

**DOCUMENT MADE AVAILABLE UNDER THE
PATENT COOPERATION TREATY (PCT)**

International application number:	PCT/KR2017/008645
International filing date:	09 August 2017 (09.08.2017)
Document type:	Certified copy of priority document
Document details:	Country/Office: US
	Number: 62/372,323
	Filing date: 09 August 2016 (09.08.2016)
Date of receipt at the International Bureau:	22 August 2017 (22.08.2017)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a),(b) or (b-bis)

CERTIFICATE OF AVAILABILITY OF A CERTIFIED PATENT DOCUMENT IN A DIGITAL LIBRARY

The International Bureau certifies that a copy of the patent application indicated below has been available to the WIPO Digital Access Service since the date of availability indicated, and that the patent application has been available to the indicated Office(s) as of the date specified following the relevant Office code:

Document details: Country/Office: US

Filing date: 09 Aug 2016 (09.08.2016)

Application number: 62372323

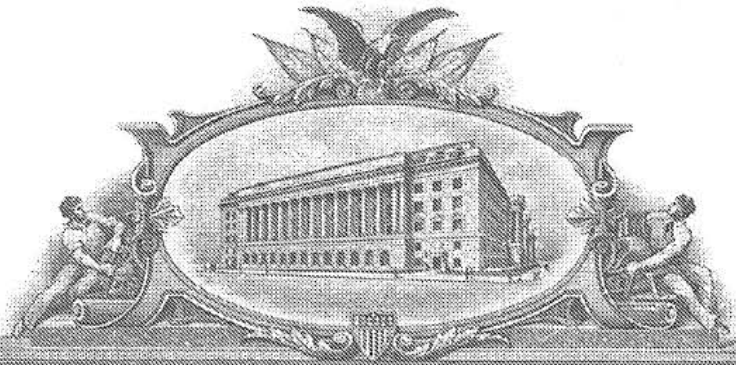
Date of availability of document: 20 Aug 2016 (20.08.2016)

The following Offices can retrieve this document by using the access code:

JP, US, SE, NZ, KR, GB, AU, ES, IB, EE, CN, MA, FI

Date of issue of this certificate: 22 Aug 2017 (22.08.2017)

34, chemin des Colombettes
1211 Geneva 20, Switzerland
www.wipo.int



THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

August 22, 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: 62/372,323
FILING DATE: August 09, 2016

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS US62/372,323



Certified by

Michelle M. Lee

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

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

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1104-US
		Application Number	
Title of Invention	SC-PIM FOR ENHANCED NB-IoT SYSTEM		
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	
	Seokmin		SHIN		
Residence Information (Select One) ☐ US Residency ☒ Non US Residency ☐ Active US Military Service					
City	Seoul		Country of Residence ⁱ	KR	
Mailing Address of Inventor:					
Address 1	19, Yangjae-daero 11gil, Seocho-gu				
Address 2					
City	Seoul		State/Province		
Postal Code	06772		Country ⁱ	KR	
Inventor	2				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Hyangsun		YOU		
Residence Information (Select One) ☐ US Residency ☒ Non US Residency ☐ Active US Military Service					
City	Seoul		Country of Residence ⁱ	KR	
Mailing Address of Inventor:					
Address 1	19, Yangjae-daero 11gil, Seocho-gu				
Address 2					
City	Seoul		State/Province		
Postal Code	06772		Country ⁱ	KR	
Inventor	3				Remove
Legal Name					

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1104-US
		Application Number	
Title of Invention	SC-PTM FOR ENHANCED NB-IoT SYSTEM		

Prefix	Given Name	Middle Name	Family Name	Suffix
	Joonkui		AHN	
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service				

City	Seoul	Country of Residence ⁱ	KR
------	-------	-----------------------------------	----

Mailing Address of Inventor:

Address 1	19, Yangjae-daero 11gil, Seocho-gu		
Address 2			
City	Seoul	State/Province	
Postal Code	06772	Country ⁱ	KR

Inventor	4	Remove
Legal Name		

Prefix	Given Name	Middle Name	Family Name	Suffix
	Yunjung		YI	
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service				

City	Seoul	Country of Residence ⁱ	KR
------	-------	-----------------------------------	----

Mailing Address of Inventor:

Address 1	19, Yangjae-daero 11gil, Seocho-gu		
Address 2			
City	Seoul	State/Province	
Postal Code	06772	Country ⁱ	KR

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

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).			
☐ An Address is being provided for the correspondence information of this application.			
Customer Number	67487		
Email Address	info@kpatent.com	Add Email	Remove Email
Email Address	uspto@kpatent.com	Add Email	Remove Email

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1104-US
		Application Number	
Title of Invention	SC-PIM FOR ENHANCED NB-IoT SYSTEM		

Application Information:

Title of the Invention	SC-PIM FOR ENHANCED NB-IoT SYSTEM		
Attorney Docket Number	UT16-1104-US	Small Entity Status Claimed	☐
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)		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	57487		

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1104-US
		Application Number	
Title of Invention	SC-PIM FOR ENHANCED NB-IoT SYSTEM		

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.			

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)	Remove
			Access Code ⁱ (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			

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	UT16-1104-US
		Application Number	
Title of Invention	SC-PIM FOR ENHANCED NB-IoT SYSTEM		

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.

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

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1104-US
		Application Number	
Title of Invention	SC-PIM FOR ENHANCED NB-IoT SYSTEM		

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.

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. ☐

Prefix	Given Name	Middle Name	Family Name	Suffix

Mailing Address Information For Applicant:

Address 1			
Address 2			
City		State/Province	
Country		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee 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.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1104-US
		Application Number	
Title of Invention	SC-PIM FOR ENHANCED NB-IoT SYSTEM		

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 must 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	/Andrew S. Park/		Date (YYYY-MM-DD)	2016-08-09
First Name	Andrew	Last Name	Park	Registration Number 47841
Additional Signature may be generated within this form by selecting the Add button. Add				

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

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1104-US
		Application Number	
Title of Invention	SC-PIM FOR ENHANCED NB-IoT SYSTEM		

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.**

Privacy Act Statement

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

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

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PROVISIONAL APPLICATION FOR UNITED STATES PATENT
IN THE NAMES OF

Seokmin SHIN, Hyangsun YOU, Joonkui AHN and Yunjung YI

for

SC-PtM FOR ENHANCED NB-IoT SYSTEM

Customer Number: 67487

Attorney Docket Number: UT16-1104-US

Total Number of pages: 25 (including cover)

Standard Patent Application

CTO) Next Generation Standards Lab		Application Date: 2016	
Inventors	SukMin SHIN, HyangSun YU, JunKi AHN, YunJeong LEE		
Title of Invention	SC-PtM for enhanced NB-IoT system		

Standardization Organization	3GPP TSG RAN1	Meeting for Presentation	
Related Technology field	LTE-A, MTC		
Related Standard Specifications			

1. Purpose of Invention

In the present invention, when attempting to operate SC-PtM in an NB-IoT system supporting cellular IoT (internet of things), the present invention proposes a suitable PRB location to which N-PDCCH/N-PDSCH, etc. transmitting SC-PtM-related information is transmitted, and a method for allocating such PRB.

2. Prior Art

Techniques, apparatus and systems described herein can be used in various wireless access technologies such as code division multiple access (CDMA), frequency division multiple access (FDMA), time division multiple access (TDMA), orthogonal frequency division multiple access (OFDMA), single carrier frequency division multiple access (SC-FDMA), etc. The CDMA may be implemented with a radio technology such as Universal Terrestrial Radio Access (UTRA) or CDMA2000. The TDMA may be implemented with a radio technology such as Global System for Mobile communications (GSM)/ General Packet Radio Service (GPRS)/ Enhanced Data Rates for GSM Evolution (EDGE). The OFDMA may be implemented with a radio technology such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802-20, evolved-UTRA (E-UTRA) etc. The UTRA is a part of a universal mobile telecommunication system (UMTS). 3rd generation partnership project (3GPP) long term evolution (LTE) is a part of an evolved-UMTS (E-UMTS) using the E-UTRA. The 3GPP LTE employs the OFDMA in downlink and employs the SC-FDMA in uplink [1]. LTE-advanced (LTE-A) is an evolution of the 3GPP LTE. For clarity, this application focuses on the 3GPP LTE/LTE-A. However, technical features of the present invention are not limited thereto.

2-1. LTE system architecture

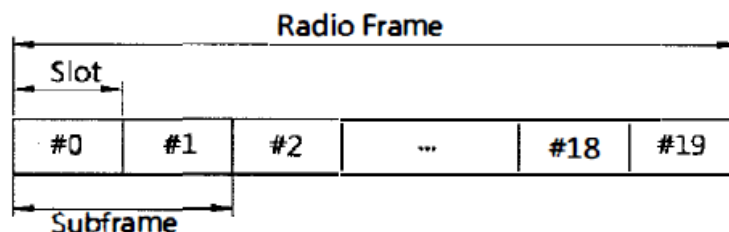


Figure 1. Structure of a radio frame of 3GPP LTE

In Figure 1, a radio frame includes 10 subframes. A subframe includes two slots in time domain. A time for transmitting one subframe is defined as a transmission time interval (TTI). For example, one subframe may have a length of 1 millisecond (ms), and one slot may have a length of 0.5 ms. One slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in time domain. Since the 3GPP LTE uses the OFDMA in the downlink, the OFDM symbol is for representing one symbol period. The OFDM symbol may also be referred to as an SC-FDMA symbol or a symbol period. A resource block (RB) is a resource allocation unit, and includes a plurality of contiguous subcarriers in one slot. The structure of the radio frame is shown for exemplary purposes only. Thus, the number of subframes included in the radio frame or the number of slots included in the subframe or the number of OFDM symbols included in the slot may be modified in various manners.

