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August 22, 2017

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APPLICATION NUMBER: 62/372,324
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 *US62/372,324*



Certified by

Michelle M. Lee

Under Secretary of Commerce
for Intellectual Property
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Patent and Trademark Office

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1105-US
		Application Number	
Title of Invention	REPETITION LEVEL OF 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.			

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Inventor Information:

Inventor	1				Remove
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1105-US
		Application Number	
Title of Invention	REPETITION LEVEL OF SC-PIM FOR ENHANCED NB-IoT SYSTEM		

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Inventor	4			Remove
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All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button.

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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	UT16-1105-US
		Application Number	
Title of Invention	REPETITION LEVEL OF SC-PIM FOR ENHANCED NB-IoT SYSTEM		

Application Information:

Title of the Invention	REPETITION LEVEL OF SC-PIM FOR ENHANCED NB-IoT SYSTEM		
Attorney Docket Number	UT16-1105-US	Small Entity Status Claimed	☐
Application Type	Provisional ▼		
Subject Matter	Utility ▼		
Total Number of Drawing Sheets (if any)		Suggested Figure for Publication (if any)	

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For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐	Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1105-US
		Application Number	
Title of Invention	REPETITION LEVEL OF SC-PIM FOR ENHANCED NB-IoT SYSTEM		

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This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

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Prior Application Status		Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. ☐ NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.
--

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1105-US
		Application Number	
Title of Invention	REPETITION LEVEL OF SC-PIM FOR ENHANCED NB-IoT SYSTEM		

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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).

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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).

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1105-US
		Application Number	
Title of Invention	REPETITION LEVEL OF 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.				
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		
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1105-US
		Application Number	
Title of Invention	REPETITION LEVEL OF 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.				
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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
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT16-1105-US
		Application Number	
Title of Invention	REPETITION LEVEL OF 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.**

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PROVISIONAL APPLICATION FOR UNITED STATES PATENT
IN THE NAMES OF

**Seokmin SHIN, Joonkui AHN, Hyangsun YOU and
Seunggye HWANG**

for

REPETITION LEVEL OF SC-PtM FOR ENHANCED NB-IoT SYSTEM

Customer Number: 67487

Attorney Docket Number: UT16-1105-US

Total Number of pages: 16 (including cover)

Standard Patent Request

CTO Next-Generation Standard Research Center	Issue Date: 2016	
Inventors	Seok-min Shin, Joon-gi An, Hyang-seon Yu, Sum-gye Hwang	
Title of Invention	Repetition level of SC-PtM for enhanced NB-IoT system	
Standardization Body	3GPP TSG RAN1	Expected conference for announcement
Related Technical Field	LTE-A, MTC	
Related Standard Specifications		

1. Purpose of Invention

The present invention proposes a method of effectively selecting a Coverage Enhancement (CE) level such as N-PDCC/N-PDSCH, and the like for transmitting MCCH/MTCH control/data when operating SC-PtM in an NB-LTE system.

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

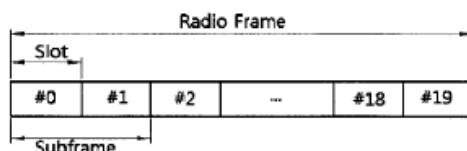


Figure 1. Structure of a radio frame of 3GPP LTE

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.

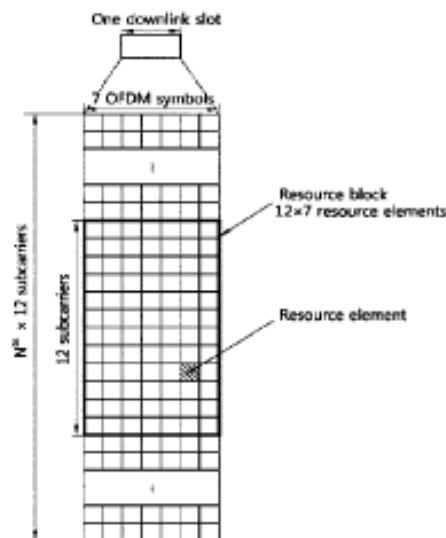


Figure 2. Resource grid for one downlink slot

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 12x7 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.

