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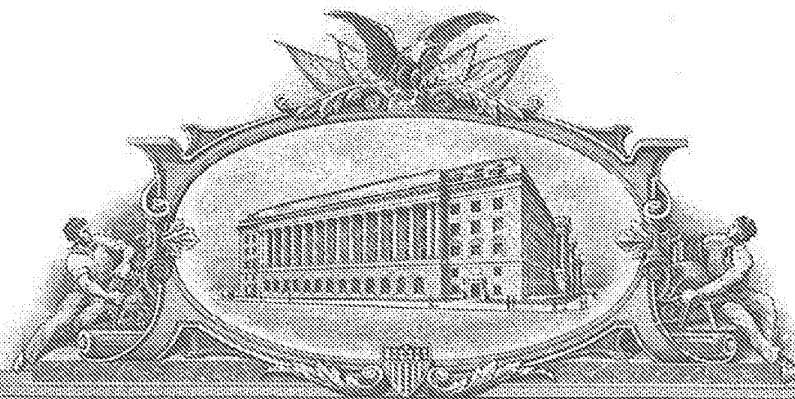
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APPLICATION NUMBER: 62/670,038

FILING DATE: *May 11, 2018*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US62/670,038*



Certified by

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		
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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	nkwon		SEO		
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		

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For further information see 37 CFR 1.33(a).

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Customer Number	67487		
Email Address	info@kpatent.com	Add Email	Remove Email
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Application Information:

Title of the Invention	CORESET AND SEARCH SPACE FOR BFR		
Attorney Docket Number	UT18-0378-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

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☐ 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	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		
Customer Number	67487		

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

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐	This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		

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

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		

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				
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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	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		

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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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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		

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

Inkwon SEO and Yunjung YI

for

CORESET AND SEARCH SPACE FOR BFR

Customer Number: 67487

Attorney Docket Number: UT18-0378-US

Total Number of pages: 16 (including cover)

Provisional Application	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR
Related Technology Field	NR control channel
Related Specification	New RAT

1. Summary of Invention

2. Background and Prior Arts in the Same Field of the Invention

< 3GPP LTE specification>

- TS36.211, TS36.212, TS36.213, TS36.214, TS36.331

As ever more communication devices demand ever greater communication capacity, a need is emerging for better mobile broadband communications than provided by existing radio access technologies. In addition, massive Machine Type Communications (MTC), which connects a plurality of devices and things to provide various services at any time and place, is also among the key issues to be considered in next-generation communications. Moreover, communication system design is under discussion that takes into consideration the sensitivity of services/UEs to reliability and latency. Likewise under discussion is the introduction of next-generation radio access technology that takes into account enhanced mobile broadband communication, massive MTC, URLLC (Ultra-Reliable and Low Latency Communication), and the like; in the present invention, for convenience, this technology is called New RAT.

[Self-contained subframe structure]

In 5th-generation new RAT, a structure in which the control channel and data channel are TDMed, as shown in FIG. 2-1 below, can be considered as one kind of frame structure for the purpose of minimizing latency.

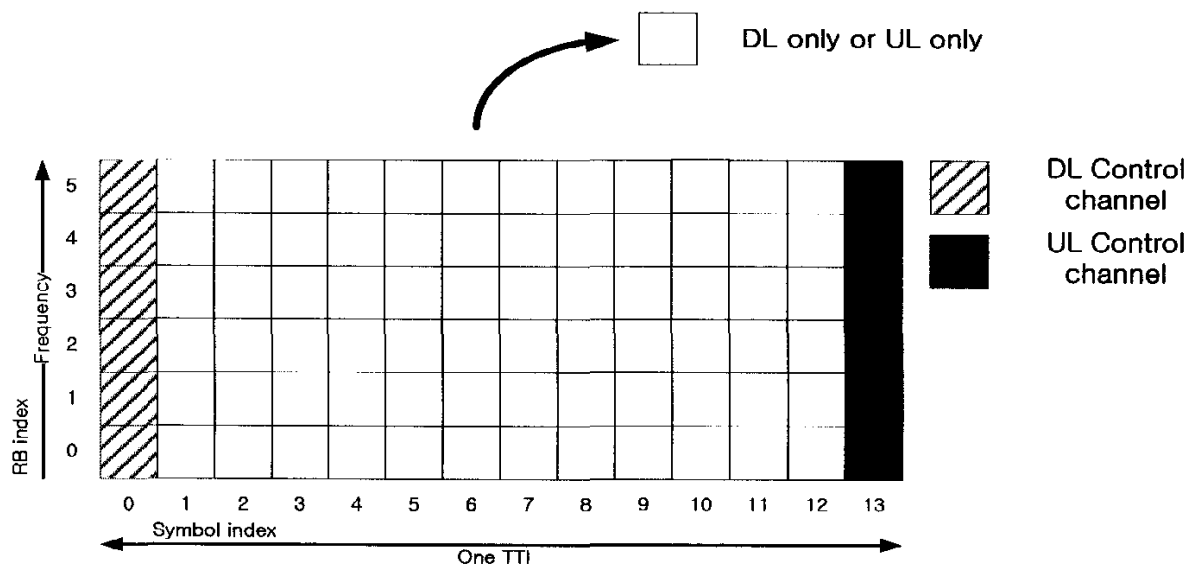


FIG. 2-1. Data and control TDMed subframe structure

In FIG. 2-1, the hatched area represents the downlink control region, and the black area represents the uplink control region. The unmarked region can be used for downlink data transmission or for uplink data transmission. A characteristic of such a structure is that DL transmission and UL transmission are performed in sequence within one subframe, so that DL data can be sent, and UL ack/nack can also be received, within one subframe. As a result, when a data transmission error occurs, the time taken to retransmit data is reduced; consequently, the latency of the final data transmission can be minimized.

In such a data and control TDMed subframe structure, a time gap is needed for the process of the base station and the UE switching from a transmitting mode to a receiving mode, or from a receiving mode to a transmitting mode. To this end, at the time of switching from DL to UL, some OFDM symbols in the subframe structure are set as guard periods (GP).

[Analog beamforming]

In mmW, the wavelength is shortened so that a plurality of antennas can be installed in the same region. Thus, in the 30 GHz band, where the wavelength is 1 cm, a total of 100 antenna elements can be installed at intervals of 0.5λ (wavelength) on a 5-by-5-cm panel in a 2-dimensional array. Accordingly, in mmW, a plurality of antenna elements are used to increase beamforming (BF) gain so as to increase coverage or throughput.

In this case, if each antenna element has a TXRU (transceiver unit) to enable transmission power and phase adjustment, then independent beamforming is possible for each frequency resource. However, a problem with this is that it is not practical, in terms of cost, to install a TXRU on all approximately 100 antenna elements. Therefore, a method is under consideration in which a plurality of antenna elements are mapped to one TXRU and the direction of the beam is adjusted by analog phase shift. Such an analog beamforming method has the drawback that only one beam direction can be created in the entire band, so that frequency-selective beaming is impossible.

By way of an intermediate mode between digital BF and analog BF, a hybrid BF can be considered that has B TXRUs, where B is less than the number of antenna elements Q. In this case, although there is variation depending on how the B TXRUs and the Q antenna elements are connected, nonetheless the number of beam directions on which it is possible to transmit at the same time is limited to B or less.

[CORESET and search space for NR PDCCH]

In NR, a control resource set (CORESET), a search space set, and the like, have been defined for a control channel. A CORESET is a resource region for control channel transmission/reception, similar to an EPDCCH set in LTE; a CORESET configuration includes a CORESET ID, a DMRS scrambling sequence initialization parameter, CORESET resource information (the frequency domain RB set and the time domain duration), a CCE-to-REG mapping, a REG bundle size, a row size and cyclic shift value of an interleaver, TCI-related information, and the like, which define the properties of the respective CORESET. A search space set configuration provides information about the components and monitoring of the search space set configuration—including: a CORESET ID that monitors the search space set; whether CSS/USS is used; information about a DCI that must be monitored; aggregation levels; a number of candidates per AL; a monitoring periodicity of the search space set; and information related to a monitoring occasion within a slot;—and provides information about

the components and monitoring of the search space set. Additionally, in NR, a maximum of three CORESETs and ten search space sets can be configured for each BWP.

[Complexity for blind decoding and channel estimation]

Because different monitoring periodicities and offsets are set for each search space set of a plurality of search space sets, there can be a significant increase in the number of candidates that must be monitored in a particular slot (e.g., a slot in which monitoring occasions for a plurality of search space sets overlap); this can significantly increase the complexity of blind decoding for the UE. Accordingly, in NR, for each numerology, there are defined a maximum number of BDs and a maximum channel estimation complexity (expressed as a number of CCEs) that a UE can perform within a single slot. If the number of BDs and/or the number of CCEs configured by the network in each slot exceeds the limit, then the UE can only perform blind decoding for a particular candidate according to priority. For example, it can be assumed that the number of BDs and the number of CCEs for the search space set(s) configured by the CSS in each slot does not exceed the limit; in the case of a USS, the SS set having a lower index has a higher priority, and whether to conduct BD on a candidate can be determined at the SS set level.

3. Composition and Method of the Invention

In NR, beam-based transmission and reception operations are carried out, and if the reception performance of the current serving beam becomes degraded, then a process of seeking a new beam is performed via a process known as beam failure recovery (BFR). Because the BFR process does not involve declaring a failure of the link between the network and the UE, it can be assumed that the connection with the current serving cell will be maintained even during the BFR process. In the BFR process, different beams are measured that are configured by the network (a beam in this case can be expressed as a CSI-RS port or an SSB index or the like) and the best beam for the UE can be selected. The UE carries out the BFR process by performing a RACH procedure associated with a beam that has a good measurement result.