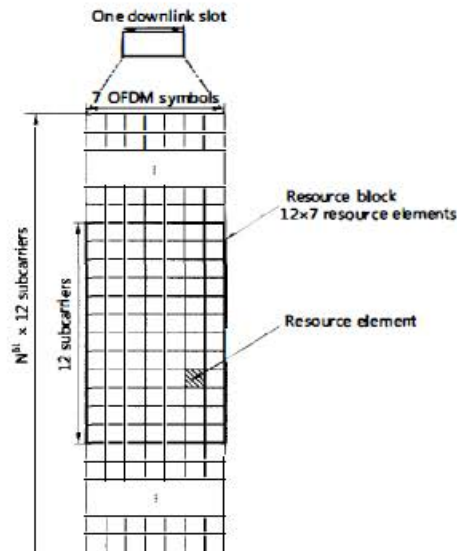


Figure 2. Resource grid for one downlink slot

In Figure 2, a downlink slot includes a plurality of OFDM symbols in time domain. It is described herein that one downlink slot includes 7 OFDM symbols, and one resource block (RB) includes 12 subcarriers in frequency domain as an example. However, the present invention is not limited thereto. Each element on the resource grid is referred to as a resource element (RE). One RB includes 12×7 REs. The number NDL of RBs included in the downlink slot depends on a downlink transmit bandwidth. The structure of an uplink slot may be same as that of the downlink slot.

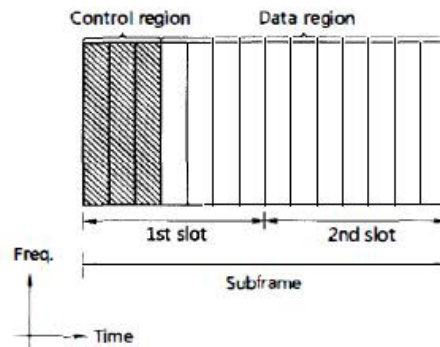


Figure 3. Structure of downlink subframe

In Figure 3, a maximum of three OFDM symbols located in a front portion of a first slot within a subframe correspond to a control region to be assigned with a control channel. The remaining OFDM symbols correspond to a data region to be assigned with a physical downlink shared channel (PDSCH). Examples of downlink control channels used in the 3GPP LTE includes a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), a physical hybrid ARQ indicator channel (PHICH), etc. The PCFICH is transmitted at a first OFDM symbol of a subframe and carries information regarding the number of OFDM symbols used for transmission of control channels within the subframe. The PHICH is a response of uplink transmission and carries an HARQ acknowledgment (ACK)/not-acknowledgment (NACK) signal. Control information transmitted through the PDCCH is referred to as downlink control information (DCI). The DCI includes uplink or downlink scheduling information or includes an uplink transmit (Tx) power control command for arbitrary UE groups.

The PDCCH may carry a transport format and a resource allocation of a downlink shared channel (DL-SCH), resource allocation information of an uplink shared channel (UL-SCH), paging information on a paging channel (PCH), system information on the DL-SCH, a resource allocation of an upper-layer control message such as a random access response transmitted on the PDSCH, a set of Tx power control commands on individual UEs within an arbitrary UE group, a Tx power control command, activation of a voice over IP (VoIP), etc. A plurality of PDCCHs can be transmitted within a control region. The UE can monitor the plurality of PDCCHs. The PDCCH is transmitted on an aggregation of one or several consecutive control channel elements (CCEs). The CCE is a logical allocation unit used to provide the PDCCH with a coding rate based on a state of a radio channel. The CCE corresponds to a plurality of resource element groups (REGs). A format of the PDCCH and the number of bits of the available PDCCH are determined according to a correlation between the number of CCEs and the coding rate provided by the CCEs. The BS determines a PDCCH format according to a DCI to be transmitted to the UE, and attaches a cyclic redundancy check (CRC) to control information. The CRC is masked with a unique identifier (referred to as a radio network temporary identifier (RNTI)) according to an owner or usage of the PDCCH. If the PDCCH is for a specific UE, a unique identifier (e.g., cell-RNTI (C-RNTI)) of the UE may be masked to the CRC. Alternatively, if the PDCCH is for a paging message, a paging indicator identifier (e.g., paging-RNTI (P-RNTI)) may be masked to the CRC. If the PDCCH is for system information (more specifically, a system information block (SIB) to be described below), a system information identifier and a system information RNTI (SI-RNTI) may be masked to the CRC. To indicate a random access response that is a response for transmission of a random access preamble of the UE, a random access-RNTI (RA-RNTI) may be masked to the

CRC.

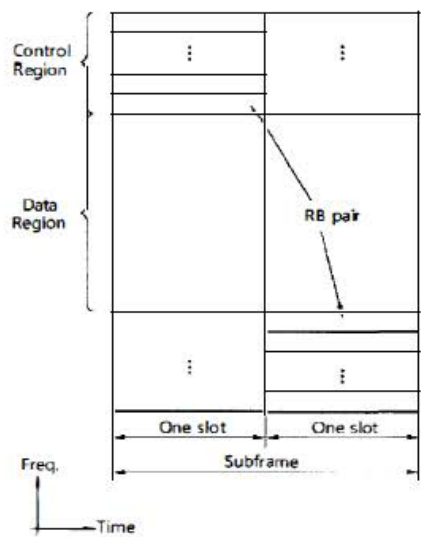


Figure 4. Structure of uplink subframe

In Figure 4, an uplink subframe can be divided in a frequency domain into a control region and a data region. The control region is allocated with a physical uplink control channel (PUCCH) for carrying uplink control information. The data region is allocated with a physical uplink shared channel (PUSCH) for carrying user data. To maintain a single carrier property, one UE does not simultaneously transmit the PUCCH and the PUSCH. The PUCCH for one UE is allocated to an RB pair in a subframe. RBs belonging to the RB pair occupy different subcarriers in respective two slots. This is called that the RB pair allocated to the PUCCH is frequency-hopped in a slot boundary.

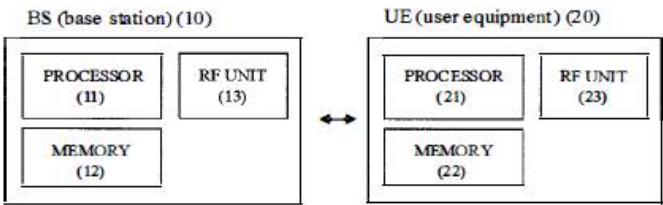


Figure 5. System for implementing present invention

In Figure 5, a wireless communication system includes a BS 10 and one or more UE 20. In downlink, a transmitter may be a part of the BS 10, and a receiver may be a part of the UE 20. In uplink, a transmitter may be a part of the UE 20, and a receiver may be a part of the BS 10. A BS 10 may include a processor 11, a memory 12, and a radio frequency (RF) unit 13. The processor 11 may be configured to implement proposed procedures and/or methods described in this application. The memory 12 is coupled with the processor 11 and stores a variety of information to operate the processor 11. The RF unit 13 is coupled with the processor 11

and transmits and/or receives a radio signal. A UE 20 may include a processor 21, a memory 22, and a RF unit 23. The processor 21 may be configured to implement proposed procedures and/or methods described in this application. The memory 22 is coupled with the processor 21 and stores a variety of information to operate the processor 21. The RF unit 23 is coupled with the processor 21 and transmits and/or receives a radio signal. The BS 10 and/or the UE 20 may have single antenna and multiple antennas. When at least one of the BS 10 and the UE 20 has multiple antennas, the wireless communication system may be called as multiple input multiple output (**MIMO**) system.

2-2. Component carrier aggregation in LTE-A

As the increased demands for the high data rate transmission, the mobile communication system composed of aggregated multiple CCs (component carriers) is now being researched. For example, Figure 6 (b) illustrates the DL/UL subframe structure considered in 3GPP LTE-A (LTE Advanced) system where multiple CCs are aggregated (in this example, 3 carriers exist), while Figure 6 (a) illustrates a single carrier operation as in conventional systems. As shown in Figure 6 (b), a UE can monitor and receive DL signal/data from multiple DL CCs at the same time. However, even if a cell is managing N DL CCs, the network may configure a UE with M DL CCs where $M \leq N$ so that the UE's monitoring of the DL signal/data is limited to those M DL CCs. In addition, the network may configure L DL CCs as the main DL CCs from which the UE should monitor/receive DL signal/data with a priority, either UE-specifically or cell-specifically, where $L \leq M \leq N$.

Here, the CCs can be separated into cells and expressed as an equivalent concept.

