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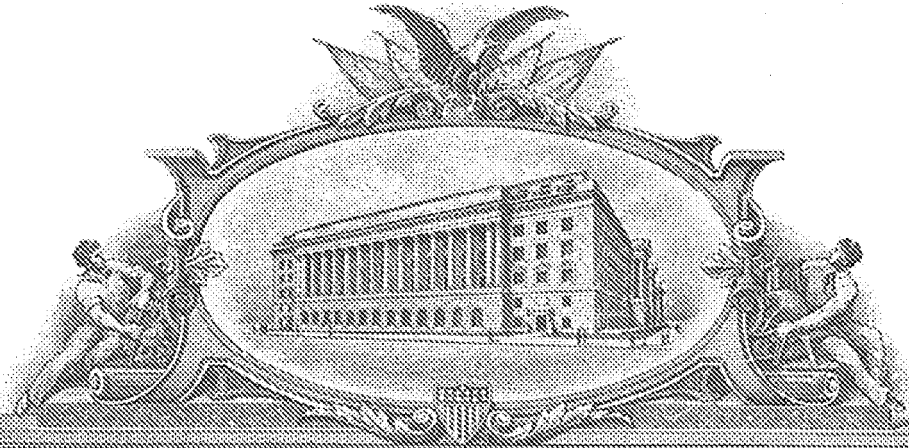
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APPLICATION NUMBER: 62/372,323

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*



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

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City	Seoul	State/Province		
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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		

Application Information:

Title of the Invention	SC-PtM 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.

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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		

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.

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Prior Application Status		Remove
Application Number	Continuity Type	Prior Application Number
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Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)	Remove
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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	UT16-1104-US
		Application Number	
Title of Invention	SC-PtM 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.

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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		

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	<button>Remove</button>		
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.				
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Assignee	Legal Representative under 35 U.S.C. 117		Joint Inventor	
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Name of the Deceased or Legally Incapacitated Inventor:				
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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		

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	UT16-1104-US
		Application Number	
Title of Invention	SC-PtM 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, 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)

표준특허의뢰서

CTO) 차세대 표준 연구소	발송일: 2016	
발명자	신석민, 유향선, 안준기, 이윤정	
발명의 명칭	SC-PtM for enhanced NB-IoT system	

표준화기구	3GPP TSG RAN1	발표예정회의	
관련기술분야	LTE-A, MTC		
관련 표준규격			

1. Purpose of Invention

본 발명에서는 cellular IoT (internet of things)를 지원하는 NB-IoT시스템에서 SC-PtM을 동작 시키려 할 경우, SC-PtM 관련 정보를 전송하는 N-PDCCH/N-PDSCH 등이 전송되는 적절한 PRB 위치 및 해당 PRB의 할당 방법에 대해 제안 한다.

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

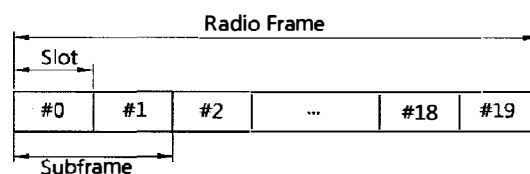


Figure 1. Structure of a radio frame of 3GPP LTE

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.

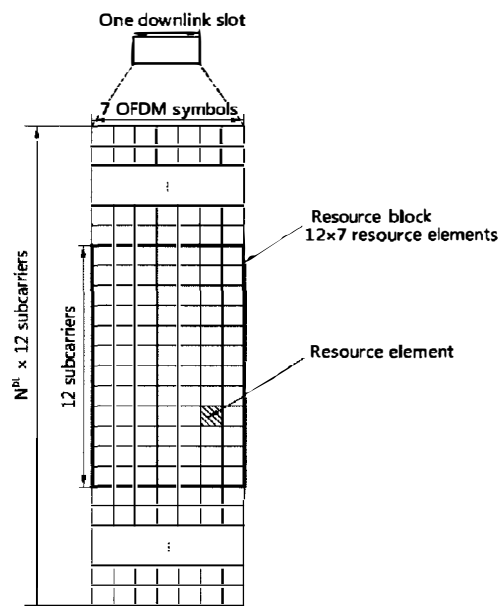


Figure 2. Resource grid for one downlink slot

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.

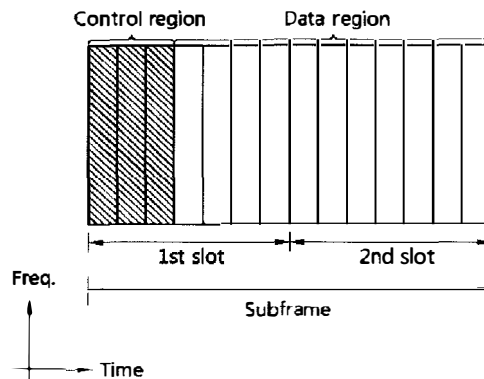


Figure 3. Structure of downlink subframe

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.

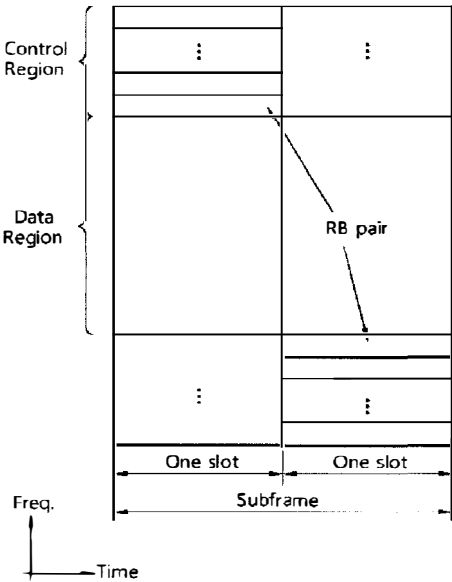


Figure 4. Structure of uplink subframe

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.

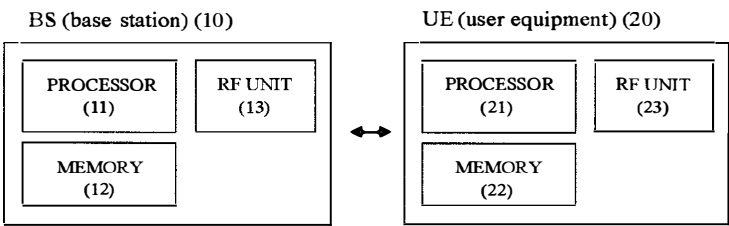


Figure 5. System for implementing present invention

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 $L \leq M \leq N$.