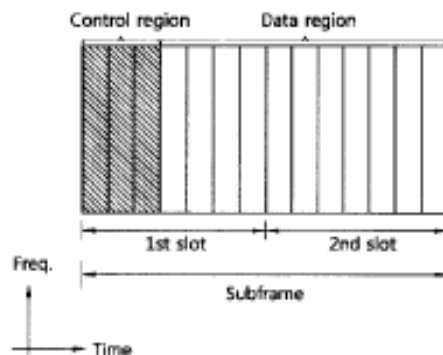


Figure 3. Structure of downlink subframe

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.

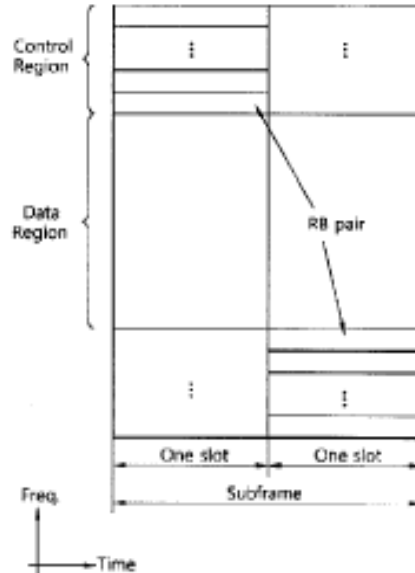


Figure 4. Structure of uplink subframe

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.

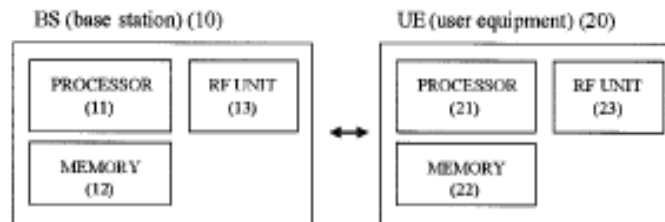


Figure 5. System for implementing present invention

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.