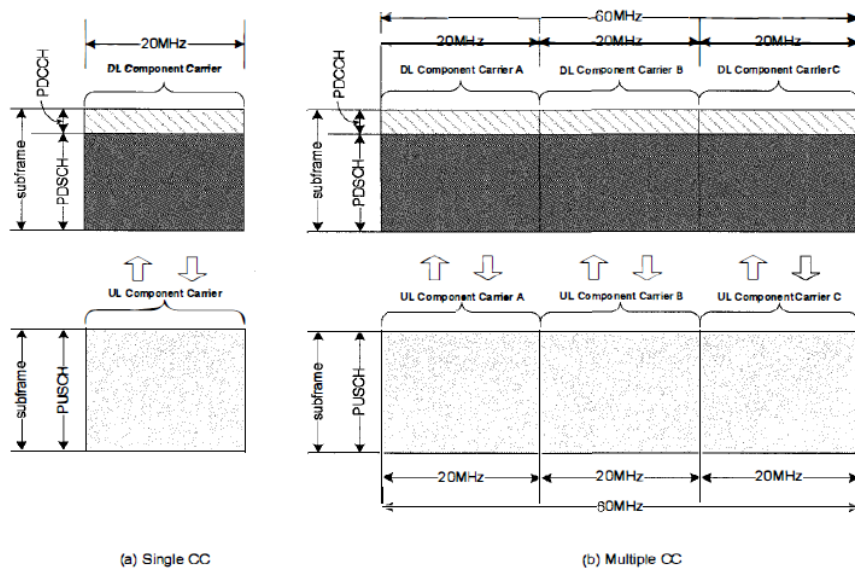


Figure 6. Subframe structure of 3GPP LTE Release-8 system and LTE-A system with CC aggregation

In a system that supports carrier aggregation, cells can be categorized as shown in the following Figure 7.

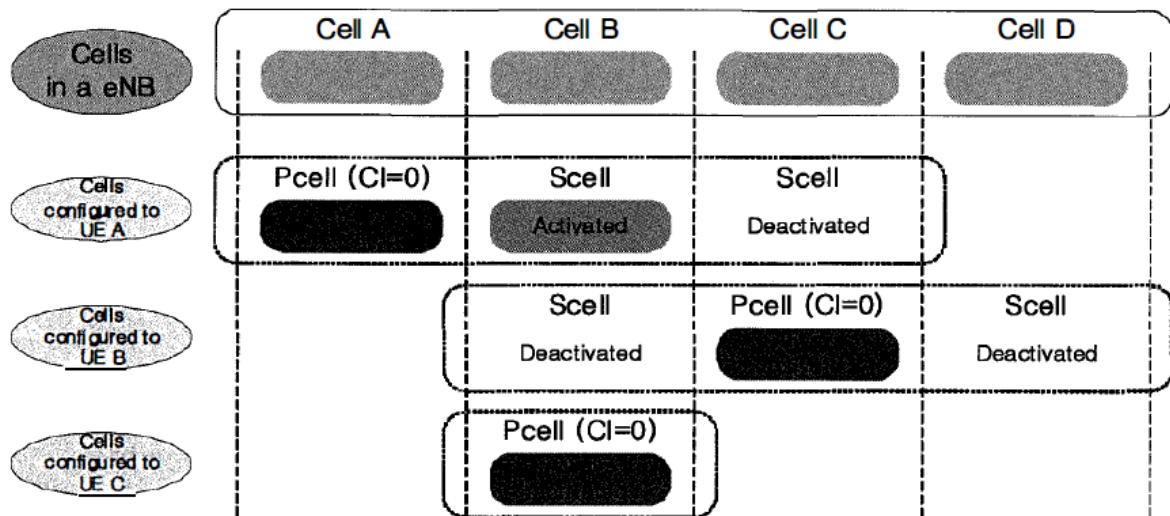


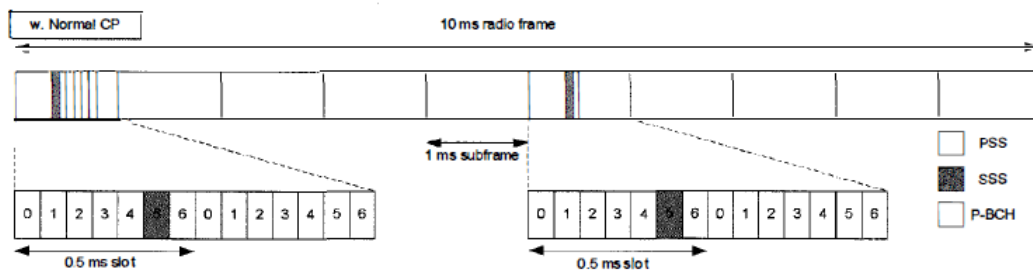
Figure 7. Configured cell, activated cell, de-activated cell

The configured cell is set per UE as a cell that allows carrier aggregation based on the measurement report among the cells of the base station as shown in Figure 7. The configured cell reserves the resource for transmitting ACK/NACK for PDSCH transmission in advance. Activated cell is a cell that is actually set to transmit PDSCH/PUSCH among the configured cells and performs CSI report and SRS transmission for PDSCH/PUSCH transmission. A de-activated cell is a cell that is prevented from transmitting PDSCH/PUSCH by a base station command or timer operation, and CSI report and SRS transmission are also stopped.

2-3 Synchronization signal (SS) in LTE-A FDD

SS consists of P-SS and S-SS, and is the signal used to perform cell discovery.

Figure 8 (a) and (b) illustrate the frame structures for the transmission of SS for systems using a basic CP and an extended CP, respectively. SS is transmitted in the second slot of subframe 0 and subframe 5, respectively, considering the GSM frame length of 4.6 ms to facilitate inter-RAT measurement, and the boundary for the corresponding radio frame is detectable by S-SS. P-SS is transmitted at the last OFDM symbol of the corresponding slot, and S-SS is transmitted at the OFDM symbol immediately before P-SS. SS can transmit a total of 504 physical cell IDs through a combination of three P-SSs and 168 S-SSs. In addition, SS and PBCH are transmitted within the middle 6 RBs of the system bandwidth to ensure that they can be detected or decoded by the UE regardless of the transmission bandwidth.



(a) Basic CP

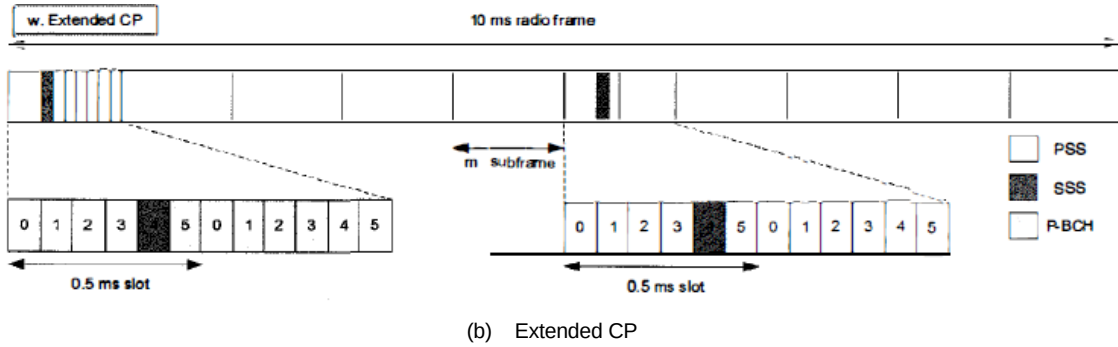


Figure 8. Frame Structures for SS transmission

The transmission diversity method of SS uses only a single antenna port and is not defined by the standard, i.e., it can use either single antenna transmission or a transmission method that is transparent to the UE (e.g., PVS, TSTD, CDD).

a. P-SS code

ZC (Zadoff-Chu) sequence of length 63 is defined in the frequency domain and used as the sequence for P-SS. ZC sequence is defined by Equation (1), where the sequence element corresponding to the DC subcarrier, $n=31$, is puncturing. In equation (1), $N_{zc}=63$.

$$d_u(n) = e^{-j \frac{\pi n(n+1)}{N_{zc}}} \quad (1)$$

The 9 remaining subcarriers of the 6RBs (=72 subcarriers) in the center section always transmit with a value of 0, which facilitates the design of filters for synchronization. To define a total of three P-SSs, the values of $u=25, 29$, and 34 in equation (1) are used. In this case, 29 and 34 have a conjugate symmetry relationship, so two correlations can be performed simultaneously. Here, conjugate symmetry refers to the relationship of the following equation (2), and using this characteristic, it allows to implement a one-shot correlator for $u=29$ and 34 , reducing the overall computational amount by about 33.3%.

$$\begin{aligned} d_u(n) &= (-1)^n \left(d_{N_{zc}-u}(n) \right)^*, \text{ when } N_{zc} \text{ is even number.} \\ d_u(n) &= \left(d_{N_{zc}-u}(n) \right)^*, \text{ when } N_{zc} \text{ is odd number.} \end{aligned} \quad (2)$$

b. S-SS code

The sequence used for S-SS interleaves two m-sequences of length 31 and combines the two sequences to transmit the 168 cell group IDs. As a sequence for S-SS, m-sequence is robust in frequency-selective environment, and the amount of computation can be reduced by a high-speed m-sequence conversion using Fast Hadamard Transform. In addition, configuring S-SS with two short codes was proposed to reduce the amount of computation of the terminal.