여기서 CC는 Cell로 구분될 수 있으며, 등가의 개념으로 표현될 수 있다.

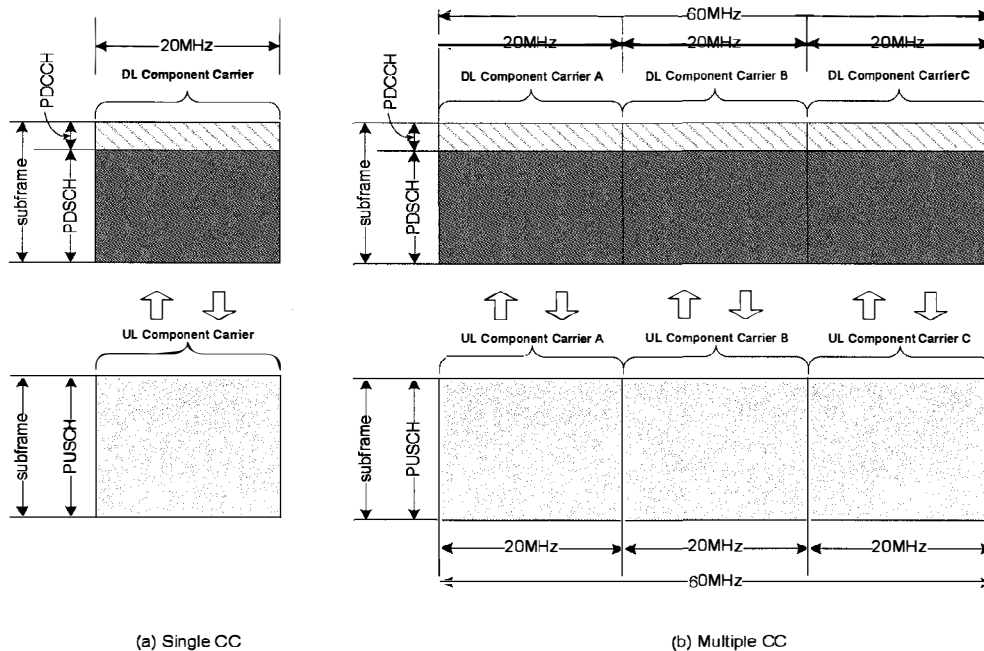


Figure 6. Subframe structure of 3GPP LTE Release-8 system and LTE-A system with CC aggregation

Carrier aggregation을 지원하는 시스템에서 cell은 다음 Figure 7과 같이 구분할 수 있다.

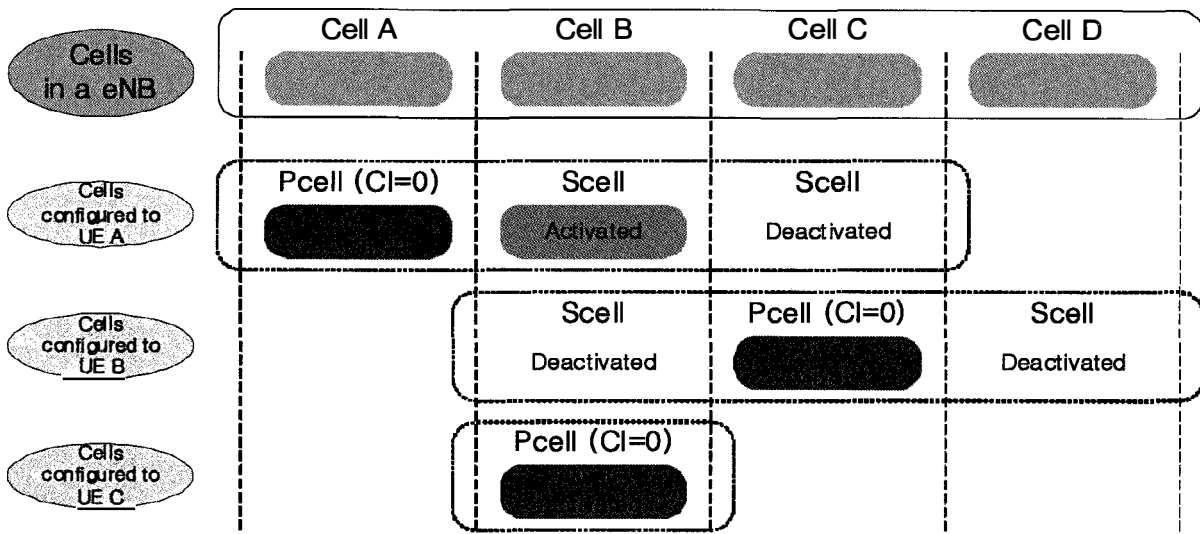


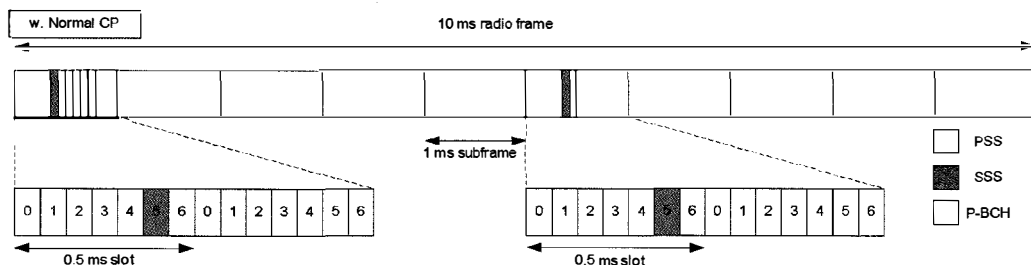
Figure 7. Configured cell, activated cell, de-activated cell

Configured cell은 Figure 7에서와 같이 기지국의 cell 중에서 measurement report를 근거로 carrier aggregation할 수 있도록 한 cell로서 UE별로 설정된다. Configured cell은 PDSCH 전송에 대한 ACK/NACK 전송을 위한 resource를 미리 예약해 놓게 된다. Activated cell은 configured cell 중에서 실제로 PDSCH/PUSCH를 전송하도록 설정된 cell로서 PDSCH/PUSCH 전송을 위한 CSI report와 SRS transmission을 수행하게 된다. De-activated cell은 기지국의 명령 또는 timer 동작에 의해서 PDSCH/PUSCH 전송을 하지 않도록 하는 cell로서 CSI report 및 SRS 전송도 중단된다.

