH, and an end point (PW_end) in the PH.

Here, PH is H-SFN, satisfying the following formula (3).

$$\text{H-SFN mod } T_{\text{eDRX, H}} = (\text{UE_ID mod } T_{\text{eDRX, H}}) \dots (3)$$

Here, UE_ID is "IMSI mod 1024." $T_{\text{eDRX, H}}$ is an extended DRX cycle (eDRX cycle) set in the UE 100.

PW_start is an SFN indicating the first radio frame of the paging window, satisfying the following formula (4).

$$\text{SFN} = 256 * i_{\text{eDRX}} \dots (4)$$

Here, i_{eDRX} is " $\text{floor}(\text{UE_ID}/T_{\text{eDRX}, H}) \bmod 4$."

PW_end is an SFN that indicates the last radio frame of the paging window, satisfying the following formula (5).

$$\text{SFN} = (\text{PW_start} + L * 100 - 1) \bmod 1024 \dots (5)$$

However, L is a paging window length set in the UE 100.

(Presumed Scenario)

A presumed scenario according to the embodiment will be described below. In the embodiment, a scenario is presumed in which a UE 100 of a new category in which transmission/reception bandwidth is limited only to a portion of a system transmission/reception band receives a multicast/broadcast service using the MBMS. Such a scenario (use case) includes a case of performing bulk distribution of firmware to a large number of UEs 100 as an MBMS service.

The new UE category is referred to as a category M1 and an NB (Narrow Band)-IoT category. The category M1 limits the transmission/reception bandwidth of the UE 100 to 1.08 MHz (that is, the bandwidth of 6 resource blocks) and supports coverage enhancement (CE: Enhanced Coverage) technology using repeated transmissions and the like. The NB-IoT category further limits the transmission/reception bandwidth of the UE 100 to 180 kHz (that is, the bandwidth of 1 resource block) and supports coverage enhancement technology. Repeated transmission is a technology that uses a plurality of subframes to repeatedly transmit the same signal. Below, the UE 100 of the category M1 is mainly presumed, but the UE 100 of the NB-IoT category may also be presumed. Note that it is presumed that an eDRX is set for power saving in this type of UE 100.

As one example, the system bandwidth of the LTE system is 10 MHz, and the transmission/reception bandwidth thereof is 9 MHz (that is, the bandwidth of 50 resource blocks). Conversely, the UE 100 of the category M1 cannot receive normal PDCCH because it cannot receive downlink radio signals transmitted with a bandwidth wider than 6 resource blocks. Therefore, an MPDCCH (MTC-PDCCH), which is a PDCCH for MTC, is introduced. For a similar reason, an NPDCCH (NB-PDCCH), which is a PDCCH for NB-IoT, is introduced.

FIG. 9 is a diagram illustrating a downlink physical channel for the category M1. As illustrated in FIG. 9, the eNB 200 transmits the MPDCCH within 6 resource blocks. The MPDCCH includes scheduling information for allocating the PDSCH. As one example, the MPDCCH assigns a PDSCH of a subframe different from the subframe in which the MPDCCH is transmitted. The eNB 200 transmits the PDSCH within 6 resource blocks. Moreover, the eNB 200 allocates the PDSCH over a plurality of subframes in order to repeatedly transmit the same signal. The UE 100 of the category M1 specifies the allocation PDSCH by receiving the MPDCCH, and receives data transmitted by the allocation PDSCH.

Next, the MBMS will be described. There are two methods of radio transmission for MBMS, being MBSFN transmission and SC-PTM transmission. In MBSFN transmission, data is transmitted via a PMCH in MBSFN area units composed of a plurality of cells. In contrast, in SC-PTM transmission, data is transmitted in cell units via the PDSCH. Below, a scenario is mainly presumed in which the UE 100 in the category M1 or NB-IoT category performs SC-PTM reception, but MBSFN may also be presumed.

The UE 100 may receive the MBMS service in the RRC connected mode. The UE 100 may receive the MBMS service in the RRC idle mode. Below, it is mainly presumed that the UE 100 receives the MBMS service in the RRC idle mode. The RRC idle mode includes a suspend state.

In the suspend state, context information of the UE 100 is maintained in the eNB 200, and thus the RRC connection can be quickly recovered.

FIG. 10 is a diagram illustrating one example of an operation where the UE 100 according to the embodiment performs SC-PTM reception. The UE 100 is a UE 100 of the category M1 or the NB-IoT category.

As illustrated in FIG. 10, in step S1, the UE 100 acquires a USD (User Service Description) from the EPC 20 via the eNB 200. The USD provides basic information for each MBMS service. The USD includes, for each MBMS service, a TMGI for identifying the MBMS service, a frequency at which the MBMS service is provided, and a service start/end time for the MBMS service.

In step S2, the UE 100 receives the MPDCCH or the NPDCCH from the eNB 200. Each of the MPDCCH and the NPDCCH includes update notification information (Direct Indication) indicating an update of system information (SIB: System Information Block). FIG. 11 is a diagram illustrating the Direct Indication. FIG. 11 (a) illustrates a Direct Indication in the MPDCCH, and FIG. 11 (b) illustrates a Direct Indication in the NPDCCH. The UE 100 recognizes that any of the system information has been updated on the basis of the Direct Indication, and further receives an SIB type 1 (SIB1). The SIB1 includes a tag number (valueTag) indicating whether each SIB is updated. The UE 100 determines whether an SIB type 20 (SIB20), being an SIB for SC-PTM, is updated based on the tag number. Here, the description will proceed assuming that the SIB20 has been updated. Note that updates are considered rare because the SIB20 includes only the scheduling information of the SC-MCCH.

In step S3, the UE 100 receives the SIB20 from the eNB 200 via the BCCH. The SIB20 includes information (scheduling information) required for acquiring the SC-MCCH. FIG. 12 is a diagram illustrating the SIB20. As illustrated in FIG. 12, the SIB20 includes an sc-mcch-Modification Period indicating a period in which the content of the SC-MCCH may be changed, an sc-mcch-Repetition Period indicating the transmission (retransmission) time interval of the SC-MCCH by the number of radio frames, an sc-mcch-Offset indicating the offset of the radio frame where the SC-MCCH is scheduled, and an sc-mcch-Subframe indicating the subframe where the SC-MCCH is scheduled, and the like. The SC-MCCH (SCPTM Configuration) is transmitted in the sc-mcch-Repetition Period (maximum of every 2,560 ms). The UE 100 acquires the SC-MCCH for each sc-mcch-Modification Period (maximum of 655,360 ms = about 10.92 minutes). The acquisition of such an SC-MCCH may increase the power consumption of the UE 100.

In step S4, the UE 100 receives SIB20 setting information (SCPTM Configuration) from the eNB 200 via the SC-MCCH based on the SCPTM. In the physical layer, SC-RNTI (Single Cell RNTI) is used for SC-MCCH transmission. FIG. 13 is a diagram illustrating SCPTM setting information (SCPTM Configuration) in the SC-MCCH. As illustrated in FIG. 13, the SCPTM configuration information includes control information applicable to the MBMS service sent via the SC-MRB (Single Cell MBMS Point to Multipoint Radio Bearer). The SCPTM setting information includes a sc-mtch-InfoList including the setting of each SC-MTCH in a cell transmitting the information, and a scptmNeighbourCellList, being a list of adjacent cells providing the MBMS service via the SC-MRB. The sc-mtch-InfoList includes one or more SC-MTCH-Info. Each SC-MTCH-Info includes information of an ongoing MBMS session (mbmsSessionInfo) transmitted via the SC-MRB, a G-RNTI (Group RNTI) corresponding to the MBMS session, and a sc-mtch-schedulingInfo, being DRX information for the SC-MTCH. The mbmsSessionInfo includes a TMGI and a session ID (sessionId) for identifying the MBMS service. The G-RNTI is a RNTI that identifies a multicast group (specifically, a SC-MTCH to a specific

group). The G-RNTI is mapped one-to-one with the TMGI. The sc-mtch-schedulingInfo includes a onDurationTimerSCPTM, a drx-InactivityTimerSCPTM, and a schedulingPeriodStartOffsetSCPTM. The schedulingPeriodStartOffsetSCPTM includes SC-MTCH-SchedulingCycle and SC-MTCH-SchedulingOffset. Here, DRX for SC-PTM transmission will be described. The DRX for SC-PTM transmission is an operation independent of the DRX described above. A UE 100 in which a DRX for SC-PTM transmission is set intermittently monitors a PDCCH by using a corresponding G-RNTI in the RRC connected mode or the RRC idle mode. When onDurationTimerSCPTM or drx-InactivityTimerSCPTM is running (running), an active time is entered. The UE 100 monitors the PDCCH in the active time. When " $[(SFN \times 10) + \text{subframe number}] \bmod (\text{SC-MTCH-Scheduling Cycle}) = \text{SC-MTCH-SchedulingOffset}$ " is satisfied, the UE 100 starts the onDurationTimerSCPTM. When the PDCCH indicates DL transmission, the UE 100 starts the drx-InactivityTimerSCPTM.

In step S5, the UE 100 receives the SCPTM service (data) corresponding to the SC-MTCH-SchedulingInfo that the SC-MTCH is interested in via the TMGI based on the MBMS in the setting information (SCPTM Configuration). In the physical layer, the eNB 200 transmits the PDCCH by using the G-RNTI, and then transmits the data via the PDSCH. The UE 100 tries data reception every 8192 ms at most. This data reception may increase the power consumption of the UE 100. (Operation Patterns)

An operation pattern according to the embodiment will be described below. As a prerequisite, the UE 100 is provided with: a transceiver (the reception unit 110 and the control unit 130) configured to transmit and receive radio signals within a limit bandwidth narrower than a system transmission/reception bandwidth; and a control unit 130 that uses the transceiver to perform radio communication with the eNB 200. The limit bandwidth is, for example, 1.08 MHz when the UE 100 belongs to the M1 category (that is, the bandwidth of 6 resource blocks), and 180 kHz when UE 100 belongs to the NB-IoT category (that is, the bandwidth of 1 resource block). The control unit 130 performs a process of receiving from the eNB 200, within a limit bandwidth, information necessary for receiving a multicast/broadcast service (MBMS service) provided via the eNB 200.