Figure 9 is a diagram illustrating how two sequences in the logical domain are interleaved and mapped in the physical domain. When the two m-sequences used to generate S-SS code are defined as $S1$ and $S2$, respectively, if the S-SS in subframe 0 transmits the cell group ID in two combinations ($S1, S2$), the S-SS in subframe 5 swaps to ($S2, S1$) and transmits to make it possible to distinguish 10ms frame boundaries. In this case, the S-SS code used employs a generating polynomial of $x^5 + x^2 + 1$, and a total of 31 codes can be generated through different circular shifts.

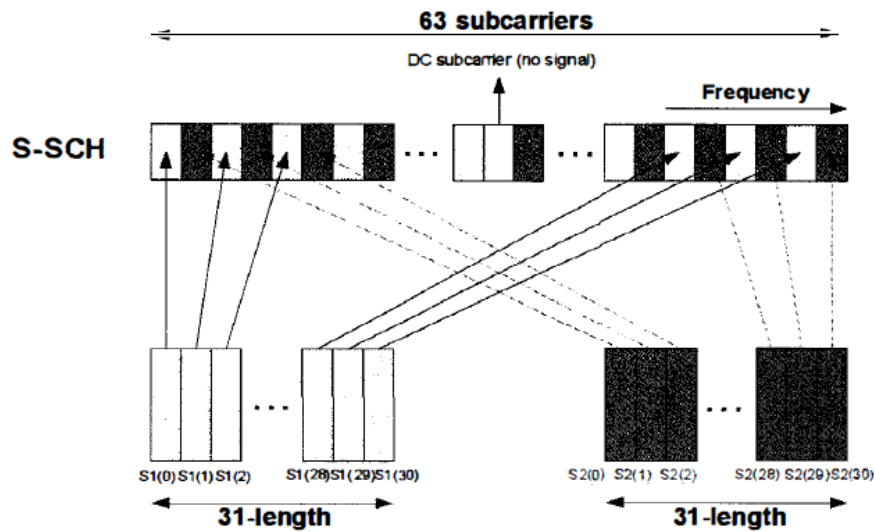


Figure 9. S-SS code generation method

To improve reception performance, two different P-SS-based sequences are defined and scrambled into S-SS, but scrambled with different sequences on S1 and S2. Afterwards, an S1-based scrambling code is defined, and scrambling is performed on S2. At this time, the S-SS codes are exchanged every 5ms, but the P-SS-based scrambling codes are not exchanged. The P-SS-based scrambling code is defined as six circular shift versions according to the P-SS index in the m-sequence generated from the generating polynomial of $x^5 + x^3 + 1$, and the S1-based scrambling code is defined as eight circular shift versions according to the S1 index in the m-sequence generated from the polynomial of $x^5 + x^4 + x^2 + x^1 + 1$.

Followings are the criterion of out-of-synch in LTE in system

- The UE shall monitor the down link link quality based on the cell-specific reference signal in order to detect the downlink radio link quality of the PCell as specified in [2].
- The UE shall estimate the downlink radio link quality and compare it to the thresholds Q_{out} and Q_{in} for the purpose of monitoring down link radio link quality of the PCell.
- The threshold Q_{out} is defined as the level at which the down link radio link cannot be reliably received and shall correspond to 10% block error rate of a hypothetical PDCCH transmission taking into account the PCFICH errors with transmission parameters in [3].
- The threshold Q_{in} is defined as the level at which the down link radio link quality can be significantly more reliably received than at Q_{out} and shall correspond to 2% block error rate of a hypothetical PDCCH transmission taking into account the PCFICH errors with transmission parameters specified in [3].

SC-PTM

5.8a.1 Introduction

5.8a.1.1 General

SC-PTM control information is provided on a specific logical channel: the SC-MCCH. The SC-MCCH carries the *SCPTM Configuration* message which indicates the MBMS sessions that are ongoing as well as the (corresponding) information on

when each session may be scheduled, i.e. scheduling period, scheduling window and start offset. The *SCPTMConfiguration* message also provides information about the neighbour cells transmitting the MBMS sessions which are ongoing on the current cell.

A limited amount of SC-PTM control information is provided on the BCCH. This primarily concerns the information needed to acquire the SC-MCCH.

5.8a.1.2 SC-MCCH scheduling

The SC-MCCH information (i.e. information transmitted in messages sent over SC-MCCH) is transmitted periodically, using a configurable repetition period. SC-MCCH transmissions (and the associated radio resources and MCS) are indicated on PDCCH.

5.8a.1.3 SC-MCCH information validity and notification of changes

Change of SC-MCCH information only occurs at specific radio frames, i.e. the concept of a modification period is used. Within a modification period, the same SC-MCCH information may be transmitted a number of times, as defined by its scheduling (which is based on a repetition period). The modification period boundaries are defined by SFN values for which $\text{SFN} \bmod m = 0$, where m is the number of radio frames comprising the modification period. The modification period is configured by means of *SystemInformationBlockType20*.

When the network changes (some of) the SC-MCCH information, it notifies the UEs about the change in the first subframe which can be used for SC-MCCH transmission in a repetition period. LSB bit in 8-bit bitmap when set to '1' indicates the change in SC-MCCH. Upon receiving a change notification, a UE interested to receive MBMS services transmitted using SC-PTM acquires the new SC-MCCH information starting from the same subframe. The UE applies the previously acquired SC-MCCH information until the UE acquires the new SC-MCCH information.

5.8a.1.4 Procedures

The SC-PTM capable UE receiving or interested to receive MBMS service(s) via SC-MRB applies SC-PTM procedures described in section 5.8a and the MBMS interest indication procedure as specified in 5.8.5.

5.8a.2 SC-MCCH information acquisition

5.8a.2.1 General



Figure 5.8a.2.1-1: SC-MCCH information acquisition

The UE applies the SC-MCCH information acquisition procedure to acquire the SC-PTM control information that is broadcast by the E-UTRAN. The procedure applies to SC-PTM capable UEs that are in RRC_IDLE or in RRC_CONNECTED.

5.8a.2.2 Initiation

A UE interested to receive MBMS services via SC-MRB shall apply the SC-MCCH information acquisition procedure upon entering the cell broadcasting *SystemInformationBlockType20* (e.g. upon power on, following UE mobility) and upon receiving a notification that the SC-MCCH information has changed. A UE that is receiving an MBMS service via SC-MRB shall apply the SC-MCCH information acquisition procedure to acquire the SC-MCCH information that corresponds with the service that is being received, at the start of each modification period.

Unless explicitly stated otherwise in the procedural specification, the SC-MCCH information acquisition procedure overwrites any stored SC-MCCH information, i.e. delta configuration is not applicable for SC-MCCH information and the UE discontinues using a field if it is absent in SC-MCCH information unless explicitly specified otherwise.

5.8a.2.3 SC-MCCH information acquisition by the UE

A SC-PTM capable UE shall:

- 1> if the procedure is triggered by an SC-MCCH information change notification:
 - 2> start acquiring the *SCPTMConfiguration* message from the subframe where the change notification was received;
- NOTE 1: The UE continues using the previously received SC-MCCH information until the new SC-MCCH information has been acquired.
- 1> if the UE enters a cell broadcasting *SystemInformationBlockType20*:
 - 2> acquire the *SCPTMConfiguration* message at the next repetition period;
- 1> if the UE is receiving an MBMS service via an SC-MRB:
 - 2> start acquiring the *SCPTMConfiguration* message from the beginning of each modification period.

5.8a.2.4 Actions upon reception of the *SCPTMConfiguration* message

No UE requirements related to the contents of this *SCPTMConfiguration* apply other than those specified elsewhere e.g. within procedures using the concerned system information, the corresponding field descriptions.

5.8a.3 SC-PTM radio bearer configuration

5.8a.3.1 General

The SC-PTM radio bearer configuration procedure is used by the UE to configure RLC, MAC and the physical layer upon starting and/or stopping to receive an SC-MRB transmitted on SC-MTCH. The procedure applies to SC-PTM capable UEs that are in RRC_CONNECTED or in RRC_IDLE and are interested to receive one or more MBMS services via SC-MRB.

NOTE: In case the UE is unable to receive an MBMS service via an SC-MRB due to capability limitations, upper layers may take appropriate action e.g. terminate a lower priority unicast service.

5.8a.3.2 Initiation

The UE applies the SC-MRB establishment procedure to start receiving a session of a MBMS service it has an interest in. The procedure may be initiated e.g. upon start of the MBMS session, upon entering a cell providing via SC-MRB a MBMS service in which the UE has interest, upon becoming interested in the MBMS service, upon removal of UE capability limitations inhibiting reception of the concerned service.

The UE applies the SC-MRB release procedure to stop receiving a session. The procedure may be initiated e.g. upon stop of the MBMS session, upon leaving the cell where a SC-MRB is established, upon losing interest in the MBMS service, when capability limitations start inhibiting reception of the concerned service.