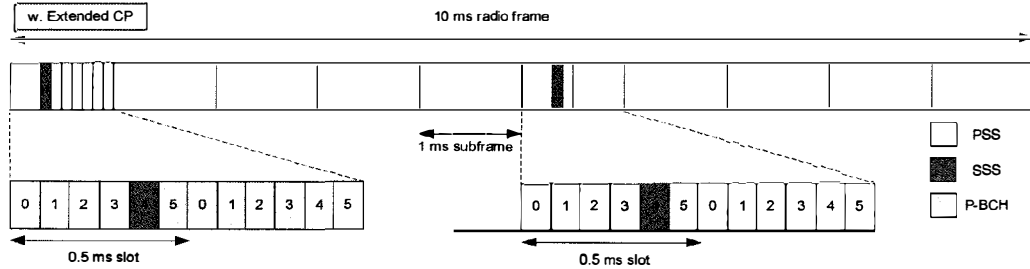
2-3 Synchronization signal (SS) in LTE-A FDD

SS는 P-SS와 S-SS로 구성되며, 셀 탐색을 수행할 때 사용되는 신호이다.

Figure 8 (a)와 (b)는 각각 기본 CP와 확장 CP를 사용하는 시스템의 경우 SS의 전송을 위한 프레임 구조를 도시한 것이다. SS는 inter-RAT measurement의 용이함을 위해 GSM 프레임 길이인 4.6ms를 고려하여 부프레임 0번과 부프레임 5번의 두 번째 슬롯에서 각각 전송되고, 해당 라디오 프레임에 대한 경계는 S-SS를 통해 검출 가능하다. P-SS는 해당 슬롯의 맨 마지막 OFDM 심볼에서 전송되고, S-SS는 P-SS 바로 앞 OFDM 심볼에서 전송된다. SS는 3개의 P-SS와 168개의 S-SS의 조합을 통해 총 504개의 물리계층 셀 식별자(physical cell ID)를 전송할 수가 있다. 또한, SS 및 PBCH는 시스템 대역폭 내의 가운데 6RB 내에서 전송되어, 전송 대역폭에 관계없이 UE가 검출 혹은 복호할 수 있도록 한다.



(a) 기본 CP의 경우



(b) 확장 CP의 경우

Figure 8. SS 전송을 위한 프레임 구조

SS의 전송 다이버시티 방식은 단일 안테나 포트 (single antenna port)만을 사용하고, 표준에서는 따로 정의하지 않는다. 즉, 단일 안테나 전송 혹은 UE에 투명한(transparent) 전송 방식 (예를 들어 PVS, TSTD, CDD)을 사용할 수가 있다.

a. P-SS 부호

길이 63의 ZC (Zadoff-Chu) 시퀀스를 주파수 영역에서 정의하여 P-SS의 시퀀스로 사용한다. ZC 시퀀스는 식 (1)에 의해 정의되며, DC 부반송파에 해당되는 시퀀스 요소(element), $n=31$ 은 천공 (puncturing)한다. 식 (1)에서 $N_{zc}=63$ 이다.

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

가운데 부분의 6RB (=72 부반송파) 중 9개의 남은 부반송파는 항상 0의 값으로 전송하며, 동기 수행을 위한 필터 설계에 용이함을 가져다 준다. 총 3개의 P-SS를 정의하기 위해 식 (1)에서 $u=25, 29$, 그리고 34의 값을 사용한다. 이 때, 29와 34는 켤레대칭(conjugate symmetry) 관계를 가지고 있어서, 2개의 상관(correlation)을 동시에 수행할 수가 있다. 여기서, 켤레대칭은 다음 식 (2)의 관계를 의미하며 이 특성을 이용하여 $u=29$ 와 34에 대한 원샷 상관기(one-shot correlator)의 구현이 가능하여, 전체적인 연산량을 약 33.3% 감소시킬 수 있다.

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

b. S-SS 부호

S-SS를 위해 사용되는 시퀀스는 길이 31의 두 개 m-시퀀스를 인터리빙된 조합을 하고 두 개의 시퀀스를 조합하여 168 셀 그룹 식별자 (cell group ID)를 전송한다. S-SS의 시퀀스로서 m-시퀀스는 주파수 선택적 환경에서 강건하고, 고속 하다마드 변환 (Fast Hadamard Transform)을 이용한 고속 m-시퀀스 변환으로 연산량을 줄일 수가 있다. 또한, 두 개의 짧은 부호 (short code)로 S-SS를 구성하는 것은 단말의 연산량을 줄이기 위해 제안되었다.

Figure 9은 논리 영역에서의 두 개의 시퀀스가 물리 영역에서 인터리빙되어 매핑되는 것을 보여주는 그림이다. S-SS부호 생성을 위해 사용되는 두 개의 m-시퀀스를 각각 S1, S2라고 정의할 때, 부프레임 0의 S-SS가 (S1, S2) 두 조합으로 셀 그룹 식별자를 전송한다면, 부프레임 5의 S-SS는 (S2, S1)으로 교환(swapping)하여 전송함으로써, 10ms 프레임 경계를 구분할 수 있게 된다. 이 때, 사용되는 S-SS 부호는 $x^5 + x^2 + 1$ 의 생성다항식을 사용하며, 서로 다른 순환 천이 (circular shift)를 통해 총 31개의 부호를 생성할 수가 있다.

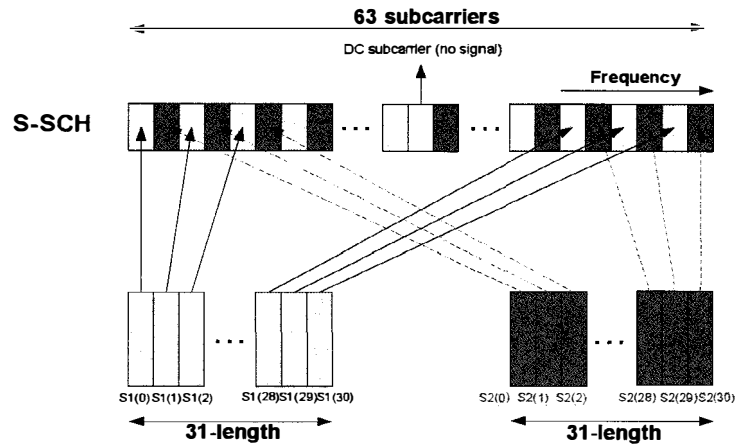


Figure 9. S-SS 부호 생성 방식

수신 성능을 향상시키기 위하여, P-SS 기반 (P-SS-based)의 서로 다른 두 개의 시퀀스를 정의하여, S-SS에 스크램블링 하되 S1과 S2에 서로 다른 시퀀스로 스크램블링 한다. 그 후, S1 기반 (S1-based)의 스크램블링 부호를 정의하여, S2에 스크램블링을 수행한다. 이 때, S-SS의 부호는 5ms 단위로 교환되지만 P-SS 기반의 스크램블링 부호는 교환되지 않는다. P-SS 기반의 스크램블링 부호는 $x^5 + x^3 + 1$ 의 생성 다항식으로부터 생성된 m-시퀀스에서 P-SS 인덱스에 따라 6개의 순환 천이 버전으로 정의하고, S1 기반의 스크램블링 부호는 $x^5 + x^4 + x^2 + x^1 + 1$ 의 다항식으로부터 생성된 m-시퀀스에서 S1의 인덱스에 따라 8개의 순환 천이 버전으로 정의한다.