Proposed in the present invention are a CORESET & search space set configuration, and a candidate mapping method for BD/CE complexity handling, that are needed in terms of control channel processing when carrying out BFR. (In the present invention, a Transmission Configuration Indication (hereinafter TCI) state can be configured for each CORESET of the control channel and can be used as a parameter for determining the Rx beam of the UE.)

[CORESET and search space set for BFR]

In the BFR process, the CORESET and the search space are resources associated with the beam that the UE selects as the best beam; during the process of carrying out the RACH procedure, these resources can be used for the purpose of receiving necessary signaling from the network, such as an RAR message or the like. Additionally, via the BFR CORESET, the UE can receive a UL grant, a DL assignment, or the like until a new CORESET and search space are received that reflect the changed beam information.

• Relation between BWP and BFR CORESET & SS set

- In NR, a maximum of three CORESETs and ten search space sets can be set for each BWP; in this case, each CORESET can have different CORESET properties (e.g., CCE-to-REG mapping (with/without interleaving) and REG bundle size (2, 3, 6 REGs), WB/NB RS, ...), and each search space set can have different monitoring occasions, ALs, and candidate numbers, and the like; as a result, scheduling flexibility can be increased. In the case of a BFR CORESET, because BFR is a process for finding a new beam owing to a degradation of beam reception performance, irrespective of the scheduling flexibility of PDCCH transmission and reception as mentioned above, it may be preferable not to apply the limit that corresponds to the maximum number of CORESETs per BWP (i.e., three CORESETs per BWP) to the BFR CORESET. In other words, for each BWP, the UE can be configured with three CORESETs, excluding the BFR CORESET, and ten search space sets, excluding the BFR search space set. (If a BFR CORESET reuses a conventional CORESET, and if the conventional CORESET is configured for a purpose other than BFR, then this CORESET can be counted in the number of CORESETs. This can be applied in the same way to a search space set.)
- A method can be considered in which a BFR CORESET is set for each BWP, or in which it is set for an initial BWP. (This includes: a case in which the BFR CORESET is set for each BWP; a case in which the configuration is not followed and the BFR CORESET is not set; and a case in which the BFR CORESET of the initial BWP is monitored.) Also, in addition to the methods below, a conventionally configured CORESET and/or SS set can be reused as a CORESET and/or SS set associated with the BFR, and some parameters of this CORESET configuration and/or SS set configuration can be newly set. (For example, in the case of a CORESET configuration parameter such as a TCI state, regardless of the existing configuration, in a BFR CORESET, it can be assumed that the TCI and/or QCL, etc., are defined by the best beam based on the UE's measurement, or by a RACH procedure that the UE carried out during the BFR process.)
 - ◆ If a BFR CORESET is set for each BWP, then:
 - For a BWP in which the UE maintains transmission and reception with the current network (i.e., an active BWP), a BFR CORESET can be permanently configured. This can be implemented via a method wherein information about the BFR CORESET is included in the BWP configuration, or the like; the monitoring occasions of the corresponding CORESET can be determined by the timing of the PRACH transmission owing to the BFR (e.g., every slot within the RAR monitoring window, after the PRACH transmission slot index + 4).
 - Because it may be preferable to recognize whether the connection with the serving cell is maintained even if the BFR procedure is in progress, the UE can, in addition to monitoring the BFR CORESET, carry out DCI monitoring according to the previously configured CORESET and SS set configuration. For example, the BFR CORESET may be defined so that only PDCCHs scrambled with C-RNTI are monitored; in this case, it may be preferable to maintain monitoring for the existing CORESET, because a case may occur in which information to which a unique RNTI has been assigned, such as SFI, SI, paging, or the like, cannot be transmitted to the UE. In this case, the actual candidate setting method whereby the UE performs monitoring is as described in the next section.
 - ◆ If a BFR CORESET is set in the initial BWP, then:

- In the initial BWP, the CORESET (CORESET#0) configured according to the PBCH, and the CORESET (CORESET#1) configured for the RACH procedure, can be set as defaults; if CORESET#1 is not configured, then CORESET#0 can be reused for CORESET#1.
- If conventional DCI monitoring is carried out, then the UE may have to monitor for different BWPs in the same slot in order to monitor for BFR and conventional DCI. In this case, the following methods can be considered.
 - Option 1) Monitoring the BFR CORESET is regarded as a special case, so that both DCI monitoring of BFR, and monitoring of the previously configured DCI, can be carried out even if the active BWP and the initial BWP do not coincide.
 - Option 2) If a BWP, in which DCI monitoring for BFR is being carried out, differs from the existing active BWP, then it is possible that DCI monitoring for the existing active BWP is not performed. (This may include a method whereby existing DCI monitoring is carried out only if the BWP in which DCI monitoring for BFR is being conducted is the same as the existing active BWP.)
- If the BFR CORESET is set in the initial BWP, then the BFR CORESET can be indicated using a method below.
 - Option 1) Reuse CORESET#0 or CORESET#1
 - ◆ The BFR CORESET can be set to reuse an already-defined CORESET via pre-definition, or via higher layer signaling in the network, or the like.
 - ◆ If CORESET#0 is reused as a BFR CORESET and a BFR procedure is performed based on a CSI-RS port, then the network can signal the relationship between: each CSI-RS port used in the BFR procedure, and the SSB index associated with CORESET#0. (For example, the mapping relationship between a CSI-RS port used in the BFR procedure and an SSB index can be indicated via higher layer signaling or the like.)
 - Option 2) New CORESET for BFR
 - ◆ The network can indicate to each UE the configuration of the BFR CORESET that is present in the initial BWP; a broadcast signal or a UE-dedicated signal can be used as the indication method.

In the case of a BFR CORESET/SS, the configuration may be optional. Accordingly, if the BFR CORESET/SS is not set in the active BWP, or if a BFR CFRA resource is not set, then the terminal can carry out the following actions.

- Carry out beam recovery according to a CBRA resource. The RAR CORESET/SS associated with the CBRA resource is assumed to be a BFR CORESET, from which a response to the beam recovery is awaited.
- Await response to the beam recovery via the RAR CORESET/SS associated with the CBRA resource.
- Return to the initial DL/UL BWP and use a CFRA/CBRA/RAR CORESET/SS resource. Alternatively, this option can be applied only if there are no BFR CORESET/SS or CFRA resources in the active DL/UL BWP.

[BD and channel estimation complexity on BFR procedure]

In NR, because monitoring for a plurality of CORESETs and SS sets can be configured in the same slot, the maximum number of BDs and channel estimations that can be performed in one slot is defined in consideration of the complexity of the UE; in a slot that exceeds the maximum, it is possible that some candidates will not be monitored. To straightforwardly monitor for the BFR CORESET, it is proposed that a candidate that must be monitored should be set, as follows, in the slot in which the BFR CORESET is monitored. (Currently, it is assumed that in a conventional slot, BD and channel estimation for the CSS are carried out preferentially, and it is assumed that each limit is not exceeded as a result of the CSS. Subsequently, candidate selection (or mapping) is carried out at the SS set level for the USS; it is assumed that the lower SS index has a higher priority for a plurality of USSs.)

- Priority of BFR SS set
 - Monitoring for the BFR SS set can be designated as having the highest priority.
 - ◆ In the BFR procedure, because the serving beam configuration and the like must be done preferentially, candidates in an SS set related to BFR must be monitored.
 - ◆ Accordingly, it can be assumed that a BFR-related SS (e.g., the response to a PRACH transmitted by the UE during the BFR process, and the subsequent process) is set to have the highest priority irrespective of the type of the BFR SS set (e.g., CSS/USS), and that a candidate in the SS set does not exceed any limit.
 - A BFR SS set can be monitored independently of the BD and CCE limits per slot.
 - ◆ A BFR-related DCI might not necessarily have to complete decoding in the slot in which it was received. Therefore, the previously configured DCI monitoring can continue to be carried out in consideration of the BD and CCE limits for each slot, and monitoring for the SFR SS set can be performed independently; in this case, it can be assumed that the number of BDs and CCEs configured by the BFR SS set do not exceed the respective limits.
- Assumptions about CSSs
 - As mentioned above, in a conventional slot (i.e., a slot in which the BFR procedure is not performed), it can be assumed that, in the configured CSSs, the maximum numbers of BDs and CCEs are not exceeded.
 - However, if a BFR CORESET is being monitored, then the number of BDs/CCEs for BFR monitoring is added; consequently, if the BDs/CCEs due to existing CSSs are also taken into account, then BD/CCE overbooking can occur. Therefore, if a BFR SS set is being monitored, then the following assumptions can be made. The below options can be implemented individually or in combination. The below options apply only to a CSS; it is possible that a USS according to a conventional configuration will not be monitored during the BFR procedure. Alternatively, among the CSSs, a candidate to be monitored can be selected according to the below options; subsequently, if there is still additional capacity for BDs/CCEs, then a PDCCH mapping to SS sets can be performed for a USS.
 - ◆ **Option 1)** It can be assumed that the CSSs already configured in the BFR slot do not exceed the BD and CCE limits. (This can also mean that, even if the network performs

BD and channel estimation for a candidate related to BFR in the BFR slot, it configures at least the number of BDs and CCEs for the already configured CSSs, so that the limit is not exceeded.)