(1) Operation Pattern 1

As described above, when the UE 100 of the category M1 or the NB-IoT category performs SC-PTM reception, the power consumption of the UE 100 is increased. In particular, when assuming a case where the eDRX is set to UE 100, there is a concern that sufficient power consumption reduction effects will not be obtained due to wake-up related to SC-PTM reception. Therefore, it is desirable to enable SC-PTM reception while suppressing an increase in the power consumption of the UE 100.

In an operation pattern 1, the UE 100 is provided with a predetermined storage medium for storing a preset service identifier (TMGI). As one example, the predetermined storage medium is a UICC (Universal Integrated Circuit Card). The preset service identifier is a service identifier dedicated to a specific MBMS service. The specific MBMS service may be a firmware distribution service.

Thus, the UE 100 can confirm that a specific MBMS service is provided from the eNB 200 by simply looking at the SC-MCCH provided from the eNB 200 (serving cell) without acquiring the USD in unicast. Therefore, the UE 100 in the RRC idle mode does not need to transition to the RRC connected mode only for acquiring USD. Furthermore, the UE 100 may receive the SC-MCCH when waking up the eDRX (when confirming paging).

(2) Operation Pattern 2

As described above, the UE 100 cannot recognize the update of the MPDCCH unless it receives and confirms the tag number (valueTag) in the SIB 1 after receiving the update notification information (Direct Indication) in the SIB 20 or the NPDCCH. The process of receiving and confirming such a tag number increases the power consumption of the UE 100.

In an operation pattern 2, the UE 100 receives update notification information (Direct Indication) from the eNB 200 on a predetermined physical downlink control channel (MPDCCH or NPDCCH) having a bandwidth not greater than a limit bandwidth. The update notification information includes at least one of a first update notification indicating an update of a system information block (SIB 20) for SC-PTM, a second update notification indicating an update of a multicast control channel (SC-MCCH) for SC-PTM, and a third update notification indicating an update related to a specific MBMS service indicated in a multicast control channel (SC-MCCH) for SC-PTM. Each of the first to third update notices may be defined as a 1-bit flag. The update notification information (Direct Indication) may use an existing format or define a new format (a new PDCCH format).

The first update notification is an update notification by the SIB 20 alone. The UE 100 can recognize the update of the MPDCCH even when the SIB1 is not received in response to the update notification information (Direct Indication) in the NPDCCH or the SIB20 including the first update notification.

The second update notification is an update notification of the SC-MCCH (that is, SCPTM Configuration). The eNB 200 may transmit a second update notification to the UE 100 by the MPDCCH or the NPDCCH scrambled by the SC-N-RNTI. The UE 100 can recognize the update of the MPDCCH in response to the update notification information (Direct Indication) in the SC-MCCH or the NPDCCH including the second update notification.

The third update notification is an update notification related to a specific sc-mtch-InfoList among the SC-MTCH-Info in the SC-MCCH. The specific SC-MTCH-Info is associated with a specific MBMS service (for example, firmware distribution service). Specifically, the specific SC-MTCH-Info includes a TMGI (service identifier) for identifying the specific MBMS service. The UE 100 can recognize the update of the specific MPDCCH in response to the update notification information (Direct Indication) in the SC-MTCH-Info or the NPDCCH including the third update notification, even when the SC-MCCH is not received. When the update of each of the plurality of MBMS services can be notified, two bits or more in the update notification information (Direct Indication) may be assigned to the third update notification. The position of each bit is associated with an MBMS service (specifically, SC-MTCH-Info). The correspondence between the bit position and the MBMS service may be set from the eNB 200 to the UE 100 by the SIB or the like. In this case, the UE 100 confirms which sc-mtch-InfoList among the SC-MTCH-Info in the SC-MCCH has been updated on the basis of the bit position of the third update notification in the update notification information (Direct Indication).

When the second and third update notifications are not provided, the UE 100 may receive the PDCCH each time it receives the SC-MCCH scrambled at SC-MCCH modification boundary or SC-N-RNTI, and confirm whether there is an update of the setting (SC-MTCH-Info) relating to the TMGI of interest.

(3) Operation Pattern 3

An operation pattern 3 is an operation pattern that enables direct notification of the distribution start of a specific MBMS service to the UE 100.

In the operation pattern 3, the UE 100 receives a paging message from the eNB 200 on a PDSCH having a bandwidth equal to or less than the limit bandwidth. The paging message includes

a service identifier (TMGI) of a specific MBMS service. The paging message may include a list comprising a plurality of service identifiers (TMGIs). Thus, the UE 100 recognizes that the distribution of the specific MBMS service is started and can start a process for receiving the specific MBMS service. Therefore, the wake-up of the UE 100 can be kept to a necessary minimum. It should be noted that a general paging message does not include a service identifier (TMGI) but includes an identifier (such as IMSI) of the UE 100 being called.

The eNB 200 designates a PDSCH (narrow band PDSCH) carrying a paging message by the MPDCCH or the NPDCCH scrambled by the P-RNTI. Then, the eNB 200 transmits the paging message on the designated PDSCH. The UE 100 receives the MPDCCH or the NPDCCH scrambled by the P-RNTI to recognize the PDSCH (narrow band PDSCH) carrying the paging message. Then, the UE 100 receives the paging message on the recognized PDSCH. The UE 100 may confirm whether the preset service identifier (TMGI) described in the operation pattern 1 is indicated in the paging message.

The UE 100 may establish an RRC connection with the eNB 200 when desiring reception of an MBMS indicated by the service identifier (TMGI) included in the paging message. In this case, the UE 100 may transmit a RRC Connection Request message to the eNB 200, or may transmit a RRC Resume Request message to the eNB 200 in the case of a suspended state. Alternatively, the UE 100 may acquire the SIB20 and/or the SC-MCCH instead of establishing the RRC connection, and then attempt to receive when the SC-PTM has been transmitted.

(4) Operation Pattern 4

In an operation pattern 4, the UE 100 receives from the eNB 200 time information indicating at least one of the time when the provision of the specific MBMS service is started and the time when the provision is terminated. The time information is transmitted from the eNB 200 by a system information block (SIB20) for SC-PTM or a multicast control channel (SC-MCCH) for SC-PTM. The SIB20 or SC-MCCH (SCPTM Configuration) may include a list comprising a plurality of service identifiers (TMGI) and time information for each of the plurality of service identifiers (TMGI). Thus, the start time or the like can be notified to the TMGI for each UE 100. Therefore, the UE 100 can maintain a sleep state until provision of the MBMS service (for example, the MBMS service indicated by the preset service identifier) in which the user is interested is started.

The time information may be a combination of a provision start time and a provision end time. Alternatively, the time information may be a combination of a start time and a duration (for example, one minute). The provision start time (and offer end time) may be expressed by H-SFN or by UTC (Coordinated Universal Time).

When expressed by H-SFN, the UE 100 recognizes that the H-SFN indicating the offer start time is the H-SFN after a wrap-around ($\#1023 \rightarrow \#0$). FIG. 14 is a diagram illustrating a provisioning start time expressed by the H-SFN. FIG. 14(a) illustrates a case where the UE 100 indicates that the provision start time is H-SFN = 200 in the SC-MCCH at a point in time of H-SFN = 150. In this case, the UE 100 recognizes that the MBMS service is started to be provided at H-SFN = 200 after the wrap-around ($\#1023 \rightarrow \#0$). FIG. 14(b) illustrates a case where the UE 100 indicates that the provision start time is H-SFN = 200 in the SC-MCCH at a point in time of H-SFN = 300. In this case, the UE 100 recognizes that the MBMS service is started to be provided at H-SFN = 200 after the wrap-around ($\#1023 \rightarrow \#0$). By establishing such a rule, it is possible to prevent deviation from occurring in the interpretation of the service start time between the UE 100 and the network. Such a rule can be, for example, a rule such that "the UE 100 must understand this as the offer start timing of the designated H-SFN after the H-SFN wraps around (reaches the

upper limit)." In a similar thought process, instead of the upper limit of H-SFN, the modification boundary of the SC-MCCH or the SIB may be used to start provision in the H-SFN corresponding to the timing after the next boundary of the modification boundary of SC-MCCH or SIB.

Conversely, when expressed in UTC, there is also a case where the UE 100 does not have GPS or the like and the current UTC cannot be confirmed. However, when the current UTC is provided with SIB type 16 (SIB16), UTC can be confirmed even when the UE 100 cannot use GPS or the like. Therefore, the eNB 200 may provide the UE 100 with the provisioning start time expressed by UTC only when it itself is transmitting the SIB16.

(5) Operation Pattern 5

As described above, repeated transmission can be applied to MPDCCH (or NPDCCH) and PDSCH (narrowband PDSCH) for the purpose of coverage enhancement (CE). When repeated transmission is applied, it is desirable that the UE 100 knows the maximum repeated transmission count and the actual repeated transmission count.

In the operation pattern 5, the UE 100 receives, from the eNB 200, repetition count information indicating at least one of the repeated transmission count of a predetermined physical downlink control channel (MPDCCH or NPDCCH) having a bandwidth no greater than a limit bandwidth and the repeated transmission count of a physical downlink shared channel (narrowband PDSCH) having a bandwidth no greater than the limit bandwidth. The repetition count information indicates at least one of the maximum repeated transmission count and the actual repeated transmission count. The repetition count information is transmitted from the eNB 200 by a system information block (SIB20) for SC-PTM or a multicast control channel (SC-MCCH) for SC-PTM.