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 $\text{SFN mod } m = 0$, 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

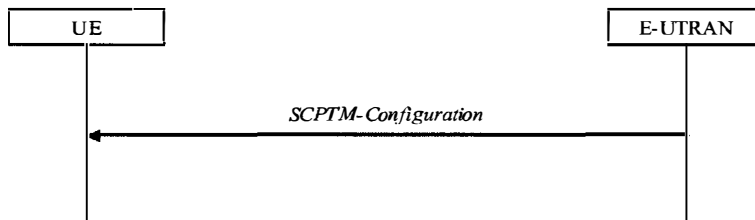


Figure 5.8a.2.1-1: SC-MCCH information acquisition

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 $SFN \bmod sc\text{-}mcch\text{-}ModificationPeriod = 0$. 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: $SFN \bmod sc\text{-}mcch\text{-}RepetitionPeriod = sc\text{-}mcch\text{-}Off.set$.
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.

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 $(10n_f + \lfloor n_s/2 \rfloor) \bmod T = \alpha_{\text{offset}} \cdot T$, where $T = R_{\max} \cdot G$
- for NPDCCH UE-specific search space,
 - G is given by the higher layer parameter *npdcch-startSF-UESS*,
 - α_{offset} is given by the higher layer parameter *npdcch-startSFOffset-UESS*,
- 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 an 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

A DCI transports 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)-LTE는 LTE system의 1 PRB에 해당하는 system BW를 갖는 낮은 complexity, 낮은 power consumption을 지원하기 위한 system이다. 이는 주로 machine-type communication (MTC)와 같은 device를 cellular system에서 지원하여 internet of things (IoT)를 구현하기 위한 통신 방식으로 이용될 수 있다. 기존의 LTE의 subcarrier spacing 등의 OFDM parameter들을 LTE와 같은 것을 사용함으로써 추가적인 band 할당 없이 legacy LTE band에 1 PRB를 NB-LTE 용으로 할당하여 주파수를 효율적으로 사용할 수 있는 장점이 있다. NB-LTE의 physical channel은 downlink의 경우, N-PSS/N-SSS, N-PBCH, N-PDCCH/N-EPDCCH, N-PDSCH 등으로 정의하고, LTE와 구별하기 위해 N-을 더해서 부르기로 한다.

Unicast와는 구분되는 multicast나 broadcast 측면에서 LTE system에서는 MBMS service를 위해 MBSFN subframe을 도입하거나, SC-PtM 방식을 도입하였다. NB-LTE system 또한 broadcast 혹은 multicast와 같은 service가 필요한 상황에서(e.g., software update) MBMS service를 사용할 수 있도록 고려해야 한다. 따라서 본 발명에서는 SC-PtM을 NB-LTE system에 동작 시키려 할 경우, SC-PtM 관련 정보를 전송하는 N-PDCCH/N-PDSCH 등이 전송되는 적절한 PRB 위치 및 해당 PRB의 할당 방법에 대해 제안 한다.

또한, search space를 모니터링 한다는 것의 의미는, 해당 search space를 통해 수신하고자 하는 DCI format에 따라 특정 영역만큼의 N-PDCCH를 decoding 한 후 해당 CRC를 미리 약속된 특징 RNTI 값으로 scrambling하여 원하는 값이 맞는지 확인하는 과정을 의미한다. 추가적으로, NB-LTE system에서 각 UE는 single PRB를 각각의 carrier로 인식하고 있기 때문에, 본 문서에서 언급하고 있는 PRB는 carrier와 같은 의미를 지니고 있다고 할 수 있다. 본 문서에서 언급하는 DCI format N0, N1, N2는 3GPP TS 36.212[2] 표준에 나와있는 DCI format N0, N1, N2를 의미한다.

문서의 통일성을 위해 다음과 같이 용어를 정하도록 한다. 'anchor-type PRB'는 e-NB 관점에서 initial access 를 위해 N-PSS/N-SSS/N-PBCH/N-PDSCH for N-SIB 등을 전송 하는 PRB를 의미 한다. 상황에 따라 하나의 anchor-type PRB가 존재할 수도 있으며 다수개의 anchor-type PRB들이 존재할 수도 있다. 다음으로, 하나 혹은 다수개의 anchor-type PRB 가 있는 상황에서, UE가 initial access를 통해 특정 anchor-type PRB를 선택했다면 해당 PRB를 'anchor PRB'라고 약속한다. 또한, initial access 이후 downlink 과정을 진행하기 위해 e-NB로부터 할당된 PRB를 'additional PRB' 라고 약속 한다.

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

우선적으로, MCCH의 control 정보 등을 전송하는 N-PDCCH와 MTCH의 control 정보 등을 전송하는 N-PDCCH가 동일한 PRB에 전송 될 수 도 있고, 서로 다른 PRB를 통해 전송 될 수도 있다. 이에 따라 크게 두 가지로 구분 할 수 있으며, 정리 하면 다음과 같다.