- ◆ **Option 2)** If the number of BDs and CCEs in the already-configured CSSs exceeds the limit owing to the number of BDs and CCEs due to the BFR SS set, then SS set level dropping can be applied to the CSS(s). In this case, the priority among SS sets can be determined according to an SS index (e.g., on the assumption that a low (or high) SS index has a high priority), a DCI format (e.g., where priority is defined by DCI format), or the like.
 - For example, if the respective BD and CCE limits defined in a slot are defined as X_{slot} and Y_{slot} , and the respective numbers of BDs and CCEs configured in the BFR SS set are defined as X_{BFR} and Y_{BFR} , then the respective numbers of BDs and CCEs allowed for the CSS(s) configured in that slot can be defined as $X_{\text{CSS}} (= X_{\text{slot}} - X_{\text{BFR}})$ and $Y_{\text{CSS}} (= Y_{\text{slot}} - Y_{\text{BFR}})$. In this case, for the CSS set that has the highest priority among the CSSs configured in the corresponding slot, if the numbers of BDs and CCEs are less than X_{CSS} and Y_{CSS} , then blind decoding of the corresponding CSS can be performed. Subsequently, the X_{CSS} and Y_{CSS} values can be updated, and the process can be repeated for the next-priority CSS, until one of the two limits is exceeded. (BD is not performed on a CSS that exceeds the limit.)
 - Option 2 can also include candidate dropping for a candidate level.
- ◆ **Option 3)** Monitoring can be configured for a BFR SS set and one or a plurality of CSS sets in a particular slot; if the number of BDs and/or CCEs due to the BFR SS set, and the number of BDs and/or CCEs due to the CSS set(s), exceed the respective limits, then it is possible that the CSS will not be monitored.
- ◆ **Option 4)** Monitoring for the BFR CORESET/SS can be additionally included among the UE's capabilities. In other words, for the BFR CORESET/SS, it can be assumed that the terminal is able to perform additional channel estimation/BD in excess of its existing capability, as per its configuration, and that this is not taken into account in the channel estimation/BD limit. This can mean that the capabilities for BFR CORESET and SS sets are defined separately, or that BFR-related BD/channel estimation is assumed to always be performed independently of the BD/channel estimation for a conventional DCI, and that limits for BD and channel estimation apply to all CORESET/SS sets other than the BFR CORESET/SS set.
- ◆ **Option 5)** In a slot in which the BFR CORESET is being monitored, it can be indicated, via pre-definition, higher layer signaling, or the like, that from among the candidates of the existing CORESET/SS set, only a candidate corresponding to a particular RNTI should be monitored. For example, a slot in which a BFR CORESET is being monitored can be defined so that, from among the already configured CORESET/SS sets, only a PDCCH candidate related to an SFI is monitored. (Additionally, in this case, if the BD/CCE limit is exceeded when monitoring for the existing CORESET, then it is possible that the existing CORESET will not be monitored.)
- ◆ **Option 6)** In a slot in which a BFR CORESET must be monitored, it can be indicated not to monitor for a CORESET other than the BFR CORESET, either by predefinition or via higher layer signaling.

[Rx beam priority]

As set forth above, in NR, limits are defined on the number of BDs, CCEs, and the like with respect to UE complexity, and if a limit is exceeded in a particular slot, then monitoring is skipped for some of the candidates. Such a method can also be applied to an Rx beam that a UE uses for a particular time resource.

In NR, a plurality of CORESETs can be monitored in the same slot; in this case, each of the CORESETs can be overlapped in the time/frequency domain. In addition, a different QCL assumption (i.e., configuring a TCI state for a PDCCH for each CORESET) can be applied for each CORESET. This means that there can be a plurality of CORESETs that must be received via different Rx beams in the same symbol; a UE that has one RF panel (i.e., a UE that can receive only one Rx beam in a particular time resource) needs to select one of the plurality of Rx beams. In the present invention, a method of setting an Rx beam is proposed for a situation in which a plurality of Rx beams are required. (This can also be interpreted as configuring priorities for a plurality of CORESETs that overlap in the time domain.) If an Rx beam that the UE applies is determined by the method below, then the network can give priority to transmitting in the CORESET associated with the Rx beam; or, if the CORESET uses an unsuitable Rx beam, then the network can compensate for reception performance via the coding rate or power boosting. The below options can be implemented individually or in combination.

Option 1) Measurement-based priority

The UE can configure Rx beams in the corresponding time resource based on outcomes of measurement and reporting. For example, if three CORESETs overlap in one symbol and the QCL assumptions of the CORESETs differ, then the Rx beam in the symbol can be configured based on the best measurement result from among the measurement results associated with the respective CORESET. By way of example, the Rx beam associated with the CORESET that has the highest value among the RSRPs measured in each CORESET can be applied to the symbol. (Option 1 can be determined based on a value currently measured by the UE, or it can be determined based on the most recently reported measurement result.)

Option 2) CORESET/SS set index-based priority

The Rx beam to be applied to the resource can be determined by assigning a priority to a CORESET index or an SS set index. For example, the UE can set the Rx beam based on the TCI state of the CORESET that has the lowest (or highest) CORESET index (or the CORESET associated with the lowest SS index).

Option 3) Message-based priority

The UE can set the Rx beam based on the priority of the message that it must monitor in each CORESET (e.g., DCI format, RNTI, BFR, or the like). For example, an Rx beam of a CORESET that is monitored for a DCI related to SFI, pre-emption, or the like, can have a higher priority than an Rx beam of a CORESET that is monitored for non-fallback DCI. By way of a further example, an Rx beam of a CORESET that is monitored for information required in order to maintain UE communication, such as RACH/SI update/paging or the like, can be set to a higher priority.

Additionally, as proposed above, regardless of CORESET priority within the slot in which monitoring must be performed, the highest priority can always be assigned for a CORESET

related to beam failure recovery (or beam management).

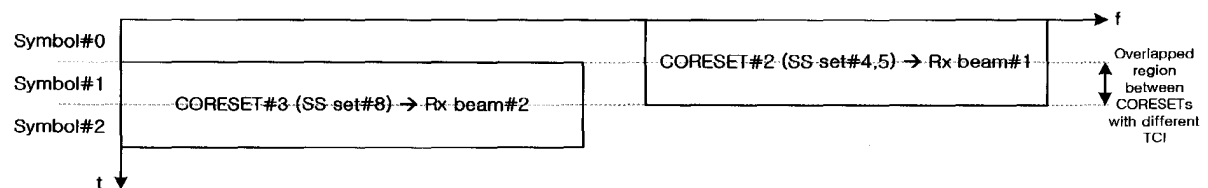
Option 4) Priority according to time order of monitoring occasions

A UE can apply an Rx beam that is associated with the beam of an SS that comes first in the SS monitoring order of each CORESET in a slot. In other words, the priority of each CORESET can be determined based on the starting symbol index of the CORESET. If the same CORESET is associated with a plurality of SS sets and has the same starting symbol, then the Rx beam can be determined based on the priority of an SS set index or the like.

Option 5) A priority of a CORESET is determined based on a number of SS sets associated with the CORESET.

As mentioned above, in NR, three CORESETs and ten search space sets can be configured for each BWP; this means that a plurality of search space sets can be associated with one CORESET. Option 5 refers to a method in which a plurality of search space sets, associated with a plurality of CORESETs in a particular slot, must be monitored; if the TCI state of each CORESET is different, then the CORESET that has a larger number of associated search space sets is given a higher priority. (In this case, the number of associated search space sets can be limited to the search space sets for which monitoring is performed in the relevant slot.)

Above, a proposal has been made for setting an Rx beam based on a TCI state in a situation in which CORESETs having different TCI states are configured to overlap in a particular time resource. The present invention additionally proposes a method for configuring an Rx beam for each region in a situation in which, within one CORESET, a time resource exists that overlaps with other CORESETs, and a time resource exists in which only the relevant CORESET exists. [FIG. 3-1] shows an example of a case in which two different CORESETs configured with different TCI states partially overlap in the time domain. As can be seen from the drawing, if monitoring is performed for each CORESET, then the Rx beams that the UE must apply are different; and, if two CORESETs overlap, then the Rx beam that the UE must apply (or the TCI state that the UE must assume) can be determined according to the priority rule proposed above. For example, if the priority of CORESET#2 in the drawing is high, then the UE can apply Rx beam#1 in the region in which there is an overlap. However, in this case, which Rx beam to use for receiving in symbol#2 of CORESET#3 must be determined. For this purpose, the present invention proposes the below options, which can be implemented individually or in combination.



[FIG. 3-1]

Additionally, the options below can be carried out for each set of CORESETs for each slot. For example, each set can consist of CORESETs that partially or fully overlap in the time domain; all CORESETs that are present in one slot can form a set.

Option 1) Rx beam configuration-based on priority for each time resource

The Rx beam in each time resource (e.g., OFDM symbol) can be set based on the TCI state of the CORESET that has the highest priority in that time resource.

In this case, a situation can arise in which the same precoding cannot be assumed between adjacent symbols, owing to different Rx beams in the same CORESET; it can be assumed that time-domain REG bundling is not applied in that CORESET. Alternatively, it can be assumed that time domain bundling is applied only in time resources that use the same Rx beam.

Option 2) Applying the Rx beam—of the CORESET that has the highest priority among the overlapped CORESETs—to a plurality of CORESETs that include the overlap region.