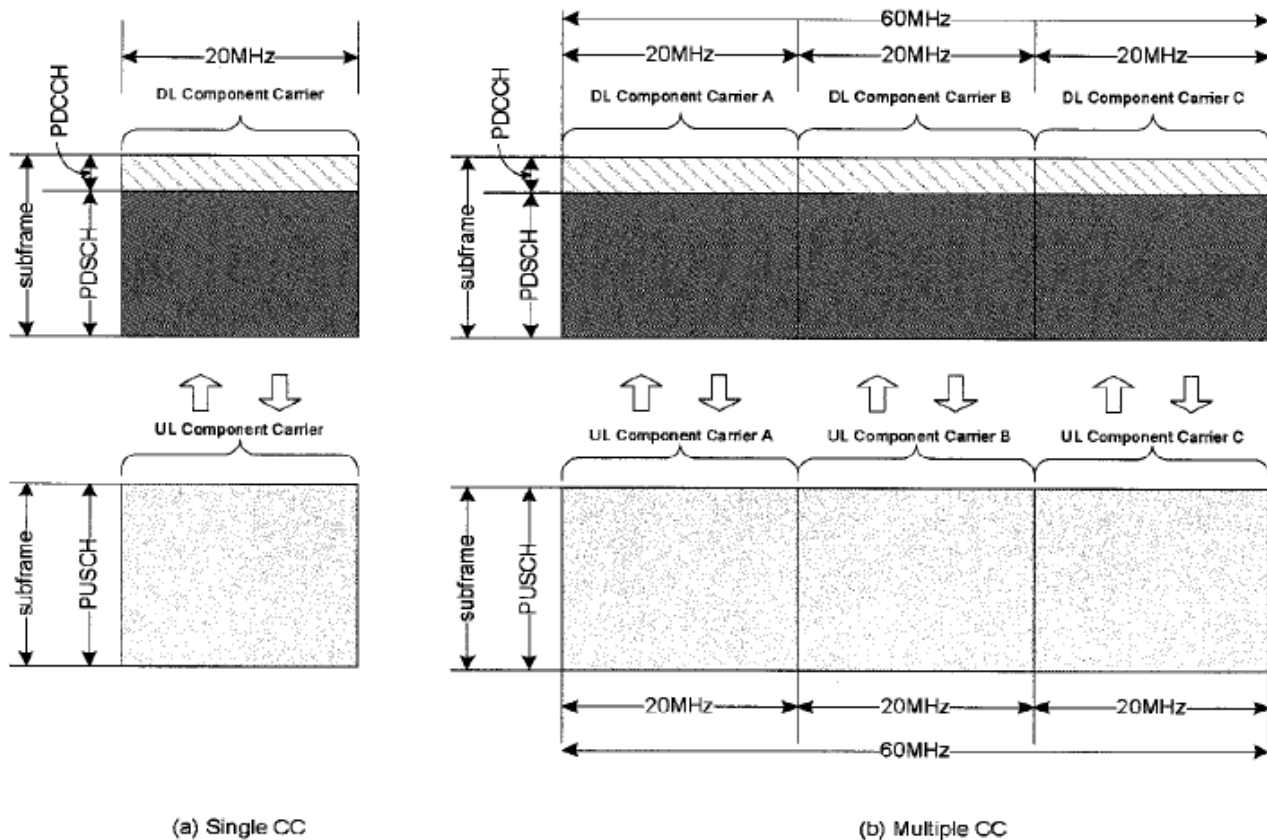


Figure 6. Subframe structure of 3GPP LTE Release-8 system and LTE-A system with CC aggregation