FIG. 15 is a diagram illustrating repetition count information. FIG. 15(a) illustrates a case where the repetition count information (#of repetition) is provided in the SIB20. As illustrated in FIG. 15(a), the eNB 200 provides, within the SIB20, repetition count information of the MPDCCH (or the NPDCCH) corresponding to the SC-MCCH and repetition count information of the narrow band PDSCH corresponding to the SC-MCCH. Even when repeated transmission is applied to the SC-MCCH, the UE 100 can appropriately receive the SIB20 on the basis of the repetition count information in the SC-MCCH. FIG. 15(b) illustrates a case where the repetition count information (#of repetition) is provided in the SC-MCCH. As illustrated in FIG. 15(b), the eNB 200 provides, within the SC-MCCH, repetition count information of the MPDCCH (or the NPDCCH) corresponding to the SC-MTCH and repetition count information of the narrow band PDSCH corresponding to the SC-MTCH. Here, an example is illustrated where the repeated transmission count information is provided for each MBMS service (for each TMGI). The UE 100 can appropriately receive the SC-MTCH based on the repetition count information in the SIB20.

(6) Operation Pattern 6

The UE 100 may move from one cell to another cell during SC-PTM reception. In such a case, it is preferable to enable the SC-PTM reception to be continued.

In an operation pattern 6, the UE 100 receives a group RNTI (G-RNTI) associated with an MBMS service provided by an adjacent cell adjacent to a serving cell managed by the eNB 200 from the eNB 200 via the serving cell. That is, the UE 100 receives the G-RNTI used by the adjacent cell from the serving cell. The G-RNTI is transmitted from the eNB 200 (serving cell) by the system information block (SIB20) for SC-PTM or a multicast control channel (SC-MCCH) for SC-PTM.

The eNB 200 (serving cell) may provide SC-MTCH scheduling information (sc-mtch-schedulingInfo) of an adjacent cell to the G-RNTI in addition to the UE 100. Alternatively, the

eNB 200 (serving cell) may provide all of the SC-MCCH information (SCPTM Configuration) of the adjacent cell to the UE 100. Thus, even when the UE 100 moves from the serving cell to the adjacent cell, the SC-MTCH of the adjacent cell can be quickly received. Note that the eNB 200 (serving cell) may provide at least a portion of the SIB20 of the adjacent cell to the UE 100.

(7) Operation Pattern 7

The UE 100 may not always succeed in receiving the MBMS service (data) sent over the SC-MTCH. Assuming a firmware distribution service, even a portion of data (firmware) being missing is a problem.

In an operation pattern 7, the UE 100 establishes an RRC connection in response to failure in reception of the eNB 200 service in a state (that is, RRC idle mode) without RRC connection with the MBMS, and transmits information about the MBMS service which has failed in reception to the eNB 200. Thus, the eNB 200 can be urged to perform unicast retransmission of the MBMS service.

In the operation pattern 7, the eNB 200 buffers the MBMS service (data) transmitted on the SC-MTCH for a fixed time. The eNB 200 may set a timer value related to the time for buffering the data to the UE 100 by the SIB or the like. The timer value defines the allowable time from when the UE 100 fails to receive the SC-MTCH until the RRC connection is established (for example, an RRC Connection Request message is transmitted). When the reception fails, the UE 100 must start a timer that has set the timer value and send a RRC Connection Request message (or a RRC Connection Resume message) before the timer expires. The eNB 200 starts the timer for each SC-MTCH transmission or buffering and abandons the buffering data when the timer expires.

The UE 100 that failed to receive the MBMS service may notify the eNB 200 of at least one of the following information after transitioning to the RRC connected mode.

- The fact that the SC-PTM reception failed
- The TMGI for which reception failed
- The leading packet number for which reception failed (such as a PDCP sequence number)
- The HARQ process ID for which reception failed

Here, by notifying the packet number and/or the HARQ process ID, the eNB 200 does not resend the entire MBMS service (data) by unicast, but can resend only the data after the point in time when the UE 100 failed in receiving by unicast. Thus, the UE 100 can utilize the data normally received by the multicast.

The eNB 200 may notify the UE 100 of at least one of the following information when performing unicast retransmission.

- The ID of the retransmission bearer
- The PDCP sequence number of the retransmission start packet
- The HARQ process ID

Note that an example has been described where the UE 100 transmits the MBMS message in response to a failure in receiving the RRC Connection Request service, but the SC-MTCH is not limited to this, and feedback information indicating a failure in receiving the RFID service may also be transmitted. The feedback information may be a retransmission control signal (ACK or NACK) or the like.

(Other Embodiments)

The present invention is not limited to a case where each operation pattern described above is implemented separately and independently, but may be implemented by combining two or more operation patterns. For example, a partial process relating to one operation pattern may be added

to another operation pattern. Alternatively, a partial process related to one operation pattern may be replaced with a partial configuration of another operation pattern.

In the embodiment described above, firmware distribution is presumed as the MBMS service. However, MBMS services such as group message distribution, group chat message distribution, virus definition file distribution, periodic update file distribution such as weather forecasts, irregular file distribution such as news flash reports, night file distribution (off-peak distribution) such as video content, audio/video streaming distribution, telephone/video telephone (group communication), live video distribution, radio audio distribution, and the like may be presumed.

In the embodiment described above, an LTE system is given as an illustration of the mobile communication system. However, the present invention is not limited to an LTE system. The present invention may be applied to a mobile communication system other than an LTE system.

(Notes)

1. Introduction

In RAN#72, the new WI on Further Enhanced MTC was approved and one of main objectives is to extend SC-PTM functionalities from RAN2 point of view [1];

Multicast [RAN2 lead, RAN1]

- Extend Rel-13 SC-PTM to support multicast downlink transmission (e.g. firmware or software updates, group message delivery)
- Introduction of necessary enhancements to support narrowband operation, e.g. support of MPDCCH, and coverage enhancement, e.g. repetitions

In this contribution, the general issues to enhance the existing multicast mechanism for FeMTC UEs are discussed.

2. Discussion

2.1. Rel-13 SC-PTM

The SC-PTM was specified on top of the eMBMS architecture to support DL multicast transmission in a single cell using PDSCH, unlike MBSFN with PMCH [2]. The PDSCH-based multicast mechanism allows dynamic scheduling by PDCCH scrambled with SC-RNTI or G-RNTI, which also well matches with the objective of this WI, i.e., “for machine-type communications for BL/CE (eMTC) UEs”, although MPDCCH has not supported SC-RNTI, SC-N-RNTI and G-RNTI in Rel-13 [3].

Observation 1 Rel-13 SC-PTM potentially supports 6 PRBs operation, although MPDCCH needs the RNTIs for SC-PTM transmission.

Before the UE receives DL multicast data, it needs to acquire SIB20 to know the occasions of SC-MCCH transmission, wherein SC-MCCH conveys the detailed information for SC-PTM reception, i.e., SC-MTCH-InfoList, such as TMGI, corresponding G-RNTI, SC-PTM scheduling information and so on [4].

The current upper bound of SC-MCCH modification period is about 10.92 minutes, i.e., rf65536. So, the UE interested in SC-PTM needs to check whether the contents of SC-MCCH has changed at least once every 10.92 minutes even if it has already received the current SC-MCCH, i.e., to try receiving the SC-MCCH change notification (PDCCH scrambled with SC-N-RNTI). On the other hand, Rel-13 eDRX extends the idle mode DRX cycle up to 43.69 minutes [2]. While it could be assumed that FeMTC UEs are configured with the eDRX cycle, if the UE is interested in SC-PTM reception then it may not take the full benefit of eDRX

from the power saving point of view.

The UE monitors the SC-RNTI in the PDCCH to obtain the SC-MCCH transmission in the DL-SCH. The SC-MCCH provides the list of all MBMS services with on-going sessions transmitted on SC-MTCH(s), including for each MBMS service TMGI and optional session ID, associated G-RNTI and scheduling information. When the TMGI of interest is available in SC-MCCH, the UE monitors PDCCH scrambled with G-RNTI, i.e., SC-PTM, in the subframe occasions. The current scheduling period of SC-PTM is defined up to 8,192 ms, i.e., sf8192 [4], so the UE needs to decode PDCCH once every 8 seconds, which is much shorter period compared to the eDRX cycle.

Observation 2 The IDLE UE interested in SC-PTM reception may need to decode PDCCH scrambled with SC-N-RNTI and/or G-RNTI in shorter period than its configured eDRX cycle.

In order to avoid the additional power consumption of FeMTC UEs, it should be discussed that the SC-MCCH change notification mechanism and/or SC-PTM scheduling period needs to be extended, e.g., to align with eDRX mechanisms using H-SFN [2].

Proposal 1 RAN2 should discuss whether the SC-MCCH change notification and SC-PTM scheduling period are extended, in order to minimize the UE power consumption.

2.2. Rel-14 multicast requirements

2.2.1. Support of Firmware update use case

The WID identifies the motivation of DL multicast for FeMTC UEs, “e.g. firmware or software updates, group message delivery” [1]. It would require more reliable communication compared to the group communication and video streaming that were assumed as main applications in the legacy eMBMS, i.e., the firmware makes no sense even if only one packet is missed.

Regarding the unicast transmissions, HARQ and ARQ functionalities ensured the reliable packet transfer which could match the required QoS of e.g., firmware update case. However, considering the massive number of connections expected for IoT devices in the near future, it could no longer make sense that the reliable communication only relies on the unicast (and possibly on a robust network deployment).

On the other hand, the multicast transmissions could provide a data transfer to multiple UEs simultaneously, which is beneficial to serve massive number of devices in a cell. However, the existing multicast scheme is not robust enough for some cases since there is no protocol support for the packet failed to decode.

Observation 3 The unicast transmission could ensure the reliable data transfer for e.g., firmware, while the multicast transmission could serve more number of UEs, massive MTC devices.

There are three approaches for the enhancements, a) a combination of unicast and multicast, b) enhancements to unicast and c) enhancements to multicast, whereby only a) and c) are in-line with the scope of WI [1].