In Option 2, the Rx beam can be set for all overlapped CORESETs based on the TCI state of the CORESET that has the highest priority among the CORESETs that include the same time resource. This also means that for CORESETs that do not overlap in the time domain (e.g. at the symbol level), the Rx beam is set based on the TCI state of each CORESET.

Option 3) If a plurality of CORESETs with different TCI states are present in one slot, then the TCI state of the CORESET that is determined to have the highest priority, according to the above-proposed priority rule, can be applied to the entire slot. This can mean that if different CORESETs that have been configured with different TCI states are monitored in the same slot, then a CORESET that has a low priority can change the Rx beam (i.e., assuming a TCI state that differs from the configuration), but only for that slot.

Option 4) The UE can assume that when CORESETs, which have been configured with different TCI states, partially or fully overlap in the time domain, monitoring should be performed only for candidates of SS sets in the highest-priority CORESET. In addition, depending on the configuration, this can include monitoring a CORESET that does not overlap in the time domain. Alternatively, in the case of CORESETs that overlap in the slot, and for which different Rx beams must be assumed, this can be interpreted as only the CORESET with the highest priority in the entire slot being monitored.

Option 4 can include a case in which a BFR CORESET/SS set must be monitored; and, if the TCI state of the BFR CORESET is different from that of the existing CORESETs (i.e., those CORESETs/SS sets that were configured to perform monitoring prior to the BFR), then only the BFR CORESET is monitored in the slot. (This can also include a case in which the existing CORESET and BFR CORESET are monitored in the same slot, a CORESET is present among the existing CORESETs that uses the same Rx beam as the BFR CORESET, and that CORESET is monitored.)

<Added 2018-05-11>

● **QCL assumption of a CORESET without tci-StatesPDCCH**

According to a current RRC specification (i.e., TS38.331), an information element "ControlResourceSet" is provided for each CORESET, and a parameter "tci-StatesPDCCH" in the IE can be configured for providing QCL relationships between the DL RS/SSB and the CORESET. However, the "tci-StatesPDCCH" is optional parameter. It means that the parameter may not be configured for some CORESETs. So, a default QCL assumption should be needed to determine Rx beam for PDCCH reception in the TCI-less CORESET. For a default QCL assumption, we propose that, for a CORESET which doesn't include "tci-StatesPDCCH", a UE assumes that a QCL from latest RACH procedure is applied to the CORESET.

In the case of BFR-CORESET (for beam failure recovery procedure), according to the previous agreement from the email discussion in MIMO session, a UE assumes that the dedicated CORESET is spatial QCL'ed with DL RS of the UE-identified candidate beam in the beam failure recovery request. From the PDCCH perspective, this agreement can be interpreted as follows; implicit spatial QCL update (regardless of CORESET configuration) via beam recovery procedure and/or beam management procedure is assumed for a BFR-CORESET.

Other than BFR-CORESET, it needs to clarify which CORESET(s) would not be associated with TCI states. At least, we consider that CORESET #0 (by PBCH) and #1 (by RMSI) would not be associated with TCI states. For other CORESETs, generally for USS operation, it is desirable to configure TCI states.

Some clarification whether this RACH procedure can include contention-free as well is necessary. In our view, contention-free may be based on CSI-RS without associated SSB and QCL associated with the CSI-RS may not be stable for CORESET#0 and/or #1. So, at least for CORESET#0 and/or #1, it is safer to change QCL information based on the recent contention-based RACH procedure.

According to the above content, a QCL assumption derived from the most recently performed RACH procedure can be applied to a CORESET for which tci-StatesPDCCH is not configured. In the present invention, a somewhat more specific method of deriving a QCL assumption is also proposed. Below, "contention-based RACH" can

refer to a situation in which a RACH procedure is performed on a resource associated with the best SSB (based on the measurement result) based on SSB, and "contention-free RACH procedure" can refer to carrying out a RACH procedure on a resource associated with a CSI-RS port (or SSB), or the like, according to gNB signaling.

Because the contention-free RACH procedure is based on a network configuration, it can be signaled independently of measurement; alternatively, the network can signal based on a measurement report of the UE. In addition, in the case of a CSI-RS port, the association with an SSB may or may not be signaled. In other words, in a contention-free RACH procedure, a situation can arise in which it is not possible to ensure association with the SSB, reflection of measurement results, and the like. This can operate as a factor that degrades performance in operations of CORESET#0, #1, and the like where the CORESET and the search space set can be configured in association with an SSB. For example, a situation can occur in which the UE configures the Rx beam based on a faulty assumption about the Tx beam.

1. A QCL assumption, derived from the most recently performed RACH procedure, regardless of the type of RACH procedure (i.e., contention-based/contention-free RACH procedure), can be applied by the UE to a TCI-less CORESET.
2. The UE can apply only the result derived from the most recently performed contention-based RACH procedure to the QCL assumption for the TCI-less CORESET. In practice, this can mean that if the most recently performed RACH procedure is of the contention-free type, then the result is ignored and a QCL assumption derived from the most recently performed contention-based RACH procedure is applied to the CORESET.
3. QCL assumptions of different RACH procedures can also be used for each CORESET. For example, for CORESET#0 (and/or #1), a QCL assumption is applied that is derived from the most recently performed contention-based RACH procedure; for the remaining CORESETs, a QCL assumption can be derived from the most recently performed RACH procedure, regardless of whether there is contention. By way of a further example, for a CORESET for which a CSS is configured, a QCL assumption is applied that is derived from the most recently performed contention-based RACH procedure; for a CORESET for which a USS is configured, a QCL assumption can be derived from the most recently performed RACH procedure, regardless of whether there is contention. (In this case, a QCL assumption derived from the most recently performed contention-based RACH procedure of a CORESET for which both a CSS and a USS are configured can also be applied.)
4. In the methods proposed above, even for the contention-free RACH procedure, if the associated SSB is indicated or the implicitly associated SSB is known, then the QCL assumption derived from the contention-free RACH procedure can also be applied to a TCI-less CORESET.

Additionally, in the present invention, for a TCI-less CORESET, it is proposed that the network indicates to the UE, via higher layer signaling or the like, which RACH procedure type the QCL assumption is derived from. This may also include a method of providing, to the UE, SSB information associated with the CSI-RS port that was provided in the contention-free RACH procedure.

• **QCL assumption between overlapped CORESETs in time domain**

According to previous agreements, each CORESET has own QCL assumption, and different

CORESETs can be overlapped on time and/or frequency domain. It means that CORESETs with different QCL assumptions can be overlapped on a same symbol. Because a UE determines an Rx beam used for monitoring each CORESET by considering TCI state of each CORESET, if multiple CORESETs with different QCL assumptions overlaps on time domain resources (e.g., OFDM symbol), a UE should support multiple Rx beams or select one Rx beam (or TCI state) by a certain selection rule. In current release, a UE which can use multiple Rx beams are not considered so far, so we can consider following options for solving the problem;

Option 1) Monitoring skip of lower prioritized CORESET

The CORESET selection rule can be applied when CORESETs with different spatial QCLs are overlapped on time resources, and a UE can skip monitoring candidates included in non-selected CORESET. The priority of each CORESET can be determined by, for example, CORESET ID, the number of SS sets associated with a CORESET, associated search space type, etc. This option is simple, but PDCCH transmission/reception opportunity cannot be guaranteed in some resources.

Option 2) Representative spatial QCL for overlapped CORESETs

This option is to list overlapped CORESETs using the priority rule as in Option 1). Instead of dropping lower priority CORESET(s), change of QCL state can be considered on lower priority CORESET(s). In other words, we propose that same spatial QCL is assumed on overlapped CORESETs, and the representative QCL can be selected by using CORESET priority as mentioned in option 1. In other words, QCL assumption for overlapped CORESET(s) follow the highest priority CORESET's QCL. This option can provide more PDCCH transmission/reception opportunity, but the PDCCH performance of CORESET with lower priority may be decreased because of mismatch between Tx beam and Rx beam.

Option 3) No overlap between CORESETs with different spatial QCLs

A UE can assume that the network doesn't schedule overlapped CORESETs with different spatial QCLs. However, it is not sure that the overlap can always be avoided by scheduling.

● **Candidate mapping in Case 2**

Search space of Case 1 and Case 2

In last meeting, it was agreed that the number of CCEs for channel estimation per slot of Case 2 is same with Case 1 (i.e., for both cases, {56, 56, 48, 32} CCEs for SCS {15kHz, 30kHz, 60kHz, 120kHz}). Regarding the agreement, it seems that either Case 1 or Case 2 can be configured to a UE. In other words, it is ambiguous whether a UE can be configured to monitor Case 1 and Case 2 SS sets in a slot. In our understanding, there is no reason to prohibit such configuration. For example, common information can be transmitted on shared resources (i.e., slot based scheduling) between eMBB and URLLC, and service-specific data can be transmitted by slot based scheduling (for eMBB) and non-slot based scheduling (for URLLC). In this case, URLLC UEs can receive both scheduling types, i.e., Case 1 and Case 2. In order to clarify previous agreements, we propose as follows;

Proposal 1: A UE can be configured to monitor both Case 1 and Case 2 search space sets, and both SS sets can be monitored in a slot.

Proposal 2: For Rel.15 December 2017 version, maximum number of CCEs for channel estimation per slot per UE per CC is {56, 56, 48, 32} CCEs for SCS {15kHz, 30kHz, 60kHz, 120kHz} regardless of CORESET/SS configurations. → This can also be applied in the same way to a BD limit.