5.8a.3.3 SC-MRB establishment

Upon SC-MRB establishment, the UE shall:

- 1> establish an RLC entity in accordance with the configuration specified in 9.1.1.7;
- 1> configure a SC-MTCH logical channel applicable for the SC-MRB and instruct MAC to receive DL-SCH on the cell where the *SCPTMConfiguration* message was received for the MBMS service for which the SC-MRB is established and using *g-RNTI* and *sc-mtch-SchedulingInfo* (if included) in this message for this MBMS service;

- 1> configure the physical layer in accordance with the *sc-mtch-InfoList*, applicable for the SC-MRB, as included in the *SCPTMConfiguration* message;
- 1> inform upper layers about the establishment of the SC-MRB by indicating the corresponding *tmgi* and *sessionId*;

5.8a.3.4 SC-MRB release

Upon SC-MRB release, the UE shall:

- 1> release the RLC entity as well as the related MAC and physical layer configuration;
- 1> inform upper layers about the release of the SC-MRB by indicating the corresponding *tmgi* and *sessionId*;

— SystemInformationBlockType20

The IE *SystemInformationBlockType20* contains the information required to acquire the control information associated transmission of MBMS using SC-PTM.

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

SystemInformationBlockType20 field descriptions

sc-mcch-ModificationPeriod	Defines periodically appearing boundaries, i.e. radio frames for which $\text{SFN mod } \text{sc-mcch-ModificationPeriod} = 0$. The contents of different transmissions of SC-MCCH information can only be different if there is at least one such boundary in-between them. Value rf2 corresponds to 2 radio frames, value rf4 corresponds to 4 radio frames and so on.
sc-mcch-duration	Indicates, starting from the subframe indicated by <i>sc-mcch-FirstSubframe</i> , the duration during which SC-MCCH may be scheduled in non-MBSFN subframes. Absence of this IE means that SC-MCCH is only scheduled in the subframe indicated by <i>sc-mcch-FirstSubframe</i> .
sc-mcch-Offset	Indicates, together with the <i>sc-mcch-RepetitionPeriod</i> , the radio frames in which SC-MCCH is scheduled i.e. SC-MCCH is scheduled in radio frames for which $\text{SFN mod } \text{sc-mcch-RepetitionPeriod} = \text{sc-mcch-Offset}$.
sc-mcch-FirstSubframe	Indicates the first subframe in which SC-MCCH is scheduled
sc-mcch-RepetitionPeriod	Defines the interval between transmissions of SC-MCCH information, in radio frames. Value rf2 corresponds to 2 radio frames, rf4 corresponds to 4 radio frames and so on.

[213]

16.6 Narrowband physical downlink control channel related procedures

A UE shall monitor a set of NPDCCH candidates (described in subclause 10.2.2.1 of [3]) as configured by higher layer signalling for control information, where monitoring implies attempting to decode each of the NPDCCHs in the set according to all the monitored DCI formats.

The set of NPDCCH candidates to monitor are defined in terms of NPDCCH search spaces.

The UE shall monitor one or more of the following search spaces

- a Type1-NPDCCH common search space,
- a Type2-NPDCCH common search space, and
- a NPDCCH UE-specific search space.

A UE is not required to simultaneously monitor a NPDCCH UE-specific search space and a Type-1-NPDCCH common search space.

A UE is not required to simultaneously monitor a NPDCCH UE-specific search space and a Type2-NPDCCH common search space.

A UE is not required to simultaneously monitor a Type-1-NPDCCH common search space and a Type2-NPDCCH common search space.

An NPDCCH search space $NS_k^{(L',R)}$ at aggregation level $L' \in \{1,2\}$ and repetition level

$R \in \{1,2,4,8,16,32,64,128,256,512,1024,2048\}$ is defined by a set of NPDCCH candidates where each candidate is repeated in a set of R consecutive NB-IoT downlink subframes excluding subframes used for transmission of SI messages starting with subframe k .

For NPDCCH UE-specific search space, the aggregation and repetition levels defining the search spaces and the corresponding NPDCCH candidates are listed in Table 16.6-1 by substituting the value of $R_{\max}$ with the higher layer configured parameter *al-Repetition-USS*.

For Type1-NPDCCH common search space, the aggregation and repetition levels defining the search spaces are listed in Table 16.6-2 by substituting the value of $R_{\max}$ with the higher layer configured parameter *al-Repetition-CSS-Paging*.

For Type2-NPDCCH common search space, the aggregation and repetition levels defining the search spaces and the corresponding monitored NPDCCH candidates are listed in Table 16.6-3 by substituting the value of $R_{\max}$ with the higher layer configured parameter *npdcch-MaxNumRepetitions-RA*.

The locations of starting subframe k are given by $k = k_b$ where k_b is the b^{th} consecutive NB-IoT DL subframe from subframe k_0 , and $b = u \cdot R$, and $u = 0, 1, \dots, \frac{R_{\max}}{R} - 1$, and where

- subframe k_0 is a subframe satisfying the condition $(10n_t + \lfloor n_s/2 \rfloor) \bmod T = \alpha_{\text{offset}} \cdot T$, where $T = R_{\max} \cdot G$
 - for NPDCCH UE-specific search space,
 - G is given by the higher layer parameter *npdcch-startSF-USS*,
 - α_{offset} is given by the higher layer parameter *npdcch-startSFOffset-USS*,
 - for NPDCCH Type2-NPDCCH common search space,
 - G is given by the higher layer parameter *npdcch-startSF-Type2CSS*,

- α_{offset} is given by the higher layer parameter $nPDCCH-startSFoffset-Type2CSS$,

For Type1-NPDCCH common search space, $k = k_0$ and is determined from locations of NB-IoT paging opportunity subframes.

If the UE is configured by high layers with a PRB for monitoring of NPDCCH UE-specific search space,

- the UE shall monitor the NPDCCH UE-specific search space on the higher layer configured PRB,
- the UE is not expected to receive NPSS, NSSS, NPBCH on the higher layer configured PRB.

otherwise,

- the UE shall monitor the NPDCCH UE-specific search space on the same PRB on which NPSS/NSSS/NPBCH are detected.

Table 16.6-1: NPDCCH UE- specific search space candidates

R_{max}	R	NCCE indices of monitored NPDCCH candidates	
		L'=1	L'=2
1	1	{0},{1}	{0,1}
2	1	{0},{1}	{0,1}
	2	-	{0,1}
4	1	-	{0,1}
	2	-	{0,1}
	4	-	{0,1}
≥ 8	$R_{max}/8$	-	{0,1}
	$R_{max}/4$	-	{0,1}
	$R_{max}/2$	-	{0,1}
	R_{max}	-	{0,1}
Note 1: {x}, {y} denotes NPDCCH Format 0 candidate with NCCE index 'x', and NPDCCH Format 0 candidate with NCCE index 'y' are monitored			
Note 2: {x,y} denotes NPDCCH Format1 candidate corresponding to NCCEs 'x' and 'y' is monitored.			

Table 16.6-2: Type 1- NPDCCH common search space candidates

R_{max}	R	NCCE indices of monitored NPDCCH candidates	
		L'=1	L'=2
1	1	-	{0,1}
2	1,2	-	{0,1}
4	1,2,4	-	{0,1}
8	1,2,4,8	-	{0,1}

16	1,2,4,8,16	--	{0,1}
32	1,2,4,8,16,32	-	{0,1}
64	1,2,4,8,16,32,64	-	{0,1}
128	1,2,4,8,16,32,64,128	-	{0,1}
256	1,4,8,16,32,64,128,256	-	{0,1}
512	1,4,16,32,64,128,256,512	-	{0,1}
1024	1,8,32,64,128,256,512,1024	-	{0,1}
2048	1,8,64,128,256,512,1024,2048	-	{0,1}
Note 1: {x}, {y} denotes NPDCCH Format 0 candidate with NCCE index 'x', and NPDCCH Format 0 candidate with NCCE index 'y' are monitored			
Note 2: {x,y} denotes NPDCCH Format1 candidate corresponding to NCCEs 'x' and 'y' is monitored.			

Table 16.6-3: Type 2- NPDCCH common search space candidates

R_{max}	R	NCCE indices of monitored NPDCCH candidates	
		$L'=1$	$L'=2$
1	1	-	{0,1}
2	1	-	{0,1}
	2	-	{0,1}
4	1	-	{0,1}
	2	-	{0,1}
	4	-	{0,1}
≥ 8	$R_{max}/8$	-	{0,1}
	$R_{max}/4$	-	{0,1}
	$R_{max}/2$	-	{0,1}
	R_{max}	-	{0,1}
Note 1: {x}, {y} denotes NPDCCH Format 0 candidate with NCCE index 'x', and NPDCCH Format 0 candidate with NCCE index 'y' are monitored			
Note 2: {x,y} denotes NPDCCH Format1 candidate corresponding to NCCEs 'x' and 'y' is monitored			

If a NB-IoT UE detects NPDCCH with DCI Format N0 ending in subframe n , and if the corresponding NPUSCH format 1 transmission starts from $n+k$, the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+k-1$.

If a NB-IoT UE detects NPDCCH with DCI Format N1 or N2 ending in subframe n , and if the corresponding NPDSCH transmission starts from $n+k$, the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+k-1$.

If a NB-IoT UE detects NPDCCH with DCI Format N1 ending in subframe n , and if the corresponding NPUSCH format 2 transmission starts from subframe $n+k$, the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+k-1$.

If a NB-IoT UE detects NPDCCH with DCI Format N1 for “PDCCH order” ending in subframe n , and if the corresponding NPRACH transmission starts from subframe $n+k$, the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+k-1$.

If a NB-IoT UE has a NPUSCH transmission ending in subframe n , the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+3$.