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

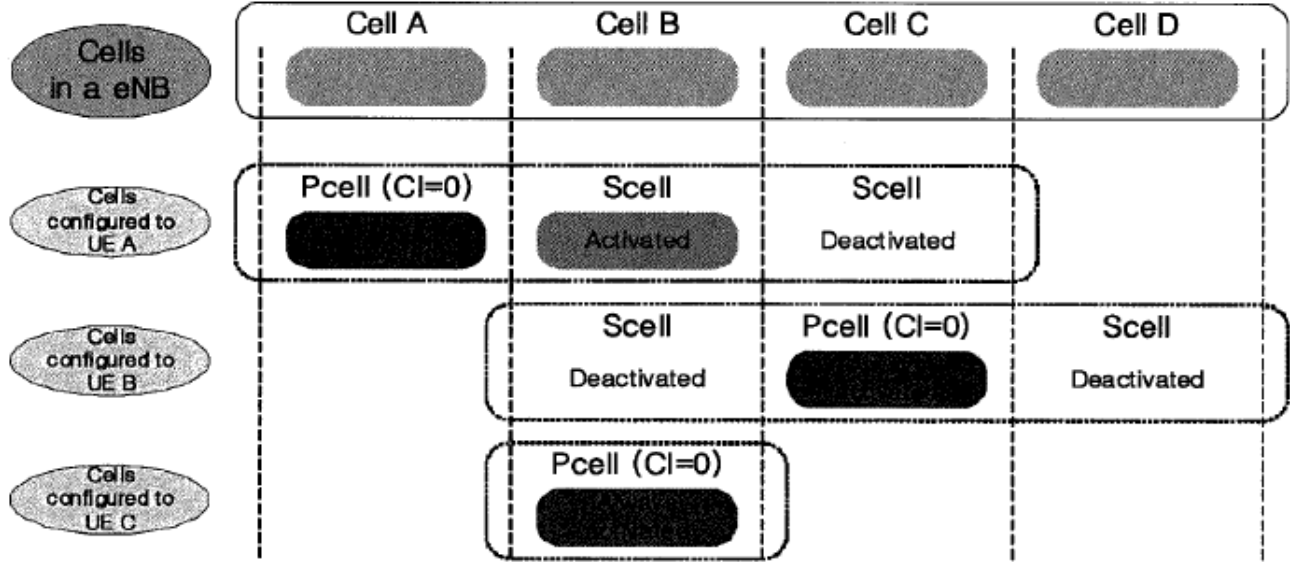


Figure 7. Configured cell, activated cell, de-activated cell

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 SCI 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.

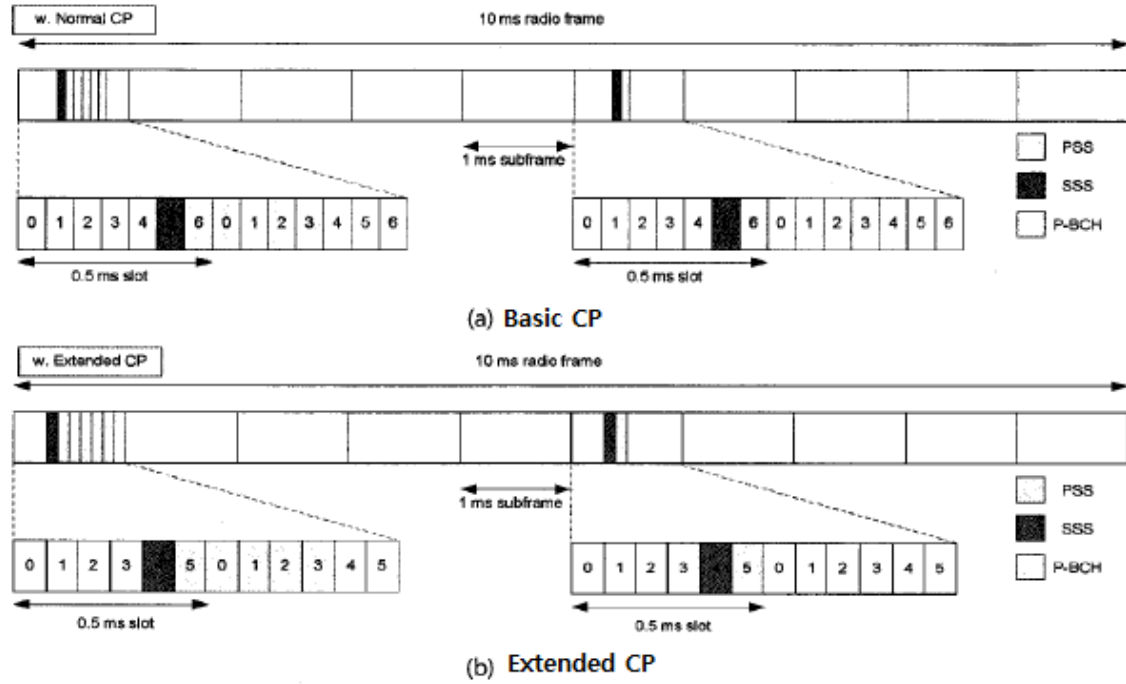


Figure 8. Frame structures for SS transmission

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 CP 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%.

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

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.