Candidate mapping in Case 2

Generally, the required number of BDs/CCEs of Case 2 is much larger than Case 1, if the configured number of BDs/CCEs in a SS set configuration is almost same between Case 1 and 2. In terms of CCE counting for Case 2 search space set, it is necessary to multiply the required CCEs for each monitoring occasion by the number of monitoring occasion in a slot. With this the necessary CCEs/BDs increases proportionally with the number of monitoring occasion. Thus, if search space set level channel estimation/BD budget handling is also used for Case 2, it may be possible that the entire monitoring occasion of Case 2 is dropped particularly when the number of monitoring occasion is high. This can have impact, for example, on URLLC support. To mitigate this impact, we can consider further candidate selection on monitoring occasion basis (e.g., some monitoring occasions are dropped). However, we don't have enough time to discuss this issue, so we propose as follows;

Proposal 1: In Rel-15, SS set-level PDCCH mapping within a slot is used for BD/CE complexity handling even for Case 2.

● BFR CORESET/SS set

The BFR CORESET and associated SS set are configured for beam failure recovery procedure. This CORESET/SS set is activated by beam failure recovery procedure, and a UE is not expected to monitor PDCCH candidates in the CORESET before beam failure recovery procedure (e.g., PRACH transmission) and after new CORESET/SS set configuration(s) or TCI update. On the other hands, it is not sure whether PDCCH monitoring in existing CORESETs (i.e., CORESETs which are configured to monitor before BFR procedure) is performed during monitoring window of BFR CORESET. In our view, as some common information (such as SFI, system information, paging ...) may not be monitored in the BFR CORESET, it is desirable that a UE can monitor PDCCH candidates in the existing CORESETs even during monitoring window of BFR CORESET.

Proposal 2: A UE may continue monitoring on other active CORESETs (than BFR-CORESET) during BFR procedure.

It is expected that TCI state of a CORESET (if configured) will be updated only via explicit configuration. Thus, during BFR procedure, the UE may monitor a CORESET with outdated TCI state. When BFR-CORESET and other CORESET(s) are monitored on the same time resource with potentially different QCL/TCI information (and thus potentially lead different Rx beam), some

handling is necessary. A simple solution is that a UE can skip monitoring old CORESET, if BFR CORESET overlaps with old CORESET in time domain. This is to prioritize BFR-CORESET in case of collision.

Another issue is whether to count CCEs/BDs for BFR-SS under UE's channel estimation/BD limit. If it is not accounted, it may be that the total number of required CCEs can be much higher than what UE can support during BFR, we propose to count CCEs/BDs of BFR-SS as well when monitored. If this is assumed, some clarification is necessary. According to previous agreement, CSS has a higher priority compared to USS for PDCCH mapping, and it is assumed that the number of BDs/CCEs for CSSs doesn't exceed each limit. But, in a slot configured to monitor BFR CORESET, the number of BDs/CCEs for BFR CORESET should be considered to PDCCH mapping rule. In order to solve this problem, BFR CORESET/SS set should have highest priority (regardless of SS type) on PDCCH mapping rule, and existing PDCCH mapping rule can be applied to other SS sets. If this is applied, unless it is ensured that the sum of CCEs of CSS and BFR-SS does not exceed UE's limit, CSS(s) may need to be dropped when BFR-SS is monitored. Not to incur too much configuration flexibility, we propose to drop CSS(s) based on SS set index when BFR-SS is monitored.

Proposal 3: If BFR CORESET overlaps with other CORESET(s) in time domain, a UE is not required to monitor PDCCH candidates in other CORESET(s) at least in case QCL information is different between BFR-CORESET and other CORESET(s).

Proposal 4: The BFR CORESET/SS set has highest priority (regardless of SS type) for PDCCH candidate mapping rule when monitored. CSS(s) associated with other CORESET(s) may be dropped based on SS set index when BFR SS is monitored.

Electronic Acknowledgement Receipt	
EFS ID:	32596686
Application Number:	62670038
International Application Number:	
Confirmation Number:	2570
Title of Invention:	CORESET AND SEARCH SPACE FOR BFR
First Named Inventor/Applicant Name:	Inkwon SEO
Customer Number:	67487
Filer:	Andrew S. Park
Filer Authorized By:	
Attorney Docket Number:	UT18-0378-US
Receipt Date:	11-MAY-2018
Filing Date:	
Time Stamp:	10:29:55
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$ 280
RAM confirmation Number	051118INTEFSW10303900
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	UT18-0378_ADS.pdf	2237135	no	8
			c8632e344b5c56ea3cc0e434652aa6f855a5de		
Warnings:					
Information:					
2	Specification - Not in English	UT18378_SPEC.pdf	1615093	no	16
			a86a1a7015f97a09a7b3cc204d5878bc479a59a8		
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	29552	no	2
			81ccb41361dabc3cfe72bd7ed9f938ba8fe84186		
Warnings:					
Information:					
Total Files Size (in bytes):			3881780		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					

**DOCUMENT MADE AVAILABLE UNDER THE
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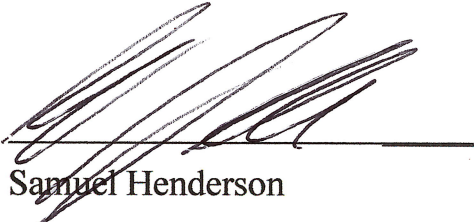
International application number:	PCT/KR2019/005493
International filing date:	08 May 2019 (08.05.2019)
Document type:	Certified copy of priority document
Document details:	Country/Office: US
	Number: 62/670,038
	Filing date: 11 May 2018 (11.05.2018)
Date of receipt at the International Bureau:	23 May 2019 (23.05.2019)

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

I, Samuel Henderson, declare as follows:

1. I am over 21 years of age and am competent to make this declaration.
2. I am a native speaker of English.
3. I am fluent in Korean.
4. I have 14 years of experience translating Korean to English.
5. I translated the attached patent document "62670038" from Korean to English.
6. I certify that the translation of the document "62670038" is, to the best of my knowledge, a true and accurate translation from Korean to English.
7. In signing this declaration, I understand that the translation and this declaration may be filed as evidence in a contested case. I acknowledge that I may be subject to cross-examination within the United States.
8. I declare under penalty of perjury that all statements made herein are true and accurate to the best of my knowledge and belief, 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 Section 1001 of Title 18 of the United States Code.

Executed: July 8, 2025

By: 

Samuel Henderson

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

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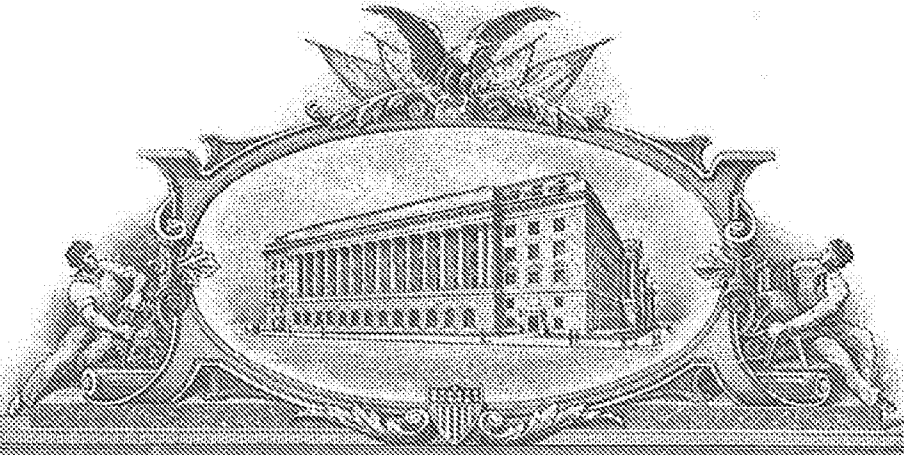
Application number: 62670038

Date of availability of document: 15 May 2018 (15.05.2018)

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THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

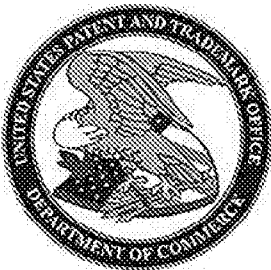
May 23, 2019

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

APPLICATION NUMBER: 62/670,038

FILING DATE: *May 11, 2018*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US62/670,038*



Certified by

Anders Iversen

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

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

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
--------------------------	---

Inventor Information:

Inventor	1				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Inkwon		SEO			
Residence Information (Select One) US Residency • Non US Residency Active US Military Service						
City	Seoul		Country of Residence ⁱ	KR		
Mailing Address of Inventor:						
Address 1		19, Yangjae-daero 11gil, Seocho-gu				
Address 2						
City	Seoul		State/Province			
Postal Code	06772		Country ⁱ	KR		
Inventor	2				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Yunjung		YI			
Residence Information (Select One) US Residency • Non US Residency Active US Military Service						
City	Seoul		Country of Residence ⁱ	KR		
Mailing Address of Inventor:						
Address 1		19, Yangjae-daero 11gil, Seocho-gu				
Address 2						
City	Seoul		State/Province			
Postal Code	06772		Country ⁱ	KR		
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.						

Correspondence Information:

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US	
		Application Number		
Title of Invention	CORESET AND SEARCH SPACE FOR BFR			

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ An Address is being provided for the correspondence information of this application.