A NB-IoT UE is not required to monitor NPDCCH candidates of an NPDCCH search space if a NPDCCH candidate of the NPDCCH search space ends in subframe n , and if the UE is configured to monitor NPDCCH candidates of another NPDCCH search space starting before subframe $n+5$.

16.6.1 NPDCCH starting position

The starting OFDM symbol for NPDCCH given by index $I_{\text{NPDCCHStart}}$ in the first slot in a subframe k and is determined as follows

- if higher layer parameter *operationModeInfo* indicates ‘00’, or ‘01’
 - $I_{\text{NPDCCHStart}}$ is given by the higher layer parameter *eutraControlRegionSize*
- if higher layer parameter *operationModeInfo* indicates ‘10’, or ‘11’
 - $I_{\text{NPDCCHStart}} = 0$

[212]

6.4.3 Downlink control information

ADCITransports downlink or uplink scheduling information for one cell and one RNTI. The RNTI is implicitly encoded in the CRC. The processing structure for one DCI is according to Section 5.3.3.

— 6.4.3.1 DCI Format N0

DCI format N0 is used for the scheduling of NPUSCH in one UL cell.

The following information is transmitted by means of the DCI format N0:

- Flag for format N0/format N1 differentiation – 1 bit, where value 0 indicates format N0 and value 1 indicates format N1
- Subcarrier indication – 6 bits as defined in section 16.5.1.1 of [3]
- Resource assignment – 3 bits as defined in section 16.5.1.2 of [3]
- Scheduling delay – 2 bits as defined in section 16.5.1 of [3]
- Modulation and coding scheme – 4 bits as defined in section 16.5.1.2 of [3]
- Redundancy version – 1 bit as defined in section 16.5.1.2 of [3]
- Repetition number – 3 bits as defined in section 16.5.1.2 of [3]
- New data indicator – 1 bit
- DCI subframe repetition number – 2 bits as defined in section 16.6 in [3]

— 6.4.3.2 DCI Format N1

DCI format N1 is used for the scheduling of one NPDSCH codeword in one cell and random access procedure initiated by a NPDCCH order. The DCI corresponding to a NPDCCH order is carried by NPDCCH.

The following information is transmitted by means of the DCI format N1:

- Flag for format N0/format N1 differentiation – 1 bit, where value 0 indicates format N0 and value 1 indicates format N1
- NPDCCH order indicator – 1 bit

Format N1 is used for random access procedure initiated by a NPDCCH order only if NPDCCH order indicator is set to '1', format N1 CRC is scrambled with C-RNTI, and all the remaining fields are set as follows:

- Starting number of NPRACH repetitions – 2 bits as defined in section 16.3.1 of [3]
- Subcarrier indication of NPRACH – 6 bits as defined in section 16.3.1 of [3]
- All the remaining bits in format N1 are set to one

Otherwise,

- Scheduling delay – 3 bits as defined in section 16.4.1 of [3]
- Resource assignment – 3 bits as defined in section 16.4.1.3 of [3]
- Modulation and coding scheme – 4 bits as defined in section 16.4.1.5 of [3]
- Repetition number – 4 bits as defined in section 16.4.1.3 of [3]
- New data indicator – 1 bit
- HARQ-ACK resource – 4 bits as defined in section 16.4.2 of [3].
- DCI subframe repetition number – 2 bits as defined in section 16.6 in [3]

When the format N1 CRC is scrambled with a RA-RNTI, then the following fields among the fields above are reserved:

- New data indicator
- HARQ-ACK resource

If the number of information bits in format N1 is less than that of format N0, zeros shall be appended to format N1 until the payload size equals that of format N0.

— 6.4.3.3 DCI Format N2

DCI format N2 is used for for paging and direct indication.

The following information is transmitted by means of the DCI format N2:

Flag for paging/direct indication differentiation – 1 bit, with value 0 for direct indication and value 1 for paging

If Flag=0:

- Direct Indication information – 8 bits provide direct indication of system information update and other fields, as defined in [6]
- Reserved information bits are added until the size is equal to that of format N2 with Flag=1

If Flag=1:

- Resource assignment – 3 bits as defined in section 16.4.1.3 of [3]

- Modulation and coding scheme – 4 bits as defined in section 16.4.1.5 of [3]
- Repetition number – 4 bits as defined in section 16.4.1.3 of [3]
- DCI subframe repetition number – 3 bits as defined in section 16.6 of [3]

3. Composition of Invention

Narrowband (NB)-LTE is a system for supporting low complexity, low power consumption with a system BW equivalent to 1 PRB of LTE system. It can be mainly used as a communication method to implement the internet of things (IoT) by supporting devices such as machine-type communication (MTC) in a cellular system. By using the same OFDM parameters as LTE such as subcarrier spacing of existing LTE, there is an advantage of being able to use frequencies efficiently by allocating 1 PRB to the legacy LTE band for NB-LTE without additional band allocation. In the case of downlink, the physical channel of NB-LTE is defined as N-PSS/N-SSS, N-PBCH, N-PDCCH/N-EPDCCH, N-PDSCH, etc., and is called by adding N- to distinguish it from LTE.

In terms of multicast or broadcast, which is distinct from unicast, the LTE system introduces an MBSFN subframe or SC-PtM method for MBMS service. The NB-LTE system should also consider using MBMS service in situations where broadcast or multicast services are required (e.g., software update). Therefore, when SC-PtM is to be operated in an NB-LTE system, the present invention proposes an appropriate PRB location where N-PDCCH/N-PDSCH, etc. transmitting SC-PtM-related information is transmitted and a method for allocating such PRB.

In addition, monitoring the search space means decoding a certain area of N-PDCCH according to the DCI format to be received via the search space, and then scrambling the corresponding CRC to a certain pre-promised RNTI value to confirm that the desired value is correct. In addition, since each UE in an NB-LTE system recognizes a single PRB as its respective carrier, the PRB referred to in this document can be said to have the same meaning as the carrier. DCI formats N0, N1, and N2 referred to in this document mean DCI formats N0, N1, and N2 as defined in 3GPP TS 36.212 [2] standard.

For the sake of document uniformity, terms should be defined as follows: "Anchor-type PRB" refers to a PRB that transmits N-PSS/N-SSS/N-PBCH/N-PDSCH for N-SIB, etc. for initial access from the e-NB perspective. Depending on the situation, there may be one anchor-type PRB or there may be multiple anchor-type PRBs. Next, in a situation where there are one or multiple anchor-type PRBs, if the UE has selected a specific anchor-type PRB through the initial access, the corresponding PRB is promised as an "anchor PRB." In addition, the PRB allocated by the eNB to proceed with the downlink process after initial access is promised as an "additional PRB."

3.1 Multicast PRB transmission different from camp-on PRB (or unicast PRB or paging PRB)

First of all, N-PDCCH, which transmits control information of MCCH, and N-PDCCH, which transmits control information of MTCH, may be transmitted in the same PRB, or they may be transmitted through different PRBs. Accordingly, it can be broadly divided into two categories, summarized as follows.

- I. A method for setting the N-PDCCH transmitting control information of MCCH and N-PDCCH transmitting control information of MTCH to be transmitted to the same PRB:

The initial UE may set that the representative PRB index information set as the representative through the anchor PRB (i.e., the initially accessed anchor-type PRB) is delivered using the system information block. That is, in the system information block, not only is SC-PtM-related information (e.g., SC-PtM is transmission cycle, etc.) transmitted, but additionally the representative PRB index-related information is delivered. Since the UE that receives this system information knows the representative PRB index at which the SC-PtM is transmitted, and also knows the cycle on which the SC-PtM is transmitted, it may obtain the SC-MCCH scheduling information (i.e., N-PDSCH scheduling) by monitoring the pre-arranged (or preset) common search space (CSS) area in the representative PRB. In this case, the UE may be set to monitor the aforementioned CSS area using the SC-RNTI value or another pre-arranged RNTI value.

In addition, the DCI format used in this case can be set to use the DCI format N1 or N2 used in the existing NB-IoT, or a new DCI format can be created and used (i.e., DCI format Nm, where m is an integer). Therefore, by decoding the corresponding N-PDSCH to obtain the SC-MCCH information, the UE can obtain the G-RNTI value per TMGI.

Subsequently, the UE may obtain the SC-MTCH scheduling information (i.e., N-PDSCH scheduling) by monitoring the pre-arranged (or preset) common search space (CSS) area in the representative PRB. In this case, the UE may be set to monitor the aforementioned CSS area using the G-RNTI value corresponding to the TMGI it wishes to receive, or another pre-arranged RNTI value. In addition, the DCI format used in this case can be set to use the DCI format N1 or N2 used in the existing NB-IoT, or a new DCI format can be created and set to be used (i.e., DCI format Nm, where m is an integer). Therefore, by decoding the corresponding N-PDSCH to obtain SC-MTCH information, the UE can obtain MBMS data (e.g., software update).