- I. MCCH의 control 정보 등을 전송하는 N-PDCCH와 MTCH의 control 정보 등을 전송하는 N-PDCCH가 동일한 PRB에 전송하도록 설정하는 방법:

최초 UE는 anchor PRB (i.e., initial access 된 anchor-type PRB)를 통해 대표로 설정된 대표 PRB index 정보를 system information block을 사용하여 전달 받는다고 설정 할 수 있다. 즉, system information block에는 SC-PtM 관련 정보 (e.g., SC-PtM 이 전송되는 주기 등)가 전송 됨은 물론이고 추가적으로 대표 PRB index 관련 정보가 전달 되는 것이다. 이러한 system information을 전달 받은 UE는 SC-PtM이 전송되는 대표 PRB index를 알 수 있고, SC-PtM 이 전송 되는 주기 또한 알 수 있기 때문에, 대표 PRB에서 미리 약속된(혹은 미리 설정된) common search space(CSS) 영역을 모니터링 하여 SC-MCCH scheduling 정보(i.e., N-PDSCH scheduling)를 획득할 수 있다. 이때, UE는 SC-RNTI 값 혹은 미리 약속된 또 다른 RNTI값을 사용하여 앞서 언급한 CSS영역을 모니터링 한다고 설정할 수 있다. 또한, 이때

사용되는 DCI format은 기존 NB-IoT에서 사용되던 DCI format N1 혹은 N2를 사용한다고 설정할 수도 있고, 새로운 DCI format을 만들어서(i.e., DCI format Nm, m은 정수) 사용한다고 설정할 수도 있다. 따라서 해당 N-PDSCH를 decoding 하여 SC-MCCH 정보를 획득 하면 UE는 TMGI 별로 G-RNTI값을 획득할 수 있다.

이어서, UE는 대표 PRB에서 미리 약속된(혹은 미리 설정된) common search space(CSS) 영역을 모니터링 하여 SC-MTCH scheduling 정보(i.e., N-PDSCH scheduling)를 획득할 수 있다. 이때, UE는 수신하기 원하는 TMGI에 해당하는 G-RNTI 값 혹은 미리 약속된 또 다른 RNTI값을 사용하여 앞서 언급한 CSS영역을 모니터링 한다고 설정할 수 있다. 또한, 이때 사용되는 DCI format은 기존 NB-IoT에서 사용되던 DCI format N1 혹은 N2를 사용한다고 설정할 수도 있고, 새로운 DCI format을 만들어서(i.e., DCI format Nm, m은 정수) 사용한다고 설정할 수도 있다. 따라서 해당 N-PDSCH를 decoding 하여 SC-MTCH 정보를 획득 하면 UE는 MBMS data(e.g., software update)를 획득 할 수 있다.

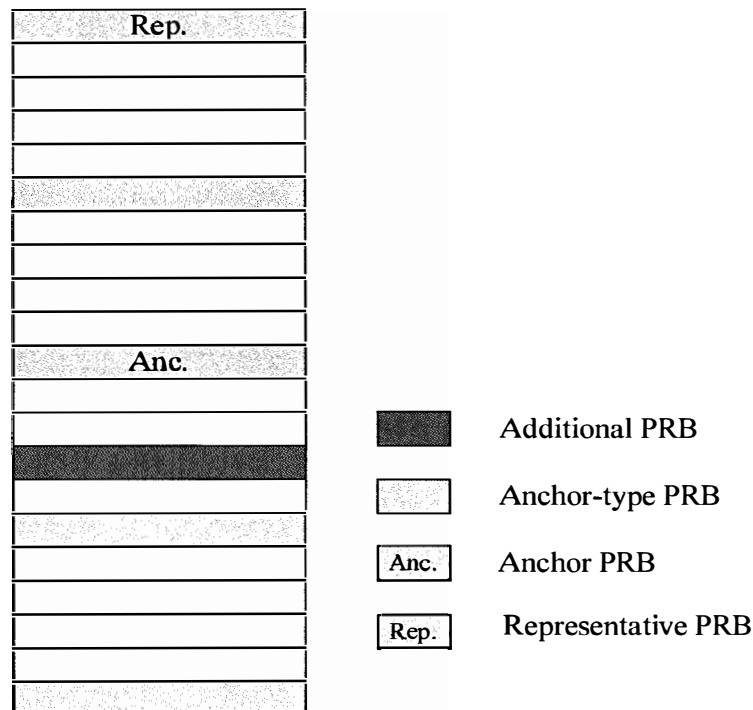


Figure 3.1.1: An example of PRB position and allocation for SC-PtM option 1.

II. MCCH의 control 정보 등을 전송하는 N-PDCCH와 MTCH의 control 정보 등을 전송하는 N-PDCCH가 서로 다른 PRB에 전송되는 경우:

최초 UE는 anchor PRB를 통해 대표로 설정된 대표 PRB index 정보를 system information block을 사용하여 전달 받는다고 설정 할 수 있다. 즉, 앞에서 언급한 것과 마찬가지로 해당 system information block에는 SC-PtM 관련 정보가 전송 됨은 물론이고 추가적으로 대표 PRB index 관련 정보가 전달 되는 것이다. 이러한 system information을 전달 받은 UE는 SC-PtM이 전송되는 대표 PRB index를 알 수 있고, SC-PtM 이 전송되는 주기 또한 알 수 있기 때문에, 대표 PRB에서 미리 약속된(혹은 미리 설정된) common search space(CSS) 영역을 모니터링 하여 SC-MCCH scheduling

정보(i.e., N-PDSCH scheduling)를 획득할 수 있다. 이때, UE는 SC-RNTI 값 혹은 미리 약속된 또 다른 RNTI값을 사용하여 앞서 언급한 CSS영역을 모니터링 한다고 설정할 수 있다. 또한, 이때 사용되는 DCI format은 기존 NB-IoT에서 사용되던 DCI format N1 혹은 N2를 사용한다고 설정할 수도 있고, 새로운 DCI format을 만들어서(i.e., DCI format Nm, m은 정수) 사용한다고 설정할 수도 있다. 따라서 해당 N-PDSCH를 decoding 하여 SC-MCCH 정보를 획득 하면 UE는 TMGI 별로 G-RNTI값을 획득할 수 있다. 추가적으로 UE는 SC-MCCH가 전송되는 N-PDSCH를 decoding 하여 G-RNTI(혹은 특정 G-RNTI group)에 따라서 서로 다른 multicast PRB(M-PRB) index 정보를 획득한다고 설정할 수도 있고, G-RNTI(혹은 특정 G-RNTI group)에 따라서 서로 다른 M-PRB index 정보를 Group specific 한 RRC signalling을 통해서 전달 받는다고 설정할 수도 있다.