Customer Number	67487		
Email Address	info@kpatent.com	Add Email	Remove Email
Email Address	uspto@kpatent.com	Add Email	Remove Email

Application Information:

Title of the Invention	CORESET AND SEARCH SPACE FOR BFR		
Attorney Docket Number	UT18-0378-US	Small Entity Status Claimed	☐
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)		Suggested Figure for Publication (if any)	

Filing By Reference:

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

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

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

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

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

Representative Information:

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

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

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		
Customer Number	67487		

Domestic Benefit/National Stage Information:

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

When referring to the current application, please leave the "Application Number" field blank.

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

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

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

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

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

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		

Authorization or Opt-Out of Authorization to Permit Access:

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

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

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

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

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

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

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

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

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

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

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

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant	1	Remove
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.		
Clear		
Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.		Person who shows sufficient proprietary interest
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:		
Name of the Deceased or Legally Incapacitated Inventor:		
If the Applicant is an Organization check here. ☐		

Prefix	Given Name	Middle Name	Family Name	Suffix
Mailing Address Information For Applicant:				
Address 1				
Address 2				
City		State/Province		
Country		Postal Code		
Phone Number		Fax Number		
Email Address				
Additional Applicant Data may be generated within this form by selecting the Add button.				Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		

Assignee	1
-----------------	---

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	Given Name	Middle Name	Family Name	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

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

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the **INITIAL** filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Andrew S. Park/		Date (YYYY-MM-DD)	2018-05-11
First Name	Andrew	Last Name	Park	Registration Number
				47841

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

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	UT18-0378-US
		Application Number	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR		

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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

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

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

PROVISIONAL APPLICATION FOR UNITED STATES PATENT
IN THE NAMES OF

Inkwon SEO and Yunjung YI

for

CORESET AND SEARCH SPACE FOR BFR

Customer Number: 67487

Attorney Docket Number: UT18-0378-US

Total Number of pages: 16 (including cover)

Provisional Application	
Title of Invention	CORESET AND SEARCH SPACE FOR BFR
Related Technology Field	NR control channel
Related Specification	New RAT

1. Summary of Invention

2. Background and Prior Arts in the Same Field of the Invention

< 3GPP LTE specification >

- TS36.211, TS36.212, TS36.213, TS36.214, TS36.331

더욱 많은 통신 기기들이 더욱 큰 통신 용량을 요구하게 됨에 따라 기존의 radio access technology 에 비해 향상된 mobile broadband 통신에 대한 필요성이 대두되고 있다. 또한 다수의 기기 및 사물들을 연결하여 언제 어디서나 다양한 서비스를 제공하는 massive MTC (Machine Type Communications) 역시 차세대 통신에서 고려될 주요 이슈 중 하나이다. 뿐만 아니라 reliability 및 latency 에 민감한 서비스/UE 를 고려한 통신 시스템 디자인이 논의되고 있다. 이와 같이 enhanced mobile broadband communication, massive MTC, URLLC (Ultra-Reliable and Low Latency Communication) 등을 고려한 차세대 radio access technology 의 도입이 논의되고 있으며, 본 발명에서는 편의상 해당 technology 를 New RAT 이라고 부른다.

[Self-contained subframe structure]

5세대 new RAT에서 latency를 최소화 하기 위한 목적으로 아래 그림 2-1과 같은 제어 채널과 데이터 채널이 TDM되는 구조가 frame structure의 한가지로서 고려될 수 있다.

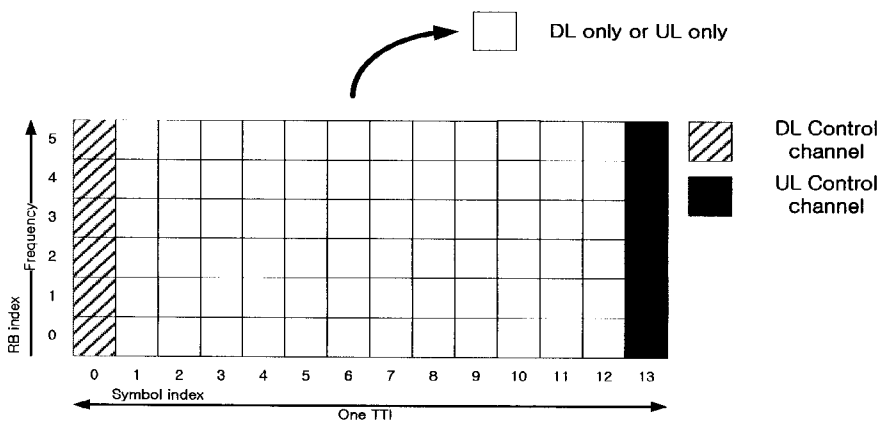


그림 2-1. Data and control TDMed subframe structure

그림 2-1에서 빗금친 영역은 downlink control 영역을 나타내고, 검정색 부분은 uplink control 영역을 나타낸다. 표시가 없는 영역은 downlink data 전송을 위해 사용될 수도 있고, uplink data 전송을 위해 사용될 수도 있다. 이러한 구조의 특징은 한 개의 subframe 내에서 DL 전송과 UL 전송의 순차적으로 진행되어, subframe 내에서 DL data를 보내고, UL ack/nack도 받을 수 있다. 결과적으로 데이터 전송 에러 발생시에 데이터 재전송까지 걸리는 시간을 줄이게 되며, 이로 인해 최종 데이터 전달의 latency를 최소화할 수 있다.

이러한 Data and control TDMed subframe structure 구조에서 기지국과 UE가 송신 모드에서 수신 모드로 전환 과정 또는 수신모드에서 송신모드로 전환 과정을 위한 time gap이 필요하다. 이를 위하여 subframe 구조에서 DL에서 UL로 전환되는 시점의 일부 OFDM symbol이 guard period(GP)로 설정되게 된다.

[Analog beamforming]

mmW에서는 파장이 짧아져서 동일 면적에 다수개의 안테나 설치가 가능해 진다. 즉 30GHz 대역에서 파장은 1cm로써 5 by 5 cm의 panel에 0.5 lambda(파장) 간격으로 2-dimension 배열 형태로 총 100개의 안테나 element 설치가 가능하다. 그러므로 mmW에서는 다수개의 안테나 element를 사용하여 beamforming(BF) 이득을 높여 커버리지를 증가시키거나, throughput을 높이려고 한다.

이 경우에 안테나 element 별로 전송 파워 및 위상 조절이 가능하도록 TXRU(transceiver unit)을 가지면 주파수 자원 별로 독립적인 beamforming이 가능하다. 그러나 100여개의 안테나 element 모두에 TXRU를 설치하기에는 가격측면에서 실효성이 떨어지는 문제를 갖게 된다. 그러므로 하나의 TXRU에 다수개의 안테나 element를 mapping하고 analog phase shifter로 beam의 방향을 조절하는 방식이 고려되고 있다. 이러한 analog beamforming 방식은 전 대역에 있어서 하나의 beam 방향만을 만들 수 있어 주파수 선택적 beaming을 해줄 수 없는 단점을 갖는다.

Digital BF와 analog BF의 중간 형태로 Q개의 안테나 element보다 적은 개수인 B개의 TXRU를 갖는 hybrid BF를 고려할 수 있다. 이 경우에 B개의 TXRU와 Q개의 안테나 element의 연결 방식에 따라서 차이는 있지만, 동시에 전송할 수 있는 beam의 방향은 B개 이하로 제한되게 된다.

[CORESET and search space for NR PDCCH]

NR에서는 control channel을 위해 control resource set (CORESET), search space set 등이 정의되었다. CORESET은 LTE의 EPDCCH set과 비슷하게, control channel transmission/reception을 위한 자원 영역을 의미하며, CORESET configuration에는 CORESET ID, DMRS scrambling sequence initialization parameter, CORESET resource 정보 (frequency domain RB set, time domain duration), CCE-to-REG mapping, REG bundle size, interleaver의 row size 및 cyclic shift value, TCI관련 정보 등이 포함되어, 각 CORESET의 특성을 정의한다. Search space set configuration에서는 해당 search space set에 대한 monitoring을 수행하는 CORESET ID, CSS/USS 여부 및 monitoring해야 하는 DCI 정보, aggregation levels, AL 별 candidate 수, 해당 search space set의 monitoring periodicity 및 slot내

에서의 monitoring occasion 관련 정보 등이 포함되어, 해당 search space set의 구성요소 및 monitoring 관련 정보를 제공한다. 추가적으로 NR에서는 각 BWP별로 최대 3개의 CORESET과 10개의 search space set이 configure될 수 있다.

[Complexity for blind decoding and channel estimation]

다수의 search space set에 대하여 서로 다른 monitoring periodicity 및 offset 등이 설정되기 때문에, 특정 slot (예를 들어, 다수의 search space set에 대한 monitoring occasion이 중복되는 slot)에서는 monitoring을 수행해야 하는 candidate의 수가 크게 증가할 수 있으며, 이는 blind decoding에 대한 UE의 complexity를 크게 증가시킬 수 있다. 따라서 NR에서는 하나의 slot내에서 UE가 수행할 수 있는 최대 BD 수 및 최대 channel estimation complexity (이는 CCE 수로 표현된다.)를 각 numerology별로 정의하고 있다. UE는 각 slot에서 network에 의해 configure된 BD 수 그리고/혹은 CCE의 수가 limit을 초과할 경우, priority에 의해 특정 candidates에 대한 blind decoding만을 수행할 수 있다. 예를 들어, 각 slot에서 CSS로 configure된 search space set(s)에 대한 BD수 및 CCE수는 limit을 초과하지 않는다고 가정할 수 있으며, USS의 경우, 낮은 index의 SS set이 high priority를 갖고, SS set level로 candidate에 대한 BD 여부가 결정될 수 있다.