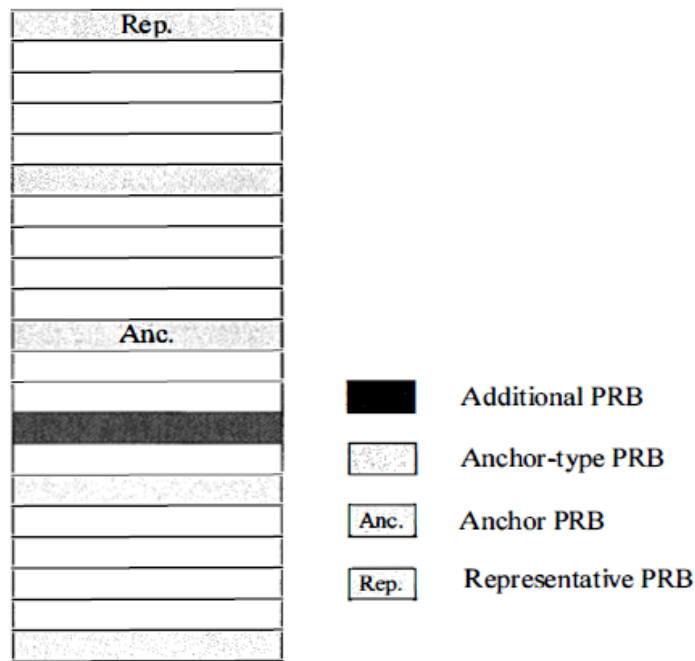


Figure 3.1.1: An example of PRB position and allocation for SC-PtM option 1.

- II. In case where the N-PDCCH transmitting the control information of the MCCH and the N-PDCCH transmitting the control information of the MTCH are transmitted to different PRBs:

The initial UE may set that the representative PRB index information set as representative by the anchor PRB is delivered using the system information block. That is, as mentioned above, in the system information block, not only is SC-PtM-related information transmitted, but additionally the representative PRB index-related information is delivered. Since the UE that receives such system information knows the representative PRB index at which SC-PtM is transmitted, and also knows the cycle on which SC-PtM is transmitted, it can obtain SC-MCCH scheduling information (i.e., N-PDSCH scheduling) by monitoring the pre-arranged (or preset) common search space (CSS) area in the representative PRB. In this case, the UE may be set to monitor the aforementioned CSS area using the SC-RNTI value or another pre-arranged RNTI value. Furthermore, the DCI format used in this case may be set to use the DCI format N1 or N2 used in the existing NB-IoT, or a new DCI format may be created and set to be used (i.e., DCI format Nm, where m is an integer). Thus, by decoding the corresponding N-PDSCH to obtain the SC-MCCH information, the UE can obtain the G-RNTI value per TMGI. Additionally, the UE may be set to obtain different multicast PRB (M-PRB) index information depending on the G-RNTI (or a specific G-RNTI group) by decoding the N-PDSCH in which the SC-MCCH is transmitted, and to receive different M-PRB index information depending on the G-RNTI (or a specific G-RNTI group) through group specific RRC signalling.

Subsequently, the UE may obtain SC-MTCH scheduling information (i.e., N-PDSCH scheduling) by monitoring the pre-arranged (or pre-set) common search space (CSS) area, user-specific search space (USS), or group-specific search space (GSS) in the M-PRB corresponding to the G-RNTI (or a specific G-RNTI group) of the TMGI to be received. In this case, the UE may be set to monitor the aforementioned CSS or USS or GSS area using a G-RNTI value corresponding to the TMGI it wishes to receive or another pre-arranged RNTI value. In addition, the DCI format used in this case can be set to use the DCI format N1 or N2 used in the existing NB-IoT, or a new DCI format can be created and set to be used (i.e., DCI format Nm, where m is an integer). Therefore, by decoding the corresponding N-PDSCH to obtain SC-MTCH information, the UE can obtain MBMS data.

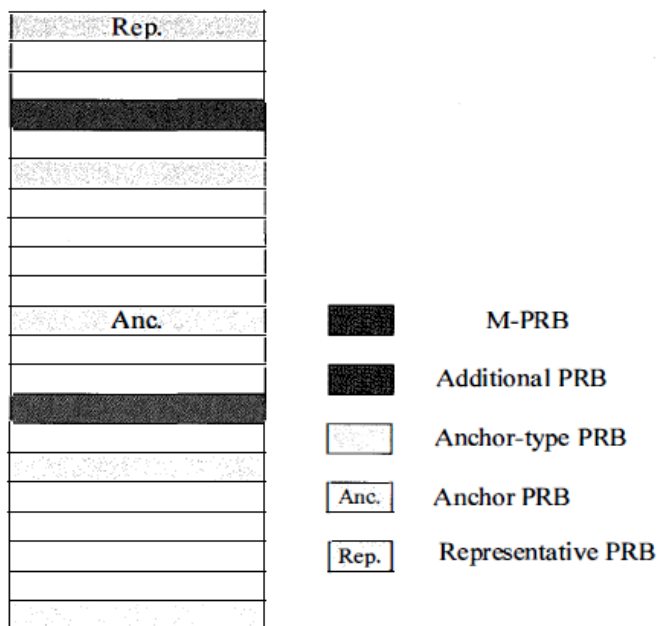


Figure 3.1.2: An example of PRB position and allocation for SC-PtM option 2.

For both I and II above, it is common for the N-PDSCH transmitting the MCCH to be transmitted in the same PRB as the PRB in which the N-PDCCH transmitting the control information of the MCCH is transmitted, and it is also common for the N-PDSCH transmitting the MTCH to be transmitted in the same PRB as the PRB in which the N-PDCCH transmitting the control information of the MTCH is transmitted. However, due to the nature of NB-IoT system using 1RB, there is no condition that the PRB transmitting N-PDCCH and the PRB transmitting N-PDSCH are necessarily the same, so it may also be set to dynamically convey the information that N-PDSCH is transmitted to a third PRB different from the PRB to which each N-PDCCH is transmitted. As an example, it may be set to inform the new PRB index on which the N-PDSCH, which transmits the MCCH, is transmitted in addition to the N-PDCCH which transmits the control information of the MCCH, etc. Similarly, it may be set to inform the new PRB index on which the N-PDSCH, which transmits MTCH, is transmitted in addition to the N-PDCCH which transmits the control information of MTCH, etc. In this case, the new PRB to which the N-PDSCH carrying the SC-MCCH is transmitted, the new PRB to which the N-PDCCH carrying the scheduling information of the SC-MTCH is transmitted, and the new PRB to which the N-PDSCH carrying the SC-MTCH is transmitted may be allocated independently of each other, or they may be the same, or they may be separated by a certain PRB interval between the three, or they may have a certain rule-based relationship.

Furthermore, for both I and II above, the UE may obtain the SC-MCCH change notification information by monitoring a pre-arranged (or preset) common search space (CSS) area in the representative PRB. In this case, the UE may be set to monitor the aforementioned CSS area using the SC-RNTI value or another pre-arranged RNTI value. Further, the DCI format used in this case may be set to use the DCI format N1 or N2 used in the existing NB-IoT, or a new DCI format may be created and set to be used (i.e., DCI format Nm, where m is an integer).

Further, it may be contemplated that in I and II above, the PRBs on which the MCCH or the N-PDCCH scheduling the MCCH are transmitted and the PRBs on which the MTCH or the PDCCH scheduling the MTCH may each be independently informed through system information (e.g., SIB). Alternatively, in I above, the representative PRB may not be applied to the MCCH or the N-PDCCH scheduling the MCCH, but only to the MTCH or the N-PDCCH scheduling the MTCH. In this case, the UE may read the MCCH or N-PDCCH scheduling MCCH from the anchor PRB.

Additionally, the representative PRB may be a representative anchor-type PRB selected from among the anchor-type PRBs.

3.2. Multicast PRB transmission same with camp-on PRB (or unicast PRB or paging PRB)

The method of transmitting MCCH N-PDCCH or MTCH N-PDCCH using a PRB different from the camp-on PRB (or unicast PRB or paging PRB) in 3.1 is to transmit multicast Tx using an independent PRB from the legacy NB-IoT Tx at the UE side, so that there is no case that unicast N-PDCCH is transmitted to the same PRB as SC-PtM N-PDCCH at the configured UE side. Also, from the idle UE perspective, paging DCIs and SC-PtM N-PDCCHs are no longer transmitted to the same PRB. On the other hand, the method of transmitting MCCH N-PDCCH or MTCH N-PDCCH using the same PRB as the camp-on PRB (or unicast PRB or paging PRB) can be summarized into two cases as follows.

- I. A method for aligning the DCI format of N-PDCCH that delivers control information of MCCH or MTCH with DCI format N1

In this case, to make the DCI format equal to N1, you can use the actual DCI format N1, or you can set to use a new DCI format to have the same payload as DCI format N1. In this case, it is important to add extra zeros (zero padding) to make the length the same as DCI format N1 if there is still space left after fitting the data. In this case, the length of DCI format N1 can mean the length after zero-padding if DCI format N1 is zero-padded to make it the same size as other DCI formats. Furthermore, the search space in which the N-PDCCH carrying the control information of the MCCH or MTCH is transmitted may be set to use the common search space for SC-PtM. Characteristically, the case where the DCI format of the N-PDCCH carrying the control information of the MCCH or MTCH is set to be equal to DCI format N1, in order to avoid increasing the number of N-PDCCH blind decoding by the UE, 1) may be set that the search space in which the N-PDCCH carrying the control information of the MCCH or MTCH is transmitted to be included in the UE-specific search space (USS) in which the N-PDCCH for the UE-specific data schedule is transmitted, and 2) may be applied to the case where the PRB on which the search space, in which the N-PDCCH carrying control information of MCCH or MTCH can be transmitted, is transmitted, is the same as the PRB in which the USS is transmitted.