Regarding a), it could be considered that the UE, which fails the integrity check of a file downloaded via multicast, would be expected to reacquire the file via unicast by e.g., an upper layer-initiated retransmission request. While it's simple mechanism from the AS specification point of view, there could be some drawbacks from the perspective of UE power consumption. For example, the UE may need to reacquire whole the file even if a part of packets is not successfully decoded, wherein it's not efficient especially if the file is not small size, e.g., firmware/software. Additionally, if the UE was in IDLE, i.e., idle mode reception of multicast, then it needs to establish RRC connection for the unicast transfer, wherein it takes additional signalling for connection establishment/resumption.

Regarding c), it may be one of the approaches to introduce the retransmission scheme in AS specifications for multicast. It needs the standardization efforts for e.g., UL feedback and/or retransmission mechanisms, while it would improve the efficiency of FeMTC UEs to download the firmware completely. Considering that low power consumption is key performance of MTC devices, the retransmission scheme should be considered for DL multicast.

Proposal 2 RAN2 should discuss whether the retransmission scheme, including UL feedback, should be introduced in SC-PTM for FeMTC UEs.

2.2.2. Support of Enhanced Coverage

Currently, pre-Rel-14 UEs in Connected and IDLE are able to receive MBMS services [2]. Since Rel-14 UEs are assumed to be in Enhanced Coverage, the principle of current multicast mechanism should be applied.

Proposal 3 Rel-14 UEs in Connected and IDLE should also be able to receive

SC-PTM in Enhanced Coverage.

The repetition of signals was a key component to support Coverage Enhancements in Rel-13, in addition to the bandwidth reduced access technology [1]. The repetition technique could be considered to be reused for Rel-14 multicast to UEs in Enhanced Coverage. From RAN2 point of view, at least BCCH (SIB20) and DL-SCH (SC-MCCH and SC-PTM) should be considered and the (maximum) number of repetitions for these channels are already provided by RRC, i.e., `pdsch-maxNumRepetitionCEmodeA`, `pdsch-maxNumRepetitionCEmodeB` and `mpdcch-NumRepetition` [4] and MPDCCH provides actual number of PDSCH repetition [3], while `mpdcch-NumRepetition` for SC-MCCH/SC-PTM transmissions may need to be provided in SIB for IDLE UEs if MPDCCH is used to assign the corresponding PDSCHs. In addition, the repetition of SC-MCCH is already provided in SIB20, i.e., `sc-mcch-RepetitionPeriod-r13`, in order to limit the access latency [4]. It may be also reused to support Enhanced Coverage. If RAN2 agrees these changes are needed, RAN1 should also be informed about RAN2's views.

Observation 4 The repetition technique should be reused for multicasting in Enhanced Coverage.

Proposal 4 If RAN2 agrees with Observation 4, an LS should be send to RAN1 to inform them of desired changes.

According to the current idle mode procedure [5], the UE receiving or interested in an MBMS service may prioritize the frequency providing SC-PTM over the other frequencies, i.e., to consider the highest priority. On the other hand, it's also specified that "Ranking with cell selection criterion S for enhanced coverage is applied for intra-frequency and inter-frequency cell reselection when the current serving cell can only be accessed using enhanced coverage", wherein it seems to handle all the frequencies as equal priority if the UE is in Enhanced Coverage. Since the SC-PTM reception in Enhanced Coverage was not clearly assumed in Rel-13, it would be confirmed that the current specification allows the UE in Enhanced Coverage to prioritize SC-PTM frequency as it is done in normal coverage. Also, RAN2 should discuss whether some small enhancements are necessary, e.g., to add notes in the specification.

Proposal 5 RAN2 should discuss and clarify whether the UE in Enhanced

Coverage is allowed to prioritize the frequency providing multicast service of interest.

2.2.3. Other optimizations

2.2.3.1. Service continuity

In the current specification [4], SC-MCCH provides the neighbour cell information in SCPTM-NeighbourCellList, i.e., physical cell ID and frequency. If the UE is interested in a TMGI of which the serving cell does not provide SC-PTM, the UE needs to decode the neighbour cells' SC-MCCHs to seek the TMGI of interest. It would consume the UE's battery for additional decoding over inter-frequency measurements, which will have more impact on UE's mobility that is somewhat enhanced in this WI [1]. So, it should be discussed whether some additional information needs to be broadcasted in order to facilitate FeMTC UEs mobility with low power consumption.

Proposal 6 RAN2 should discuss whether additional information is broadcasted in e.g., SC-MCCH, to assist the UE mobility with lower power consumption.

2.2.3.2. One-shot multicasting

As discussed in section 2.2.1, the use case of firmware/software update is the multicast-type service rather than the broadcast service. It could be also assumed that the firmware is a (set of) file(s), so it would be not efficient that the same firmware is multicasted many times. In the current MBMS service, it's assumed that "the application/service layer provides for each service the TMGI, the session start and end time, the frequencies and the MBMS service area identities" in the USD [2]. It may allow performing a one-shot multicasting, i.e., the one firmware is multicasted only once, by setting appropriate start/end time in the USD. However, the USD should be obtained via unicast; therefore, the associated UEs needs to establish RRC Connection at least once when the firmware is delivered, which is not efficient from the perspectives of NW capacity and UE power consumption. So, it may need some sort of RAN-level optimizations, e.g., RAN-level information like the start/stop time, TMGI-based paging and so on, which may interact with/complement the USD.

Proposal 7 RAN2 should discuss whether RAN-level optimization to

facilitate the one-shot multicast delivery is necessary.

3. Conclusion

In this contribution, the potential issues of Rel-13 SC-PTM are discussed. Also, some enhancements to support FeMTC requirements and optimizations are considered. RAN2 is kindly asked to take into account the observations/proposals below:

Observation 1 Rel-13 SC-PTM potentially supports 6 PRBs operation, although MPDCCH needs the RNTIs for SC-PTM transmission.

Observation 2 The IDLE UE interested in SC-PTM reception may need to decode PDCCH scrambled with SC-N-RNTI and/or G-RNTI in shorter period than its configured eDRX cycle.

Proposal 1 RAN2 should discuss whether the SC-MCCH change notification and SC-PTM scheduling period are extended, in order to minimize the UE power consumption.

Observation 3 The unicast transmission could ensure the reliable data transfer for e.g., firmware, while the multicast transmission could serves more number of UEs, massive MTC devices.

Proposal 2 RAN2 should discuss whether the retransmission scheme, including UL feedback, should be introduced in SC-PTM for FeMTC UEs.

Proposal 3 Rel-14 UEs in Connected and IDLE should also be able to receive SC-PTM in Enhanced Coverage.

Observation 4 The repetition technique should be reused for multicasting in Enhanced Coverage.

Proposal 4 If RAN2 agrees with Observation 4, an LS should be send to RAN1 to inform them of desired changes.

Proposal 5 RAN2 should discuss and clarify whether the UE in Enhanced Coverage is allowed to prioritize the frequency providing multicast service of interest.

Proposal 6 RAN2 should discuss whether additional information is broadcasted in e.g., SC-MCCH, to assist the UE mobility with lower power consumption.

Proposal 7 RAN2 should discuss whether RAN-level optimization to facilitate the one-shot multicast delivery is necessary.

4. References

- [1] RP-161321, "New WI proposal on Further Enhanced MTC", Ericsson, RAN#72
- [2] TS 36.300, "Overall description; Stage 2 (Release 13)", 3GPP
- [3] TS 36.213, "Physical layer procedures (Release 13)", 3GPP
- [4] TS 36.331, "Radio Resource Control (RRC); Protocol specification (Release 13)", 3GPP
- [5] TS 36.304, "User Equipment (UE) procedures in idle mode (Release 13)", 3GPP

[Document Name] Scope of Claims

[Claim 1]

A radio terminal for a mobile communication system, comprising:
a transmitter/receiver configured to transmit/receive radio signals within a limit bandwidth narrower than a system transmission/reception bandwidth; and
a control unit that uses the transmitter/receiver to perform radio communication with a base station, wherein
the control unit performs a process of receiving, from the base station within the limit bandwidth, information necessary to receive an MBMS service provided via the base station.

[Claim 2]

The radio terminal according to claim 1, wherein
the radio terminal is provided with a predetermined storage medium that stores a preset service identifier, and
the preset service identifier is a dedicated service identifier for a specific MBMS service.

[Claim 3]

The radio terminal according to claim 1, wherein
the control unit performs a process for receiving update notification information from the base station on a predetermined physical downlink control channel having a bandwidth no greater than the limit bandwidth, and
the update notification information includes at least one of
a first update notification indicating an update of a system information block for SC-PTM,
a second update notification indicating an update of a multicast control channel for SC-PTM, and
a third update notification indicating an update of a specific MBMS service indicated in the multicast control channel.

[Claim 4]

The radio terminal according to claim 1, wherein
the control unit performs a process of receiving a paging message from the base station on a physical downlink shared channel having a bandwidth no greater than the limit bandwidth, and
the paging message includes a service identifier of a specific MBMS service.

[Claim 5]

The radio terminal according to claim 1, wherein
the control unit performs a process of receiving from the base station time information indicating at least one of a time when provision of a specific MBMS service is started and a time when the provision is ended, and
the time information is transmitted from the base station via a system information block for SC-PTM or a multicast control channel for SC-PTM.

[Claim 6]

The radio terminal according to claim 1, wherein
the control unit performs a process of receiving from the base station repetition count information indicating at least one of a repetition count of a predetermined physical downlink control channel having a bandwidth no greater than the limit bandwidth and a repetition count of a physical downlink shared channel having a bandwidth no greater than the limit bandwidth, and
the repetition count information is transmitted from the base station by a system information block for SC-PTM or a multicast control channel for SC-PTM.

[Claim 7]

The radio terminal according to claim 1, wherein
the control unit performs a process of receiving, from the base station via the serving cell,
a group RNTI associated with an MBMS service provided by an adjacent cell that is adjacent to a
serving cell managed by the base station, and

the group RNTI is transmitted from the base station by a system information block for SC-
PTM or a multicast control channel for SC-PTM.