3. Composition and Method of the Invention

NR에서는 beam 기반의 송수신 동작이 수행되며, 현재 serving beam의 수신 성능이 저하될 경우, beam failure recovery (BFR)이라는 과정을 통해 새로운 beam을 찾는 과정을 수행하게 된다. BFR은 network와 UE간의 link에 대한 failure를 선언하는 과정이 아니므로, BFR 과정을 수행하더라도 현재 serving cell과의 connection은 유지되고 있다고 가정할 수도 있다. BFR 과정에서는 network에 의해 configure된 서로 다른 beam (이 때 beam은 CSI-RS의 port 혹은 SSB index 등으로 표현될 수 있다.)에 대한 measurement를 수행하고, 해당 UE에게 best beam을 선택할 수 있다. UE는 measurement 결과가 좋은 beam에 대하여, 해당 beam과 연계된 RACH procedure를 수행하는 방식으로 BFR 과정을 진행하게 된다.

본 발명에서는 control channel processing 관점에서 BFR 수행 시 필요한 CORESET & search space set configuration 및 BD/CE complexity handling을 위한 candidate mapping 방법을 제안한다. (본 발명에서 Transmission Configuration Indication (이하 TCI) state는 control channel의 CORESET별로 configure될 수 있으며, UE의 Rx beam을 결정하기 위한 parameter로 사용될 수 있다.)

[CORESET and search space set for BFR]

BFR 과정에서 CORESET 및 search space는 UE가 best beam으로 선정한 beam에 연계된 자원으로 RACH procedure를 수행하는 과정에서 RAR message 등 network로부터 필요한 signaling을 수신하기 위한 용도로 사용될 수 있다. 추가적으로 변경된 beam 정보를 반영한 새로운 CORESET 및 search space를 설정받기 전까지 UE는 BFR CORESET을 통해 UL grant, DL assignment등을 수신할 수 있다.

● Relation between BWP and BFR CORESET & SS set

- NR에서는 각 BWP별로 최대 3개의 CORESET, 10개의 search space set이 설정될 수 있으며, 이 때 각각의 CORESET은 서로 다른 CORESET 특성(e.g., CCE-to-REG mapping (with/without interleaving), REG bundle size (2,3,6 REGs), WB/NB RS, ...), 각각의 search space set은 서로 다른 monitoring occasion, AL, candidate 수 등을 가지도록 하여 scheduling flexibility를 증가시킬 수 있다. BFR CORESET의 경우, 위에서 언급한 PDCCH 송수신의 scheduling flexibility와 관계없이 beam 수신 성능 저하로 인해 새로운 beam을 찾기 위한 과정이므로 BWP별 최대 CORESET의 수에 해당하는 limit(즉, BWP당 3개의 CORESET)은 BFR CORESET에 적용하지 않는 것이 바람직할 수 있다. 다시 말해서, UE는 BWP별로 BFR CORESET을 제외한 3개의 CORESET, BFR search space set을 제외한 10개의 search space set을 configure 받을 수 있다. (BFR CORESET이 일반 CORESET을 reuse하는 경우, 해당 일반 CORESET이 BFR이 아닌 용도로 configure된 경우에는 CORESET 개수로 count 할 수 있다. 이는 search space set에도 동일하게 적용될 수 있다.)
- BFR CORESET은 BWP별로 설정되거나, initial BWP에 설정하는 방식을 고려할 수 있다. (이는 BWP별로 BFR CORESET이 설정될 경우, 해당 configuration을 따르고, 설정되지 않을 경우, initial BWP의 BFR CORESET을 monitoring하는 경우를 포함한다.) 추가적으로 아래의 방법 외에 기존 configure된 CORESET 그리고/혹은 SS set을 BFR에 연계된 CORESET 그리고/혹은 SS set으로 reuse할 수 있으며, 이 경우, CORESET configuration 그리고/혹은 SS set configuration의 일부 parameter는 새롭게 설정할 수 있다. (예를 들어, CORESET configuration 중 TCI state와 같은 parameter의 경우, 기존의 configuration과 상관없이 BFR CORESET에서는 UE의 measurement 결과 best beam 혹은 BFR 과정에서 UE가 진행한 RACH procedure에 의해 TCI 그리고/혹은 QCL 등이 정의된다고 가정할 수 있다.)
 - ◆ BFR CORESET이 BWP별로 설정될 경우,
 - UE가 현재 network와의 송수신을 유지하는 BWP(즉, active BWP)에는 BFR CORESET이 항상 configure될 수 있다. 이는 BWP configuration내에 BFR CORESET에 대한 정보를 포함시키는 방법 등을 통해 구현될 수 있으며, 해당 CORESET의 monitoring occasions는 BFR로 인한 PRACH 전송 시점에 의해 결정 (e.g., PRACH 전송 slot index + 4 이후 RAR monitoring window내의 매 slot)될 수 있다.
 - BFR procedure가 진행되더라도 serving cell과의 connection은 유지되고 있다고 인식하는 것이 바람직할 수 있으므로, UE는 BFR CORESET에 대한 monitoring 뿐만 아니라 이전에 configure된 CORESET & SS set configuration에 따라 DCI monitoring을 수행할 수 있다. 예를 들어, BFR CORESET에서는 C-RNTI로 scrambling된 PDCCH만을 monitoring하도록 정의될 수 있으며, 이 경우 SFI, SI, paging 등의 고유 RNTI를 부여받은 정보는 UE에게 전달할 수 없는 경우가 발생할 수 있기 때문에, 기존 CORESET에 대한 monitoring을 유지하는 것이 바람직할 수 있다. 이 때 UE가 monitoring을 수행하는 실제 candidate 설정방법은 다음 section에서 기술하도록 한다.
 - ◆ BFR CORESET이 initial BWP에 설정될 경우,

- Initial BWP에는 기본적으로 PBCH에 의해 configure된 CORESET (CORESET#0)와 RACH procedure를 위해 configure된 CORESET (CORESET#1)이 설정될 수 있으며, CORESET#1이 configure되지 않을 경우, CORESET#0를 CORESET#1 용도로 reuse 할 수 있다.
- 기존 DCI monitoring이 수행될 경우, UE는 BFR과 기존 DCI를 monitoring하기 위해 동일 slot에서 서로 다른 BWP에 대한 monitoring을 수행해야 할 수 있다. 이 경우, 아래의 방법들이 고려될 수 있다.
 - Option 1) BFR CORESET에 대한 monitoring은 special case로 간주하여, active BWP와 initial BWP가 일치하지 않을 경우에도, BFR에 대한 DCI monitoring과 기존 configure된 DCI에 대한 monitoring을 모두 수행할 수 있다.
 - Option 2) BFR에 대한 DCI monitoring을 수행하는 BWP와 기존 active BWP가 다를 경우, 기존 active BWP에 대한 DCI monitoring은 수행하지 않을 수 있다. (이는 BFR에 대한 DCI monitoring을 수행하는 BWP가 기존 active BWP와 같을 경우에만, 기존 DCI monitoring을 수행하는 방식을 포함할 수 있다.)
- BFR CORESET이 initial BWP에 설정될 경우, 다음의 방식을 이용하여 BFR CORESET을 indicate할 수 있다.
 - Option 1) Reuse CORESET#0 or CORESET#1
 - ◆ 사전 정의를 통해, 혹은 network이 higher layer signaling등을 통해 BFR CORESET이 기존에 정의된 CORESET을 reuse하도록 설정할 수 있다.
 - ◆ CORESET#0를 BFR CORESET으로 reuse하고, BFR procedure가 CSI-RS port를 기반으로 수행될 경우, network은 BFR procedure에 사용되는 각 CSI-RS port와 CORESET#0에 연계된 SSB index와의 관계를 signaling할 수 있다. (예를 들어, BFR procedure에 사용한 CSI-RS port와 SSB index간의 mapping 관계를 higher layer signaling 등을 통하여 indicate할 수 있다.)
 - Option 2) New CORESET for BFR
 - ◆ Network은 각 UE에게 initial BWP내에 존재하는 BFR CORESET에 대한 configuration을 indicate할 수 있으며, indication 방법은 broadcast signal 혹은 UE-dedicated signal을 사용할 수 있다.

BFR CORESET/SS의 경우 configuration 이 optional 일 수 있다. 따라서 BFR CORESET/SS가 해당 active BWP내에 설정되지 않은 경우, 혹은 BFR CFRA 자원이 설정되지 않은 경우, 단말은 다음 동작을 수행할 수 있다.

- CBRA 자원을 따라 beam recovery 를 수행한다. 해당 CBRA자원에 연계된 RAR CORESET/SS를 BFR-CORESET으로 가정하고 이에서 beam recovery 에 대한 response를 기대한다.
- CBRA자원에 연계된 RAR CORESET/SS를 통해 beam recovery 에 대한 response를 기대한다.
- Initial DL/UL BWP로 돌아가 CFRA/CBRA/RAR CORESET/SS자원을 이용한다. 혹은 이 옵션은 해당 active DL/UL BWP내에 BFR CORESET/SS 혹은 CFRA 자원이 없는 경우에만 적용할 수 있다.