First, considering the case of connected mode, the UE may be set that the search space in which the MCCH and MTCH DCIs are transmitted is the same as the USS (i.e., the NPDCCH UE-specific search space) or has a relationship that is included in the USS. In this case, the connected mode UE may be distinguished using CRC masking by employing different RNTI values (e.g., unicast: C-RNTI, MCCH: SC-RNTI, MTCH: G-RNTI) for the unicast control DCI and the DCI of the MCCH or the MTCH it was looking at without any additional BD. In addition, the UE will be able to decode MCCH control or MTCH control without frequency shift and without unicast interruption.

On the other hand, for idle mode UE, since the DCI format is set to N1, an additional action is required compared to the legacy operation to view the control information of MCCH or MTCH transmitted in DCI format N1 for idle mode UE. In this case, the additional actions are as follows. The idle mode UEs will monitor the DCI format N2 size using P-RNTI to view the paging that was originally intended to be viewed during the UE DRX cycle. In this case, when SC-PtM (i.e., MCCH or MTCH control) related DCI is transmitted in the same subframe, it is tailored to DCI format N1 size and cannot be decoded without additional BD (i.e., to satisfy the max BD requirement), so it is impossible to obtain SC-PtM related information. However, if the terminal is capable of performing additional BD, it can obtain SC-PtM related information by additionally monitoring the DCI format N1 size using SC-RNTI or G-RNTI.

II. A method for aligning the DCI format of N-PDCCH that delivers control information of MCCH or MTCH with DCI format N2

In this case, to make the DCI format equal to N2, you can use the actual DCI format N2, or you can set to use a new DCI format to have the same payload as DCI format N2. In this case, it is important to add extra zeros (zero padding) to make the length the same as DCI format N2 if there is still space left after fitting the data. In this case, the length of DCI format N2 can mean the length after zero-padding if DCI format N2 is zero-padded to make it the same size as other DCI formats. Further, it may be set that the search space in which the N-PDCCH delivering the control information of the MCCH or MTCH is transmitted uses the common search space for SC-PtM. Characteristically, the case where the DCI format of the N-PDCCH carrying the control information of the MCCH or MTCH is set to be equal to DCI format N2, in order to avoid increasing the number of N-PDCCH blind decoding by the UE, 1) may be set that the search space in which the N-PDCCH carrying the control information of the MCCH or MTCH is transmitted to be included in the cell-specific search space (CSS) in which the N-PDCCH for paging schedule is transmitted, and 2) may be applied to the case where the PRB to which the search space in which the N-PDCCH carrying the control information of the MCCH or MTCH can be transmitted is transmitted is the same as the PRB to which the CSS in which the N-PDCCH scheduling paging is transmitted is transmitted.

First, considering the case of idle mode, the UE may set that the search space in which the MCCH and MTCH DCIs are transmitted is the same as the CSS used by the paging signal (i.e., Type1-NPDCCH common search space) or has a relationship that is included in that CSS. In this case, the idle mode UE may be distinguished using CRC masking by employing different RNTI values (e.g., paging DCI: P-RNTI, MCCH: SC-RNTI, MTCH: G-RNTI) for the paging DCI and the DCI of the MCCH or MTCH it was looking at without any additional BD.

On the other hand, in case of connected mode UE, since the DCI format is set to N2, the connected mode UE needs an additional action compared to the legacy operation to view the control information of MCCH or MTCH transmitted in DCI format N2. The additional actions are as follows. In the case of connected mode UE, the DCI format N1 size is monitored using C-RNTI to view the unicast control information. At this time, when SC-PtM (i.e., MCCH or MTCH control) related DCI is transmitted in the same subframe, it is not possible to decode it without additional BD because it is tailored to DCI format N2 size, so it has to choose between obtaining SC-PtM related information or obtaining unicast control information. At this point, it is necessary to decide the priority of which one should be received first. First of all, it can be set to determine whether to receive multicast or not depending on the service type. As a specific example, you can set up for receiving multicast first for critical firmware updates, even if it receives unicast later. It can also be advantageous to set multicast to be received first because unicast has an A/N, so it can immediately tell you that it hasn't been received, whereas multicast doesn't have an A/N, so there's no way to tell until the information is exchanged at a higher layer. Alternatively, the determination can be made based on the amount of data sent in unicast. At the present time, if unicast data exceeding a certain pre-arranged threshold value has been received, unicast transmission can be continued, otherwise, multicast can be set to be received. This is because there is already a lot of unicast data in the buffer, and it is more burdensome to set it to receive it again. However, if the terminal is capable of performing additional BD, it can obtain SC-PtM-related information by additionally monitoring the DCI format N2 size using SC-RNTI or G-RNTI. Also, if the terminal has already received a scheduled unicast PDSCH via N-PDCCH decoded via USS, it can continue to receive unicast PDSCH without attempting to receive multicast in that segment.

The method of determining the priority of which to receive between unicast transmission and multicast transmission is applied even in the same PRB, but can also be applied when transmitted to the same SF in different PRBs.

In I and II above, the MCCH changing notification is transmitted in CSS type 1 using DCI format N2, but it is transmitted once in a very long time, and since the MCCH changing notification is transmitted to a different SF than the SF from which MCCH control is transmitted, it can be said that no additional BD problems occur in either connected mode or idle mode.

3.3 Multiple PRBs transmission for MCCH control

It is possible to consider a method where N-PDCCH transmitting MCCH control information is transmitted with multiple PRBs instead of being transmitted with one PRB. In other words, if the eNB transmits MCCH control information using several number of PRBs set semi-statically, each UE can select one of the several PRBs to check the MCCH control information and decode the MCCH to check the G-RNTI value per TMGI. At this time, if the several PRBs transmitting the MCCH control information overlap with the PRBs performing unicast transmissions that each UE is watching, PRBs looking at paging signals, or camp-on PRBs, the UE can decode the MCCH control information and MCCH without frequency shift and without unicast interruption.

Then, UEs that have identified the G-RNTI value through the MCCH N-PDSCH can move to the PRB where the MTCH control information is transmitted and identify the MTCH control information using the G-RNTI value corresponding to the TMGI they wish to receive, and decode the MTCH accordingly to receive the MBMS data.

Furthermore, the UE may obtain SC-MCCH change notification information by monitoring a pre-arranged (or preset) common search space (CSS) area in the PRB where the control information of the MCCH is transmitted. In this case, the UE may set to monitor the aforementioned CSS area using the SC-RNTI value or another pre-arranged RNTI value. In addition, the DCI format used in this case can be set to use the DCI format N1 or N2 used in the existing NB-IoT, or a new DCI format can be created and set to be used (i.e., DCI format Nm, where m is an integer).

4. Effectiveness of Invention

In the present invention, when SC-PtM is to be operated in an NB-IoT system supporting cellular IoT (internet of things), a suitable PRB location to which N-PDCCH/N-PDSCH, etc. transmitting SC-PtM-related information is transmitted and a method for allocating such PRB are proposed. Furthermore, although the present invention is mainly concerned with NB-IoT systems, it can be extended to similar narrow band systems. In general, the PRB (i.e., carrier) can be applied by replacing it with the narrow band (i.e., 6RB) of the MTC system, and DCI format N1 can be applied by replacing it with DCI format 6-1A/1B, and DCI format N2 can be applied by replacing it with DCI format 6-2.

5. References

- [1] 3GPP TS 36.211 V13.2.0, *Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation (Release 13)*
- [2] 3GPP TS 36.212 V13.2.0, *Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding (Release 13)*
- [3] 3GPP TS 36.213 V13.2.0, *Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (Release 13)*
- [4] 3GPP TS 36.331 V13.2.0, *Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (Release 13)*

Electronic Acknowledgement Receipt	
EFS ID:	26583971
Application Number:	62372323
International Application Number:	
Confirmation Number:	2126
Title of Invention:	SC-PtM FOR ENHANCED NB-IoT SYSTEM
First Named Inventor/Applicant Name:	Seokmin SHIN
Customer Number:	67487
Filer:	Andrew S. Park
Filer Authorized By:	
Attorney Docket Number:	UT16-1104-US
Receipt Date:	09-AUG-2016
Filing Date:	
Time Stamp:	06:04:15
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$ 260
RAM confirmation Number	080916INTEFSW06054000
Deposit Account	4364
Authorized User	Andrew PARK
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	UT16-1104_ADS.pdf	1826320	no	9
			b58155dca90f9aabb844cd28043b618bf5f684b		
Warnings:					
Information:					
2	Specification - Not in English	UT161104_SPEC.pdf	3248946	no	25
			622c612cac3bc6fb0531226ef5c5a8712c094f9		
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	29773	no	2
			7daf1c0f85a1a8260da37ac807118af626f9940f		
Warnings:					
Information:					
Total Files Size (in bytes):			5105039		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> 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. <u>National Stage of an International Application under 35 U.S.C. 371</u> 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. <u>New International Application Filed with the USPTO as a Receiving Office</u> 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, [SooJin Namgung], hereby declare:

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

I translated U.S. Application Number 62/372,323 from Korean into English and to the best of my knowledge and belief, the attached Document is a true and accurate translation from Korean 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 18, 2024

남궁수진