[Claim 8]

The radio terminal according to claim 1, wherein,
in a state where the radio terminal does not have an RRC connection with the base station,
the control unit establishes the RRC connection in response to a failure in receiving the MBMS
service, and performs a process of transmitting to the base station information relating to the
MBMS service having failed in the reception.

[Claim 9]

A base station for a mobile communication system, comprising
a control unit for transmitting, within a limit bandwidth, information required for receiving
an MBMS service provided via the base station to a radio terminal configured to transmit/receive
a radio signal within the limit bandwidth narrower than the system transmission/reception
bandwidth.

[Document Name] Abstract

A radio terminal according to a first feature is a radio terminal for a mobile communication system. The radio terminal is provided with: a transceiver configured to transmit and receive radio signals within a limit bandwidth narrower than a system transmission/reception band; and a control unit that uses the transceiver to perform radio communication with a base station. The control unit performs a process for receiving from the base station information required for receiving an MBMS service provided via the base station within the limit bandwidth.

1/13

FIG. 1

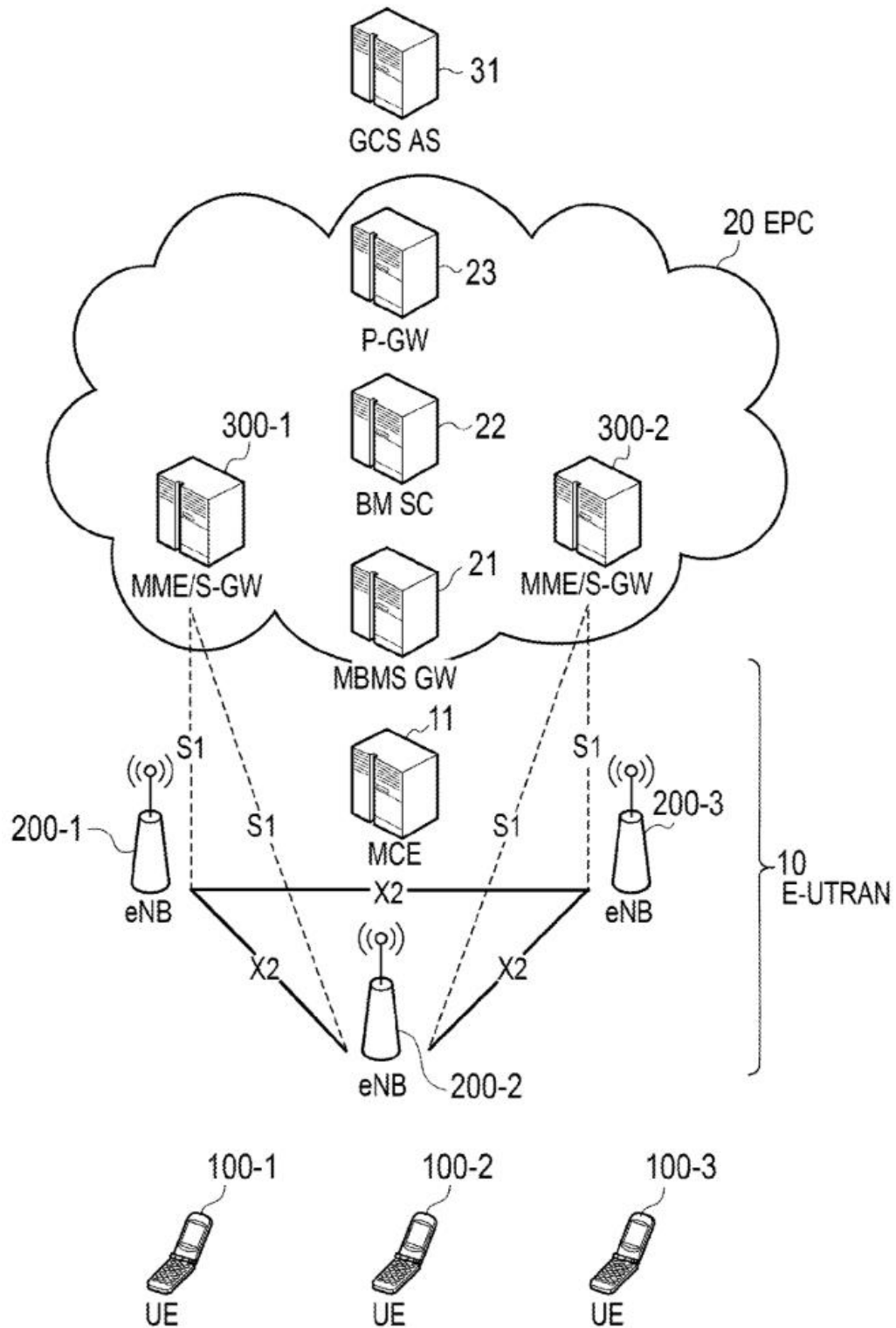


FIG. 2

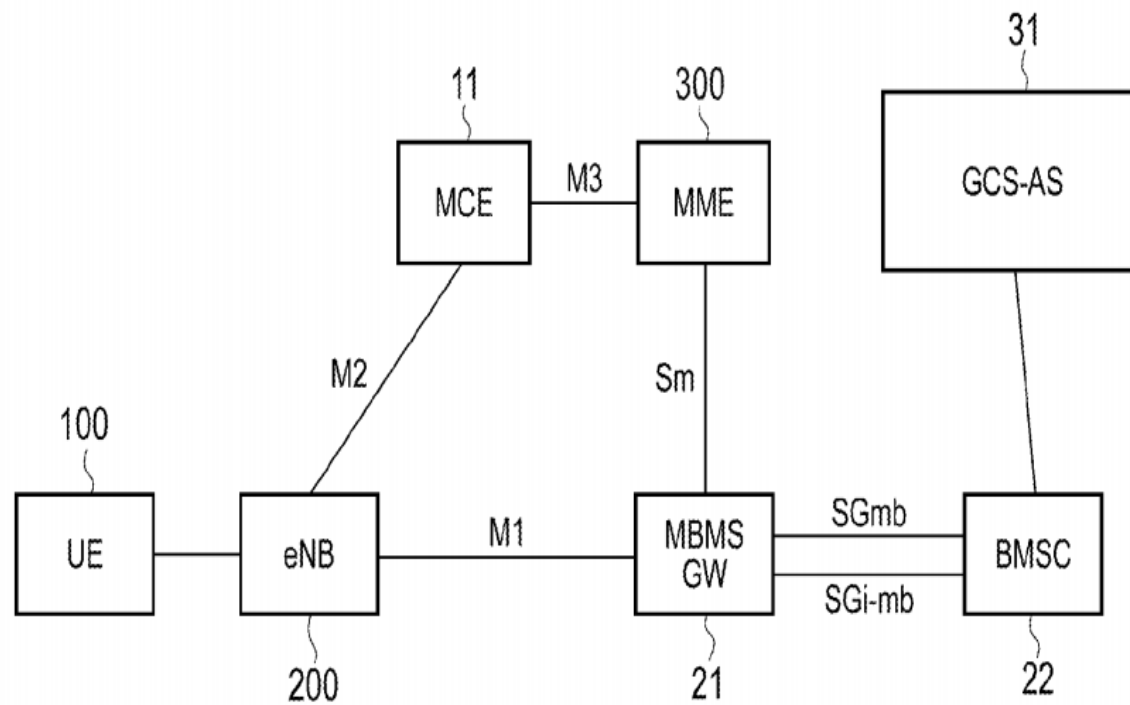


FIG. 3

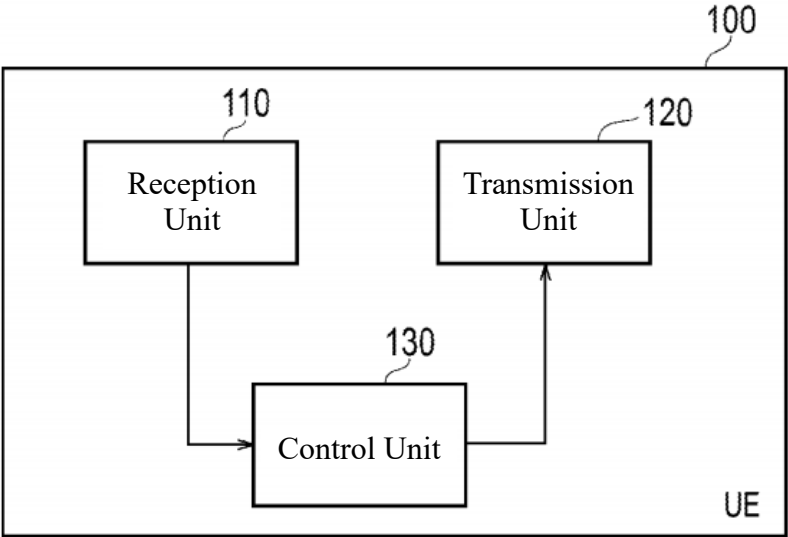


FIG. 4

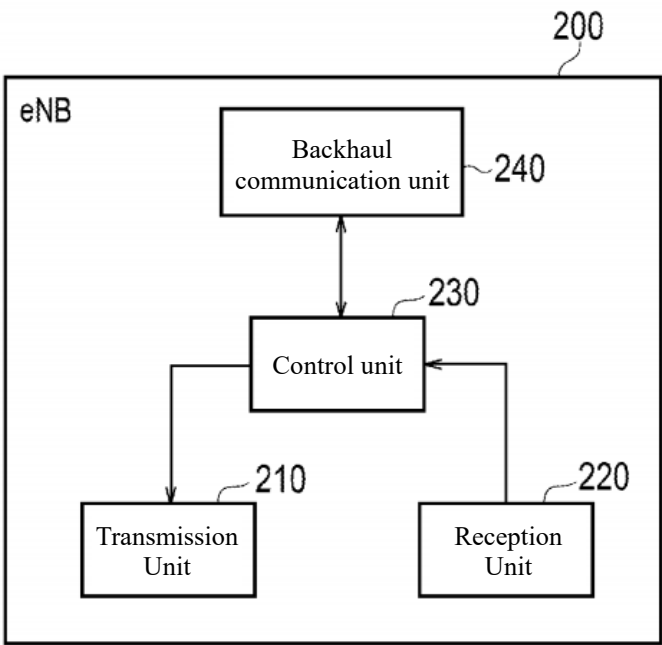


FIG. 5

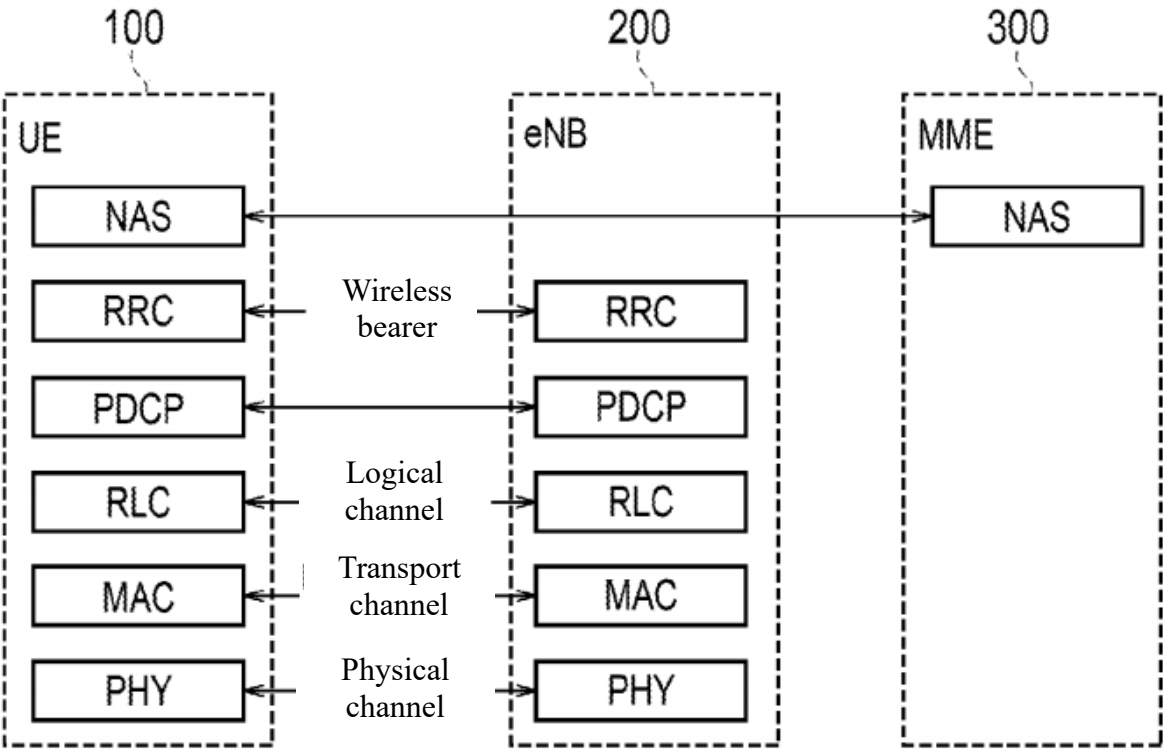


FIG. 6A

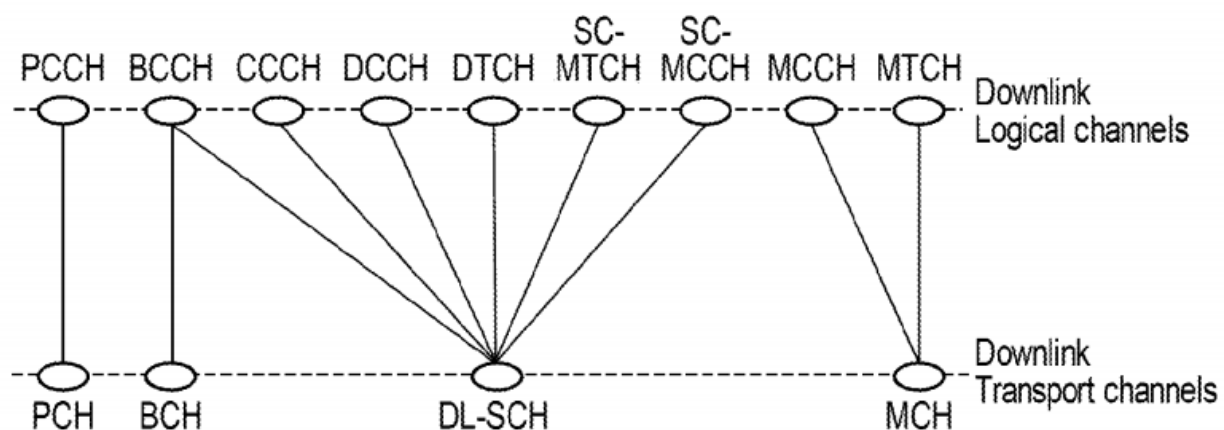


FIG. 6B

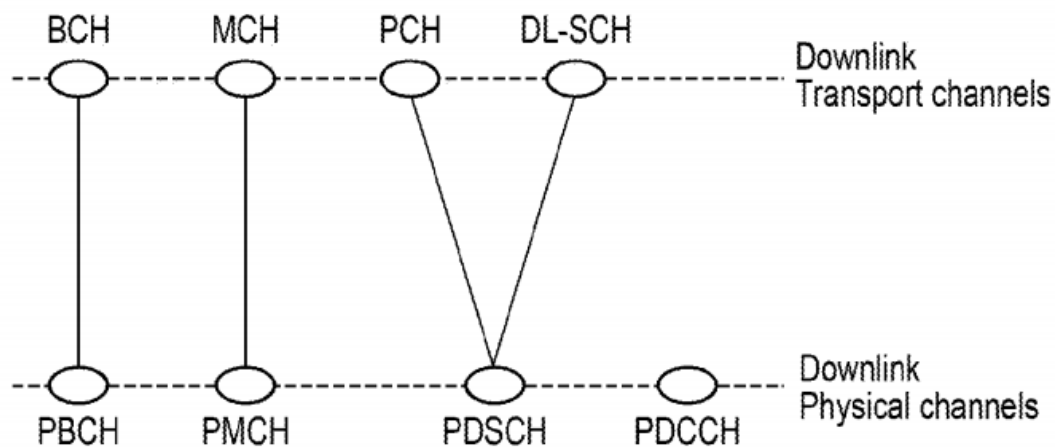


FIG. 7

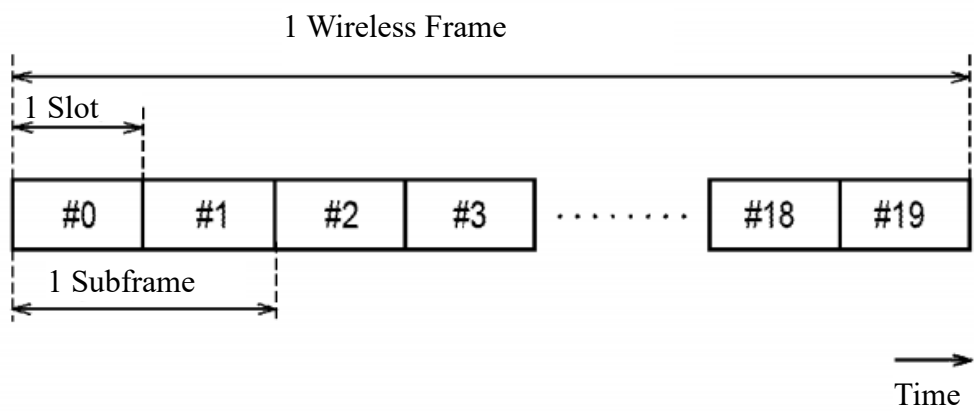
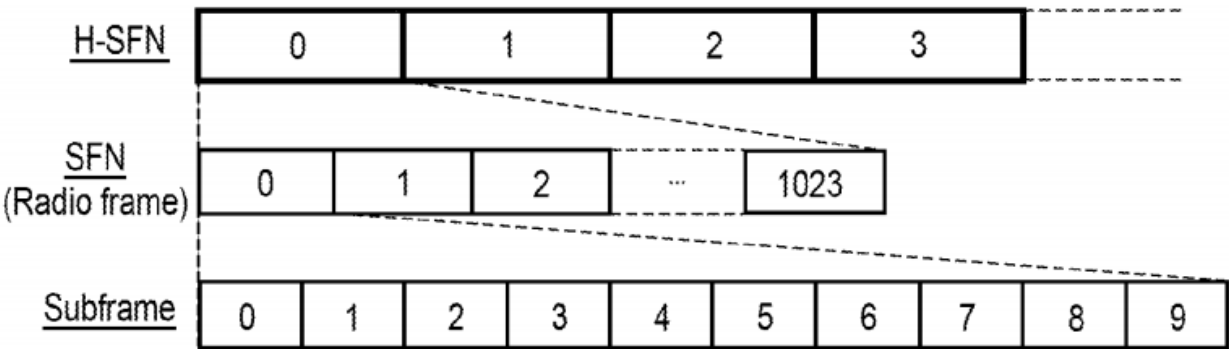