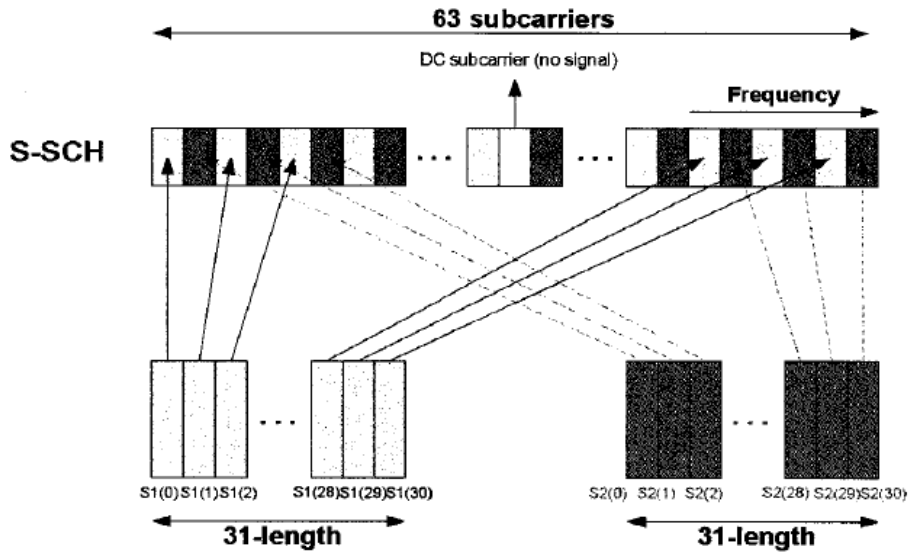


Figure 9. S-SS code generation method

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 downlink 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 downlink radio link quality of the PCell.
- The threshold Q_{out} is defined as the level at which the downlink 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 downlink 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 *SCPTMConfiguration* 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-mtch-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 *sc-mcch-FirstSubframe*, 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 *sc-mcch-FirstSubframe*.

sc-mcch-Offset

Indicates, together with the *sc-mcch-RepetitionPeriod*, 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.

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). Also, since there may be situations where some UEs need coverage enhancement, such as in NB-LTE system, it is necessary to consider the CE level for multicast transmission. Therefore, in the present invention, when trying to operate SC-PtM in the NB-LTE system, a method for efficiently setting the CE (coverage enhancement) level of N-PDCCH/N-PDSCH etc., which transmits control/data of MCCH/MTCH, is proposed.

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 "additional PRB." Further, since each UE in NB-LTE system recognizes a single PRB as its respective carrier, the PRB mentioned in this document can be considered to have the same meaning as the carrier.

3.1. CE level of N-PDCCH/N-PDSCH for SC-PtM

A. First of all, a method to set the CE level of the N-PDCCH or N-PDSCH carrying SC-PtM information to a single CE level may be considered. In this case, the CE level may mean the repetition number set or maximum repetition number of N-PDCCH or N-PDSCH. Therefore, a change in the CE level may mean changes in the repetition number set or the maximum repetition number of N-PDCCH or N-PDSCH. Also, the repetition number set or maximum repetition number of N-PDCCH or N-PDSCH corresponding to each CE level may be defined/set. The use of one CE level is advantageous because it has low complexity in terms of system implementation. Exemplary embodiments of the above methods are as follows.

1. A Method setting the CE level used in the system to a fixed CE level (repetition number set or maximum repetition number corresponding to the fixed CE level) (i.e., in all cells, NB-IoT multicast CE level uses a specific fixed CE level):

This method is applicable to both determining the CE level of the N-PDCCH that carries the control information of the MCCH or MTCH, e.g., setting the fixed CE level to the maximum CE level (repetition number set or maximum repetition number corresponding to the maximum CE level) may be advantageous for systems with a large number of UEs in a location with poor channel conditions (e.g., underground, warehouse, etc.) because service is available to most UEs that belong to the system (or cell). However, it may be disadvantageous to UEs in a location with good channel conditions as it may result in unnecessary repetition.

2. A method that each cell sets to one CE level value cell specifically and the eNB informs the UE of this via system information:

This method is applicable to both determining the CE level of N-PDCCH that carries control information of MCCH or MTCH, and it can be set that the eNB determines the average channel situation by knowing the channel characteristics of the UEs configured to it and the location of those UEs, and then sets the CE level value semi-statically and provides notification thereof through system information. Using this method, since the CE level can be determined cell-specifically, it has the advantage of lowering the complexity of each system implementation and reducing unnecessary repetitions.