이어서, UE는 수신하기 원하는 TMGI가 갖는 G-RNTI(혹은 특정 G-RNTI group)에 해당하는 M-PRB 에서 미리 약속된(혹은 미리 설정된) common search space(CSS) 영역, 혹은 user-specific search space(USS), 혹은 group-specific search space(GSS)를 모니터링 하여 SC-MTCH scheduling 정보(i.e., N-PDSCH scheduling)를 획득할 수 있다. 이때, UE는 수신하기 원하는 TMGI에 해당하는 G-RNTI 값 혹은 미리 약속된 또 다른 RNTI값을 사용하여 앞서 언급한 CSS or USS or GSS 영역을 모니터링 한다고 설정할 수 있다. 또한, 이때 사용되는 DCI format은 기존 NB-IoT에서 사용되던 DCI format N1 혹은 N2를 사용한다고 설정할 수도 있고, 새로운 DCI format을 만들어서(i.e., DCI format Nm, m은 정수) 사용한다고 설정할 수도 있다. 따라서 해당 N-PDSCH를 decoding 하여 SC-MTCH 정보를 획득 하면 UE는 MBMS data를 획득 할 수 있다.

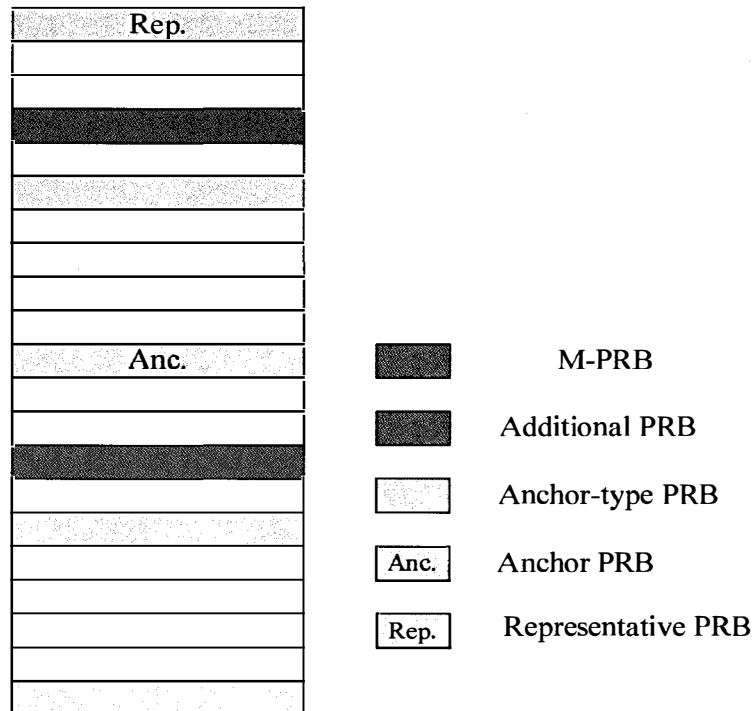


Figure 3.1.2: An example of PRB position and allocation for SC-PtM option 2.

상기 I과 II 모두에 대해서 MCCH를 전송하는 N-PDSCH는 MCCH의 control 정보 등을 전송하는 N-PDCCH가 전송되는

PRB와 같은 PRB에 전송되는 것이 일반적이고 또한, **MTCH**를 전송하는 N-PDSCH는 MTCH의 control 정보 등을 전송하는 N-PDCCH가 전송되는 PRB와 같은 PRB에 전송되는 것이 일반적이다. 하지만, 1RB를 사용하는 NB-IoT system 특성상 N-PDCCH를 전송하는 PRB와 N-PDSCH를 전송하는 PRB가 무조건 동일해야 한다는 조건은 없기 때문에, 각각의 N-PDCCH가 전송되는 PRB와 다른 제 3의 PRB로 N-PDSCH가 전송된다는 정보를 dynamic하게 전달한다고 설정할 수도 있다. 일례로, MCCH의 control 정보 등을 전송하는 N-PDCCH에 추가로 MCCH를 전송하는 N-PDSCH가 전송되는 새로운 PRB index를 알려준다고 설정할 수도 있으며, 이와 비슷하게, MTCH의 control 정보 등을 전송하는 N-PDCCH에 추가로 MTCH를 전송하는 N-PDSCH가 전송되는 새로운 PRB index를 알려준다고 설정할 수도 있다. 이때, SC-MCCH가 실려오는 N-PDSCH가 전송되는 새로운 PRB와, SC-MTCH의 scheduling 정보가 내려오는 N-PDCCH가 전송되는 새로운 PRB, 그리고 SC-MTCH가 실려오는 N-PDSCH가 전송되는 새로운 PRB는 서로 독립적으로 allocation 될 수도 있으며, 서로 같거나, 혹은 가령 셋 사이에 일정한 PRB 간격만큼 떨어져 있거나 특정한 규칙을 갖는 관계를 가질 수도 있다.

추가적으로, 상기 I과 II 모두에 대해서 **UE**는 대표 PRB에서 미리 약속된(혹은 미리 설정된) common search space(CSS) 영역을 모니터링 하여 SC-MCCH change notification 정보를 획득할 수 있다. 이때, UE는 SC-RNTI 값 혹은 미리 약속된 또 다른 RNTI값을 사용하여 앞서 언급한 CSS영역을 모니터링 한다고 설정할 수 있다. 또한, 이때 사용되는 DCI format은 기존 NB-IoT 에서 사용되던 DCI format N1 혹은 N2를 사용한다고 설정할 수도 있고, 새로운 DCI format을 만들어서(i.e., DCI format Nm, m은 정수) 사용한다고 설정할 수도 있다.

추가적으로, 상기 I과 II에서 MCCH 혹은 MCCH를 scheduling하는 N-PDCCH가 전송되는 PRB와 MTCH 혹은 MTCH를 scheduling하는 PDCCH가 전송되는 PRB를 각각 독립적으로 system information (e.g., SIB) 을 통해서 알려 주는 방식을 고려할 수 있다. 혹은 상기 I에서 대표 **PRB**는 MCCH 혹은 MCCH를 scheduling하는 N-PDCCH에는 적용되지 않고 MTCH 혹은 MTCH를 scheduling하는 N-PDCCH에만 적용될 수 있다. 이 때에 UE는 MCCH 혹은 MCCH를 scheduling하는 N-PDCCH는 anchor PRB에서 읽을 수 있다.

추가적으로, 상기 대표 PRB는 anchor-type PRB 들 중에서 선택된 대표 anchor-type PRB 일 수 있다.

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

3.1 에서의 camp-on PRB (or unicast PRB or paging PRB)와 다른 PRB를 사용하여 MCCH N-PDCCH 혹은 MTCH N-PDCCH를 전송 받는 방법은, UE 입장에서 legacy NB-IoT Tx로부터 독립적인 PRB를 사용하여 multicast Tx를 전송 받기 때문에, configured UE 입장에서 unicast N-PDCCH가 SC-PtM N-PDCCH와 같은 PRB로 전송되는 경우가 존재 하지 않게 된다. 또한, idle UE 입장에서 paging DCI와 SC-PtM N-PDCCH와 같은 PRB로 전송되는 경우가 존재 하지 않게 된다. 반면 camp-on PRB (or unicast PRB or paging PRB)와 동일한 **PRB**를 사용하여 MCCH N-PDCCH 혹은 MTCH N-PDCCH를 전송 받는 방법은 다음과 같이 2가지 경우로 정리할 수 있다.