FIG. 8



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FIG. 9

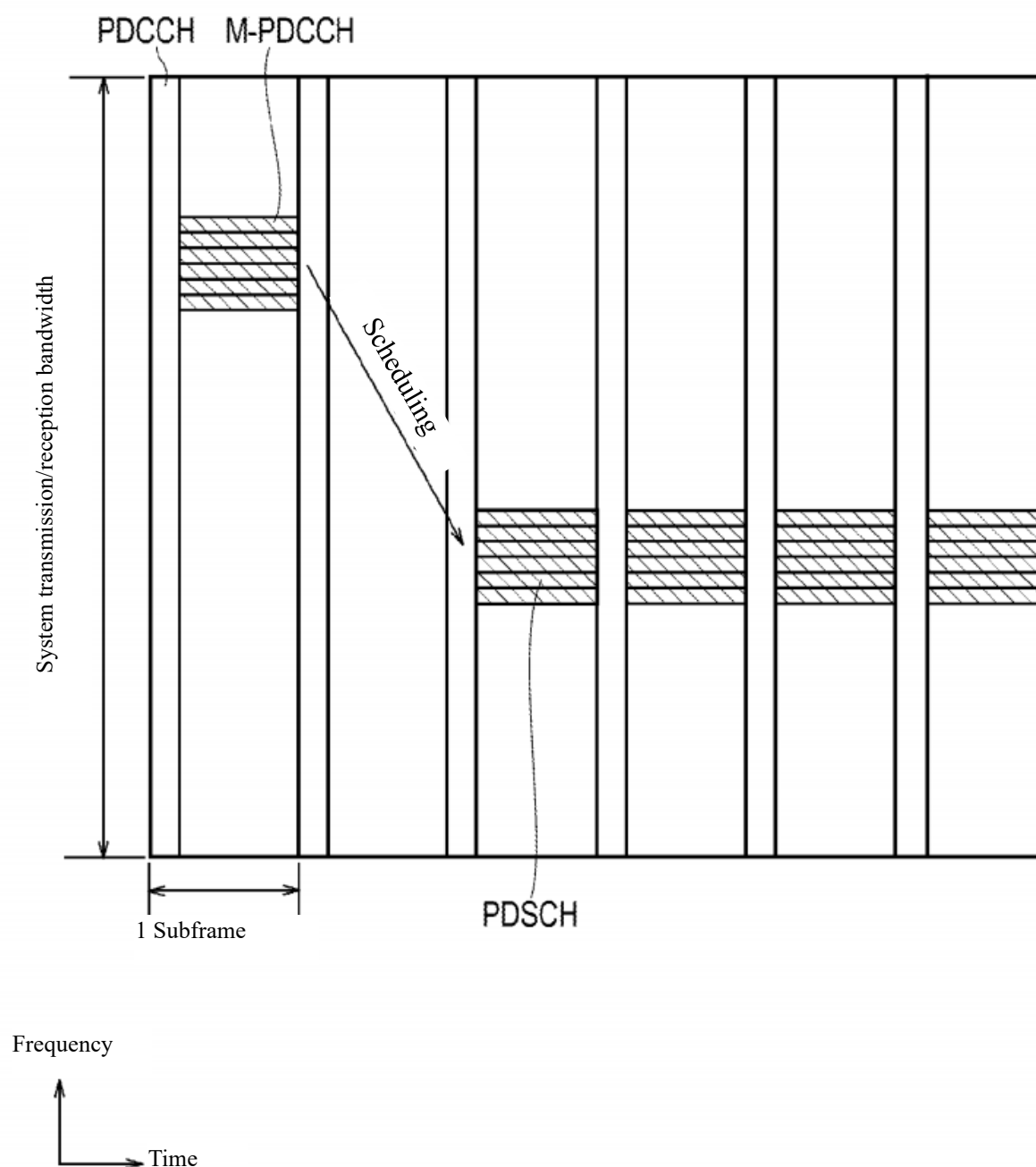


FIG. 10

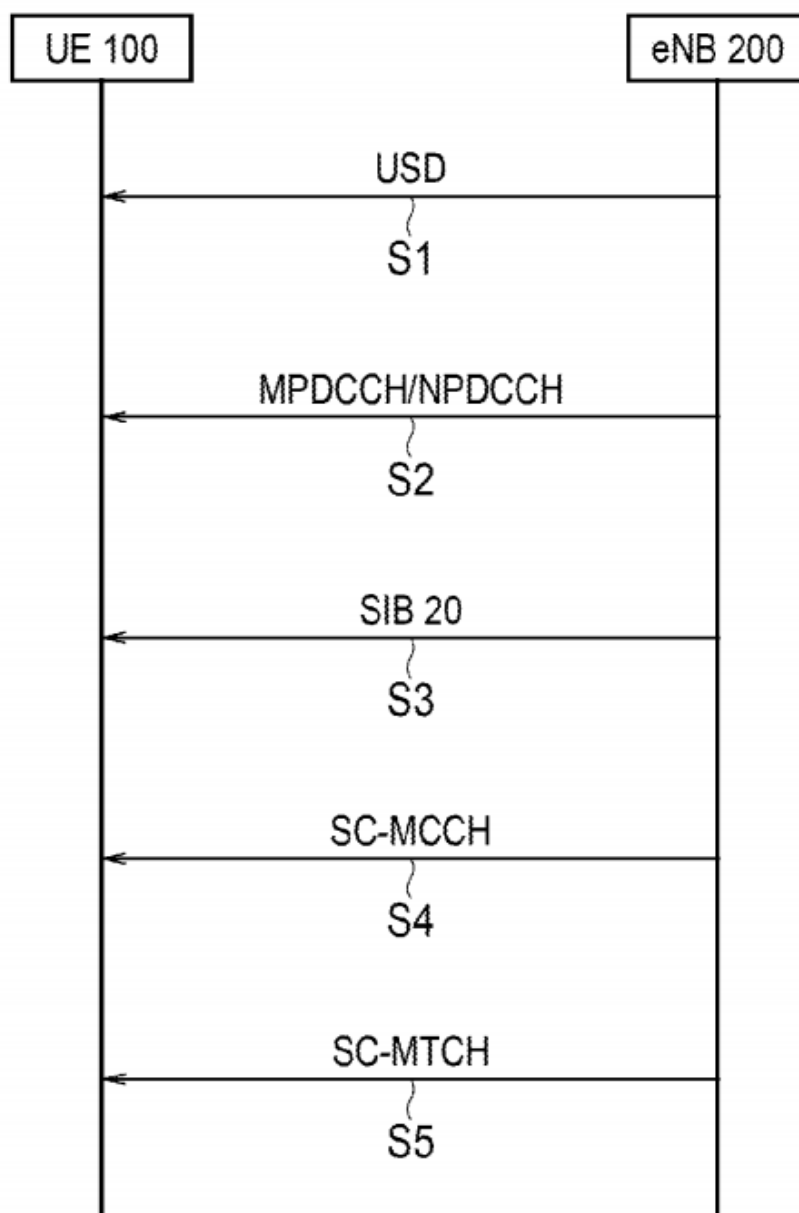


FIG. 11A

Bit	Direct Indication information
1	systemInfoModification
2	etws-Indication
3	cmas-Indication
4	eab-ParamModification
5	systemInfoModification-eDRX
6, 7, 8	Not used, and shall be ignored by UE if received.

FIG. 11B

Bit	Field in Direct Indication information
1	systemInfoModification
2	systemInfoModification-eDRX
3, 4, 5, 6, 7, 8	Not used, and shall be ignored by UE if received

FIG. 12

SystemInformationBlockType20 information element

```

-- ASN1START

SystemInformationBlockType20-r13 ::= SEQUENCE {
    sc-mcch-RepetitionPeriod-r13    ENUMERATED {rf2, rf4, rf8, rf16, rf32, rf64, rf128, rf256},
    sc-mcch-Offset-r13              INTEGER (0..10),
    sc-mcch-FirstSubframe-r13       INTEGER (0..9),
    sc-mcch-duration-r13            INTEGER (2..9) OPTIONAL,
    sc-mcch-ModificationPeriod-r13  ENUMERATED {rf2, rf4, rf8, rf16, rf32, rf64, rf128, rf256,
                                                rf512, rf1024, r2048, rf4096, rf8192, rf16384, rf32768,
                                                rf65536},
    lateNonCriticalExtension         OCTET STRING                               OPTIONAL,
    ...
}

-- ASN1STOP

```

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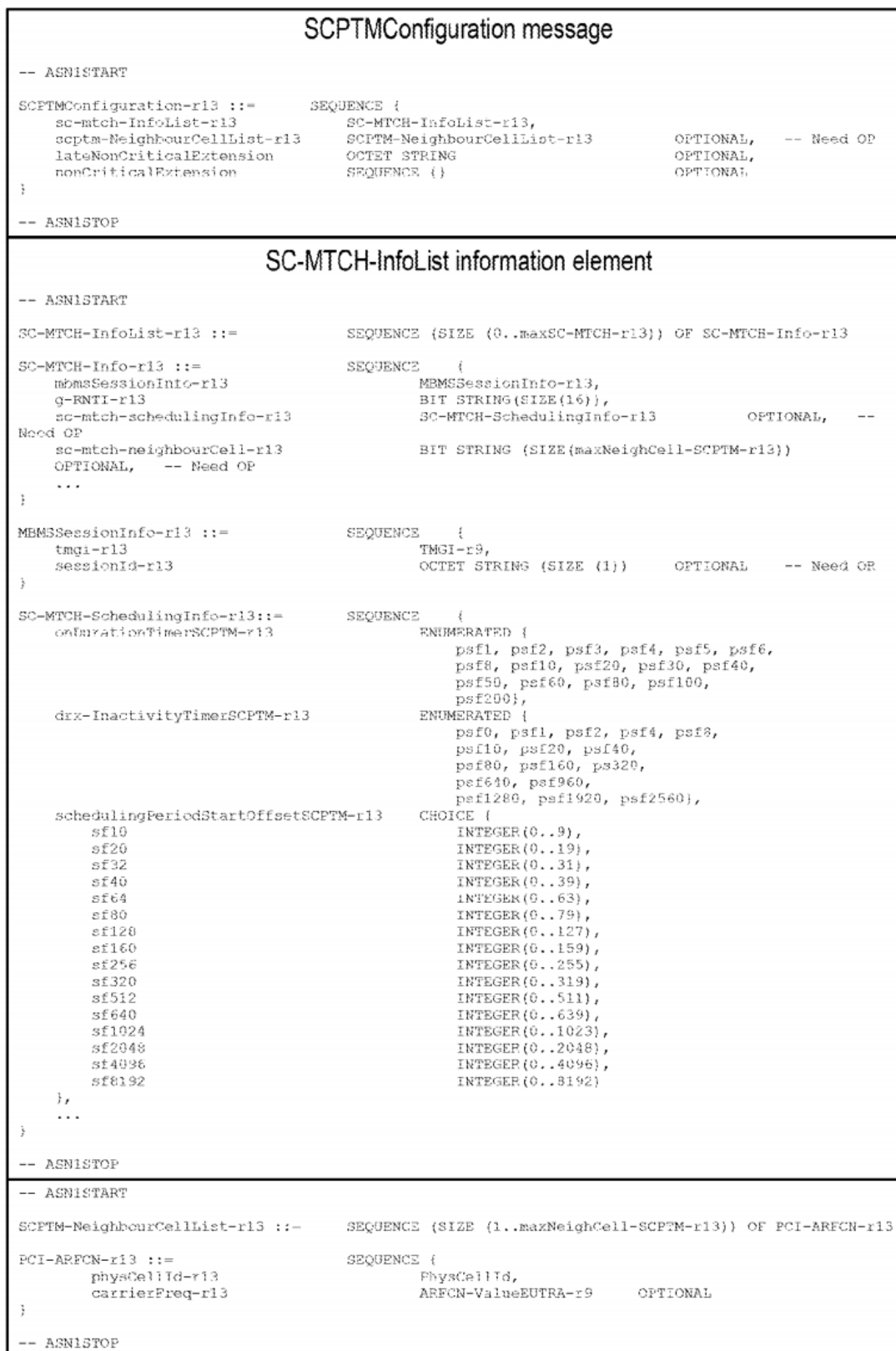