B. Next, a method to set the CE level of the N-PDCCH or N-PDSCH carrying SC-PtM information to multiple CE levels (i.e., repetition number sets, multiple maximum repetition numbers) may be considered. The advantage of using multiple CE levels is that the CE level can be set differently depending on the channel situation of the UE or depending on the multicast service type to reduce unnecessary repetitions, and the CE level can be applied appropriately depending on the situation. Exemplary embodiments of the above method are as follows:

1. A method setting the CE level for each TMGI (or G-RNTI or service type) as known in advance between the eNB and the terminal:

This method is applicable to determine the CE level of the N-PDCCH carrying the control information of the MTCH and/or the CE level of the N-PDSCH carrying the MTCH, by setting the CE level differently for each TMGI (or G-RNTI or service type) that can be done via the MCCH N-PDSCH. In other words, for example, if the multicast service type is an important update that all UEs need to perform immediately, the CE level can be set to a large value so that all UEs with poor channel environment can receive it, or if the multicast service type is a group call for UEs located in a good channel environment, the CE level can be set to the minimum value that the UEs can receive to avoid unnecessary repetition. Characteristically, this CE level setting information for each TMGI (or G-RNTI or service type) can be sent to the UEs via RRC signal or MCCH.

2. A method setting the CE level differently for each UE group (or each UE):

This method is applicable to both determining the CE level of N-PDCCH carrying control information of MCCH or MTCH and/or N-PDSCH carrying MCCH or MTCH. From the eNB perspective, it can set that control information of MCCH or MTCH and/or N-PDSCH carrying MCCH or MTCH are transmitted using different CE levels using different PRBs. The CE levels used at this time can be set independently for each cell, but it can be set that the CE level transmitted to a specific PRB should be transmitted to all UEs via system information. The UE that has received the system information can select the desired CE level for each UE, move to the PRB to which the control information is transmitted and set it to receive control information from the MCCH or MTCH. Using this method has the advantage that each UE can select the desired CE level according to its channel environment, but from the eNB perspective, it has the disadvantage that it must use multiple PRBs to send the same information with only different repetitions.

Furthermore, from the eNB perspective, it may be set that the control information of the MCCH or MTCH is transmitted not using different PRBs but using the same PRB but with different subframes (i.e., timing) and using different CE levels. The CE levels used in this case can be set independently for each cell as mentioned above, but it may be set that the subframe (i.e., timing) in which N-PDCCHs with different CE levels are allocated should be transmitted to all UEs through system information.

The UE that has received the system information can select the desired CE level for each UE and set that they can receive the control information of the MCCH or MTCH according to the timing of the subframe being transmitted. Using this method reduces the disadvantage of having to send the same information using multiple PRBs from the eNB perspective, which occurred earlier, but it may cause a delay problem that exist to support all the desired repetitions of each UE.

4. Effectiveness of Invention

In the present invention, when trying to operate SC-PtM in an NB-LTE system, a method for efficiently setting the CE (coverage enhancement) level of N-PDCCH/N-PDSCH etc., which transmits control/data of MCCH/MTCH, has been proposed. Furthermore, although the present invention is mainly concerned with NB-IoT system, it can be extended to similar narrow band systems (e.g., LTE MTC, etc.).

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 36.213 V13.2.0, *Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (Release 13)*
- [3] 3GPP TS 36.331 V13.2.0, *Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (Release 13)*

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First Named Inventor/Applicant Name:	Seokmin SHIN
Customer Number:	67487
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Deposit Account	4364
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Warnings:					
Information:					
2	Specification - Not in English	UT161105_SPEC.pdf	1829226 e0808ac825794d4db325db290a0a6053da7a1e77	no	16
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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 62/372,324 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 16, 2024

_____남궁수진_____