I. MCCH 혹은 MTCH의 control 정보를 전달하는 N-PDCCH의 DCI format을 DCI format N1과 같게 맞추는 방법

이때, DCI format을 N1과 같게 맞추는 방법은 실제 DCI format N1을 사용할 수도 있고, DCI format N1과 같은 payload를 갖도록 새로운 DCI format을 사용한다고 설정할 수도 있다. 이때, data를 다 넣고도 공간이 남을 경우에는 0을 추가로 넣어서(zero padding) 길이를 DCI format N1과 같게 맞추는 것이 중요하다. 이 때, DCI format N1의 길이라 함은, DCI format N1이 다른 DCI format과 size를 맞추기 위해 zero-padding이 수행될 경우 해당 zero-padding을 수행한 이후의 길이를 의미할 수 있다. 추가로, MCCH 혹은 MTCH의 control 정보를 전달하는 N-PDCCH가 전송되는

search space는 SC-PtM 을 위한 common search space를 사용한다고 설정할 수 있다. 특징적으로 MCCH 혹은 MTCH 의 control 정보를 전달하는 N-PDCCH의 DCI format을 DCI format N1과 같게 맞추는 경우는, UE의 N-PDCCH blind decoding 횟수를 늘이지 않기 위하여 1) MCCH 혹은 MTCH의 control 정보를 전달하는 N-PDCCH가 전송되는 search space를 UE-specific data schedule을 위한 N-PDCCH가 전송되는 USS(UE-specific search space)에 포함되도록 설정할 수 있으며, 2) MCCH 혹은 MTCH의 control 정보를 전달하는 N-PDCCH가 전송될 수 있는 search space가 전송되는 PRB가 USS가 전송되는 PRB와 동일한 경우에 적용될 수 있다.

일단, connected mode의 경우를 살펴보면, 해당 UE는 MCCH 및 MTCH DCI가 전송되는 search space가 USS(i.e., NPDCCH UE-specific search space)와 같거나, 혹은 해당 USS에 포함되는 관계를 갖는다고 설정할 수 있다. 이렇게 되면, connected mode UE는 별도의 추가 BD 없이도 자신이 보고 있던 unicast control DCI와 MCCH 혹은 MTCH의 DCI 모두 서로 다른 RNTI값(e.g., unicast: C-RNTI, MCCH: SC-RNTI, MTCH: G-RNTI)을 사용하여 CRC masking 을 사용하여 구분할 수 있다. 또한, 해당 UE는 frequency 이동 없이, 그리고 unicast interruption 없이 MCCH control 혹은 MTCH control을 decoding 할 수 있게 된다.

반면, idle mode UE의 경우에, DCI format이 N1으로 맞춰져 있기 때문에, idle mode UE의 경우에는 DCI format N1 으로 전송되는 MCCH 혹은 MTCH의 control 정보를 보기 위해 legacy 동작 대비 추가 action 이 필요하게 된다. 이때 추가 action은 다음과 같다. Idle mode UE의 경우는 UE DRX cycle 동안에 원래 보려고 했던 paging을 보기 위해 P-RNTI를 사용하여 DCI format N2 size를 모니터링 하게 된다. 이때, 동일한 subframe에 SC-PtM(i.e., MCCH or MTCH control) 관련 DCI가 전송될 때는 DCI format N1 size로 맞춰져 있어서 추가적인 BD 없이는(i.e., max BD requirement 를 만족시키기 위해서는) decoding이 불가능 하기 때문에 SC-PtM 관련 정보를 얻는 것을 포기할 수 밖에 없다. 단, 단말이 추가적인 BD를 할 능력이 있는 경우에는, SC-RNTI 혹은 G-RNTI를 사용하여 DCI format N1 size를 추가적으로 모니터링 하여 SC-PtM 관련 정보를 얻어낼 수 있다.

II. MCCH 혹은 MTCH의 control 정보를 전달하는 N-PDCCH의 DCI format을 DCI format N2와 같게 맞추는 방법

이때, DCI format을 N2와 같게 맞추는 방법은 실제 DCI format N2를 사용할 수도 있고, DCI format N2와 같은 payload를 갖도록 새로운 DCI format을 사용한다고 설정할 수도 있다. 이때, data를 다 넣어도 공간이 남을 경우에는 0을 추가로 넣어서(zero padding) 길이를 DCI format N2와 같게 맞추는 것이 중요하다. 이 때, DCI format N2의 길이 라 함은, DCI format N2가 다른 DCI format과 size를 맞추기 위해 zero-padding이 수행될 경우 해당 zero-padding을 수행한 이후의 길이를 의미할 수 있다. 추가로, MCCH 혹은 MTCH의 control 정보를 전달하는 N-PDCCH가 전송되는 search space는 SC-PtM 을 위한 common search space를 사용한다고 설정할 수 있다. 특징적으로 MCCH 혹은 MTCH 의 control 정보를 전달하는 N-PDCCH의 DCI format을 DCI format N2와 같게 맞추는 경우는, UE의 N-PDCCH blind decoding 횟수를 늘이지 않기 위하여 1) MCCH 혹은 MTCH의 control 정보를 전달하는 N-PDCCH가 전송되는 search space를 paging schedule을 위한 N-PDCCH가 전송되는 CSS(Cell-specific search space)에 포함되도록 설정할 수 있으며, 2) MCCH 혹은 MTCH의 control 정보를 전달하는 N-PDCCH가 전송될 수 있는 search space가 전송되는 PRB가 paging을 scheduling하는 N-PDCCH가 전송되는 CSS가 전송되는 PRB와 동일한 경우에 적용될 수 있다.

일단, idle mode의 경우를 살펴보면, 해당 UE는 MCCH 및 MTCH DCI가 전송되는 search space는 paging signal이 사용하는 CSS(i.e., Type1-NPDCCH common search space)와 같거나 혹은 해당 CSS에 포함되는 관계를 갖는다고 설정할 수 있다. 이렇게 되면, idle mode UE는 별도의 추가 BD 없이도 자신이 보고 있던 paging DCI와 MCCH 혹은 MTCH의 DCI 모두 서로 다른 RNTI값(e.g., paging DCI: P-RNTI, MCCH: SC-RNTI, MTCH: G-RNTI)을 사용하여

CRC masking 을 사용하여 구분할 수 있다.