FIG. 14A

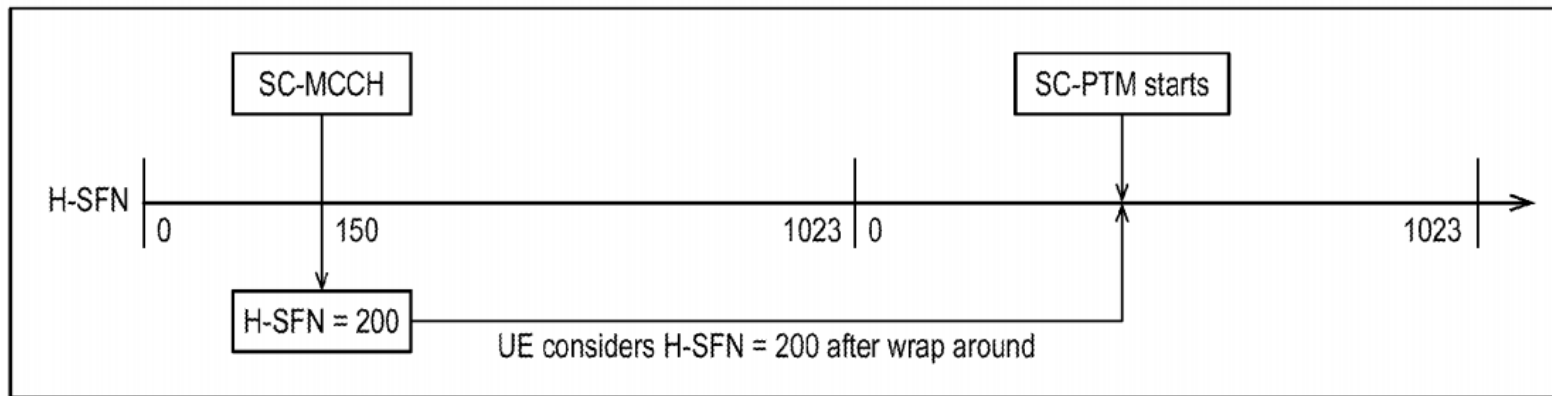


FIG. 14B

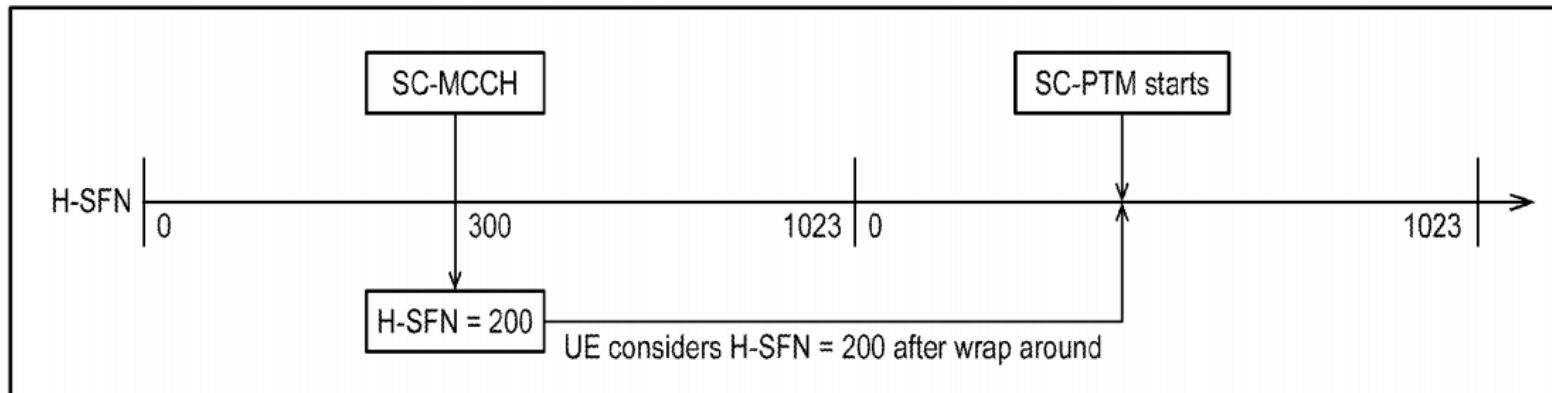
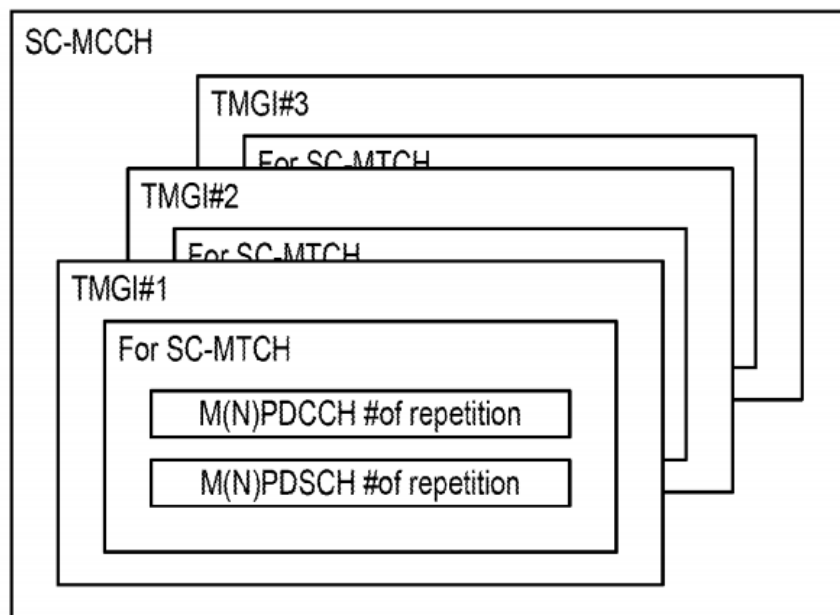


FIG. 15A



FIG. 15B



Electronic Acknowledgement Receipt	
EFS ID:	26601013
Application Number:	62372919
International Application Number:	
Confirmation Number:	9363
Title of Invention:	RADIO TERMINAL AND BASE STATION
First Named Inventor/Applicant Name:	Masato FUJISHIRO
Customer Number:	32968
Filer:	Kathleen Lynn Connell/tokiko kinoshita
Filer Authorized By:	Kathleen Lynn Connell
Attorney Docket Number:	16P01405US00
Receipt Date:	10-AUG-2016
Filing Date:	
Time Stamp:	13:19:57
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$260
RAM confirmation Number	081016INTEFSW13202300
Deposit Account	1024
Authorized User	Tokiko Kinoshita
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	Application Data Sheet	2016-08-10_ADS_16P01405US00.pdf	1823267	no	8
			4517a56a0c089d47583a6d343e208538cb212ee4		
Warnings:					
Information:					
2	Provisional Cover Sheet (SB16)	2016-08-10_ProvCvrSheet_16P01405US00.pdf	1477396	no	3
			8c327ac4b511f7f6ba24eb00b4006efdcab7bdf6		
Warnings:					
Information:					
3	Specification - Not in English	2016-08-10_ProvApp_Spec_16P01405US00.pdf	680172	no	28
			07bcb2407b7e7e918e1cd3f603052e64ba577fd		
Warnings:					
Information:					
4	Drawings-only black and white line drawings	2016-08-10_ProvApp_Drawings_16P01405US00.pdf	1858059	no	13
			8fee83030779cea081a6cf10422fa58a04cd4e9f		
Warnings:					
Information:					
5	Fee Worksheet (SB06)	fee-info.pdf	29651	no	2
			21201e44207039c445f4460c4a8a38842566e53a		
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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.

Declaration of Translation

I, Eric Vance, hereby declare:

I possess advanced knowledge of the Japanese and English languages and am qualified to translate documents from Japanese to English;

I translated U.S. Application Number 62/372,919 from Japanese into English and to the best of my knowledge and belief, the attached Document is a true and accurate translation from Japanese into English;

I also declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and 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 18 U.S.C. § 1001.

Dated: May 27, 2024