반면, connected mode UE의 경우에, DCI format이 N2로 맞춰져 있기 때문에, connected mode UE의 경우에는 DCI format N2로 전송되는 MCCH 혹은 MTCH의 control 정보를 보기 위해 legacy 동작 대비 추가 action 이 필요하게 된다. 이때 추가 action은 다음과 같다. Connected mode UE의 경우는 unicast control 정보를 보기 위해 C-RNTI를 사용하여 DCI format N1 size를 모니터링 하게 된다. 이때, 동일한 subframe에 SC-PtM(i.e., MCCH or MTCH control) 관련 DCI가 전송될 때는 DCI format N2 size로 맞춰져 있어서 추가적인 BD 없이는 decoding이 불가능 하기 때문에 SC-PtM 관련 정보를 얻는 것을 포기하거나 unicast control 정보를 얻는 것을 포기할 수 밖에 없다. 이 때 어느 것을 먼저 받아야 할지에 대한 priority를 결정해야 할 필요가 있다. 우선, service type에 따라서 multicast를 수신할지 말지에 대한 결정을 한다고 설정할 수 있다. 구체적인 예로, 중요도가 높은 firm ware update 의 경우는 unicast를 나중에 받더라도 multicast를 먼저 받도록 설정할 수 있다. 또한, unicast는 A/N이 존재하기 때문에, 받지 못했음을 바로 알릴 수 있지만, multicast의 경우는 A/N이 존재하지 않기 때문에 상위 layer에서 정보를 주고 받기 전까지 알려줄 방법이 없다는 점도 multicast를 먼저 받도록 설정하는 것이 유리할 수 있다. 다른 방법으로는, unicast의 data 전송 량에 따라서 결정할 수도 있다. 현재 시점에서 미리 약속된 일정 threshold 값 이상의 unicast data를 전송 받았다면, unicast 전송을 계속 받고, 그렇지 않다면, multicast를 수신 받도록 설정할 수도 있다. 이는 buffer에 이미 많이 전송 받은 unicast data가 존재하고, 이를 다시 받도록 설정하는 것이 더 burden이기 때문이다. 단, 단말이 추가적인 BD를 할 능력이 있는 경우에는, SC-RNTI 혹은 G-RNTI를 사용하여 DCI format N2 size를 추가적으로 모니터링 하여 SC-PtM 관련 정보를 얻어낼 수 있다. 또한, 단말이 이미 USS를 통해서 decoding한 N-PDCCH를 통해서 unicast PDSCH를 스케줄 받은 경우에 해당 구간에서는 multicast 수신을 시도하지 않고 unicast PDSCH 수신을 계속할 수 있다.

상기 unicast transmission과 multicast transmission 중 어느 것을 받아야 할지에 대한 priority를 결정하는 방식은 동일한 PRB에서도 적용되지만, 서로 다른 PRB에서 동일한 SF에 전송될 때도 적용 될 수 있다.

상기 I과 II에서 이때, MCCH changing notification은 DCI format N2를 사용하여 CSS type 1으로 전송되지만, 매우 긴 시간에 한번씩 전송되며, MCCH control이 전송되는 SF와 다른 SF에 MCCH changing notification이 전송되기 때문에 connected mode든 idle 모드든 추가 BD 문제는 발생하지 않는다고 할 수 있다.

3.3. Multiple PRBs transmission for MCCH control

MCCH의 control 정보 등을 전송하는 N-PDCCH가 하나의 PRB로 전송되는 것이 아닌 다수개의 PRB로 전송되는 방식을 고려할 수 있다. 즉, eNB가 semi-statistic하게 설정한 여러 개의 PRB들을 사용하여 MCCH의 control 정보를 전송하면, 각 UE들은 여러 PRB들 중 하나의 PRB를 선택하여 MCCH의 control 정보를 확인하고, MCCH를 decoding하여 TMGI 별 G-RNTI값을 확인할 수 있다. 이때, MCCH의 control 정보를 전송해주는 여러 PRB들이 각각의 UE들이 보고 있는 unicast transmission을 하고 있는 PRB, 혹은 paging signal을 보고 있는 PRB, 혹은 camp-on 한 PRB 와 겹치게 된다면, 해당 UE는 frequency 이동 없이, 그리고 unicast interruption 없이 MCCH control 정보 및 MCCH를 decoding 할 수 있게 된다.

이후, MCCH N-PDSCH를 통해 G-RNTI값을 확인한 UE들은 MTCH의 control 정보가 전송되는 PRB로 이동하여 수신하기 원하는 TMGI에 해당하는 G-RNTI값을 사용하여 MTCH의 control 정보를 확인할 수 있고, 그에 따라 MTCH를 decoding하여 MBMS data를 전송 받을 수 있다.

추가적으로, UE는 MCCH의 control 정보가 전송된 PRB에서 미리 약속된(혹은 미리 설정된) common search space(CSS)

영역을 모니터링 하여 SC-MCCH change notification 정보를 획득할 수 있다. 이때, UE는 SC-RNTI 값 혹은 미리 약속된 또 다른 RNTI값을 사용하여 앞서 언급한 CSS영역을 모니터링 한다고 설정할 수 있다. 또한, 이때 사용되는 DCI format은 기존 NB-IoT 에서 사용되던 DCI format N1 혹은 N2를 사용한다고 설정할 수도 있고, 새로운 DCI format을 만들어서(i.e., DCI format Nm, m은 정수) 사용한다고 설정할 수도 있다.

4. Effectiveness of Invention

본 발명에서는 cellular IoT (internet of things)를 지원하는 NB-IoT시스템에서 SC-PtM을 동작 시키려 할 경우, SC-PtM 관련 정보를 전송하는 N-PDCCH/N-PDSCH 등이 전송되는 적절한 PRB 위치 및 해당 PRB의 할당 방법에 대해 제한 했다. 추가 적으로 본 발명에서 주로 다루는 내용은 NB-IoT system 이지만, 이와 비슷한 narrow band system으로도 확장 가능하다. 일반적으로, PRB(i.e., carrier)를 MTC system의 narrow band(i.e., 6RB)로 대체하여 적용할 수 있고, DCI format N1 은 DCI format 6-1A/1B로, DCI format N2는 DCI format 6-2로 대체하여 적용할 수 있다.

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)*

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