[BD and channel estimation complexity on BFR procedure]

NR에서는 다수의 CORESET과 SS set에 대한 monitoring을 동일 slot에 설정할 수 있기 때문에, UE의 complexity를 고려하여 하나의 slot내에서 수행할 수 있는 BD와 channel estimation의 최대값을 정의하고, 해당 max 값을 초과하는 slot에서는 일부 candidate에 대한 monitoring을 수행하지 않을 수 있다. BFR CORESET에 대한 monitoring을 원활히 수행하기 위해, BFR CORESET에 대한 monitoring을 수행하는 slot에서는 아래와 같이 monitoring해야 하는 candidate를 설정할 것을 제안한다. (현재 일반적인 slot에서는 CSS에 대한 BD 및 channel estimation은 우선적으로 수행되고, CSS로 인한 각 limit의 초과는 없다고 가정한다. 이후 USS에 대하여 SS set level의 candidate selection (혹은 mapping)이 수행되며, 다수의 USS에 대하여 lower SS index가 higher priority를 갖는다고 가정한다.)

- Priority of BFR SS set
 - BFR SS set에 대한 monitoring을 최우선 순위로 지정할 수 있다.
 - ◆ BFR procedure에서는 serving beam 설정 등이 우선적으로 수행되어야 하므로, BFR에 관련된 SS set에 속한 candidate의 monitoring을 반드시 수행되어야 한다.
 - ◆ 따라서 BFR에 관련된 SS set (예를 들어, BFR 과정에서 UE가 송신한 PRACH에 대한 response 및 이후 과정)은 해당 BFR SS set의 type (e.g., CSS/USS)에 관계없이 가장 높은 priority를 설정하고, 해당 SS set에 속한 candidate에 의한 limit 초과는 없다고 가정할 수 있다.
 - BFR SS set에 대한 monitoring은 slot당 BD 및 CCE limit과 별도로 수행될 수 있다.
 - ◆ BFR관련 DCI는 반드시 수신한 slot에서 decoding을 완료해야만 하는 것은 아닐 수 있다. 따라서, 기존에 configure된 DCI monitoring은 slot별 BD 및 CCE limit을 고려하여 계속 수행하고, SFR SS set에 대한 monitoring을 독립적으로 수행할 수 있으며, 이때, BFR SS set에 의해 configure된 BD 및 CCE 수는 limit을 초과하지 않는다고 가정할 수 있다.
- CSSs에 대한 assumption
 - 위에서 언급했듯이, 일반적인 slot (즉, BFR procedure를 수행하지 않는 slot)에서는 configure된 CSSs는 max. BD 및 CCE 수를 초과하지 않음을 가정할 수 있다.
 - 하지만 BFR CORESET을 monitoring할 경우 BFR monitoring을 위한 BD/CCE 수가 더해지기 때문에 기존 CSSs에 의한 BD/CCE까지 고려할 경우 BD/CCE limit을 초과하는 경우가 발생할 수 있다. 따라서 BFR SS set을 monitoring하는 slot에서는 다음과 같이 가정할 수 있다. 아래 option들은 단독으로 혹은 조합을 통해 구현될 수 있다. 아래 옵션들은 CSS에만 적용하고, 기존 configuration에 의한 USS는 BFR procedure 중 monitoring하지 않을 수도 있다. 혹은 아래 option에 의해 CSS 중 monitoring을 수행할 candidate를 선정하고, 이후에도 BD/CCE에 대한 여유가 있을 경우, USS에 대하여 PDCCH mapping to SS sets을 진행할 수도 있다.
 - ◆ **Option 1)** BFR slot에서도 기존에 configure된 CSSs는 BD 및 CCE limit을 초과하지 않는다고 가정할 수 있다. (이는 network이 BFR slot에서 BFR에 관련된 candidate에 대

한 BD 및 channel estimation을 수행하더라도, 최소한 기존에 configure된 CSSs에 대한 BD 및 CCE 수는 limit을 초과하지 않도록 configure함을 의미할 수도 있다.)

- ◆ **Option 2)** BFR SS set에 의한 BD 및 CCE수에 의해 기존에 configure된 CSSs에서의 BD 및 CCE 수가 limit을 초과할 경우, CSS(s)에 대하여 SS set level dropping을 적용할 수 있다. 이 때, SS set간 priority는 SS index (예를 들어, 낮은(높은) SS index가 높은 priority를 갖는다고 가정), DCI format (예를 들어, DCI format별로 priority가 정의됨) 등에 의하여 결정될 수 있다.
 - 예를 들어, 하나의 slot내에서 정의된 BD 및 CCE limit을 X_{slot} , Y_{slot} 이라 정의하고, BFR SS set에 configure된 BD 및 CCE 수가 X_{BFR} , Y_{BFR} 이라 할 때, 해당 slot에 configure된 CSS(s)에 허용된 BD 및 CCE 수는 $X_{CSS} (=X_{slot} - X_{BFR})$, $Y_{CSS} (=Y_{slot} - Y_{BFR})$ 라 할 수 있다. 이 때 해당 slot에 configure된 CSS 중 가장 priority가 높은 CSS set의 BD 및 CCE 수가 X_{CSS} , Y_{CSS} 보다 작을 경우 해당 CSS에 대한 blind decoding은 수행할 수 있다. 이후 X_{CSS} , Y_{CSS} 값은 update되고, 해당 과정을 다음 priority의 CSS에 대하여 두 개의 limit 중 하나라도 초과하는 경우까지 반복할 수 있다. (limit을 초과하는 CSS에 대한 BD는 수행하지 않는다.)
 - Candidate level의 candidate dropping도 option 2)에 포함될 수 있다.
- ◆ **Option 3)** 특정 slot에서 BFR SS set과 하나 혹은 다수의 CSS set에 대한 monitoring을 configure 받고, BFR SS set에 의해 BD and/or CCE 수와 CSS set(s)에 의한 BD and/or CCE의 수가 해당 limit을 초과한 경우, CSS에 대한 monitoring을 수행하지 않을 수 있다.
- ◆ **Option 4)** BFR CORESET/SS를 위한 monitoring은 UE이 capability에 추가적으로 포함될 수도 있다. 즉, BFR CORESET/SS는 구성받은 만큼 단말이 추가적으로 channel estimation/BD를 기존 능력보다 수행할 수 있다고 가정하고 channel estimation/BD limit에 고려하지 않을 수 있다. 이는 BFR CORESET 및 SS set에 대한 capability는 따로 정의되거나, BFR 관련 BD/channel estimation은 일반적인 DCI에 대한 BD/channel estimation과 독립적으로 항상 수행된다고 가정하는 것을 의미하며, BD 및 channel estimation에 대한 limit은 BFR CORESET/SS set을 제외한 나머지 CORESET/SS set에 적용됨을 의미할 수 있다.
- ◆ **Option 5)** BFR CORESET에 대한 monitoring을 수행하는 slot에서는 기존 CORESET/SS set의 candidate 중 특정 RNTI에 해당하는 candidate만 monitoring하도록 사전에 정의되거나 higher layer signaling 등을 통하여 indicate될 수 있다. 예를 들어, BFR CORESET에 대한 monitoring을 수행하는 slot에서는 기존에 configure된 CORESET/SS set 중 SFI에 관련된 PDCCH candidate만을 monitoring하도록 정의될 수 있다. (추가로 이 경우, 기존 CORESET에 대한 monitoring 시 BD/CCE limit을 초과할 경우, 기존 CORESET에 대한 monitoring을 수행하지 않을 수 있다.)
- ◆ **Option 6)** BFR CORESET을 monitoring해야 하는 slot에서는 BFR CORESET을 제외한 다른 CORESET에 대한 monitoring을 수행하지 않도록 사전에 정의하거나 higher layer signaling을 통해 indicate할 수 있다.

[Rx beam priority]

위에서 밝혔듯이, NR에서는 UE complexity 측면에서 BD, CCE 수 등에 대한 limit을 정의하고, 특정 slot에서 해당 limit를 초과할 경우, candidate 중 일부에 대한 monitoring을 skip하는 방식을 사용한다. 이와 같은 방식은 UE가 특정 time resource에 사용하는 Rx beam에 대해서도 적용될 수 있다.

NR에서는 다수의 CORESET에 대한 monitoring을 동일한 slot에서 수행할 수 있으며, 이 때 각 CORESET들은 time/frequency domain에서 overlap될 수 있다. 또한 각 CORESET은 서로 다른 QCL assumption (i.e., CORESET별로 PDCCH를 위한 TCI state를 configure)이 적용될 수 있다. 이는 동일 symbol에서 서로 다른 Rx beam으로 수신해야 하는 CORESET이 다수 포함될 수 있음을 의미하며, RF 패널이 하나인 UE (즉, 특정 time resource에서 하나의 Rx beam만을 수신할 수 있는 UE)는 다수의 Rx beam 중 하나를 선택해야 한다. 본 발명에서는 이와 같이 다수의 Rx beam이 필요할 경우, 하나의 Rx beam을 설정하는 방법을 제안한다. (이는 time domain에서 overlap되는 다수의 CORESET에 대한 priority를 설정하는 것으로 해석될 수도 있다.) 아래의 방법에 의해 UE가 적용하는 Rx beam이 결정될 경우, network은 해당 Rx beam에 연계된 CORESET에서의 송신을 우선적으로 수행하거나, 부적절한 Rx beam이 사용되는 CORESET의 경우 coding rate 혹은 power boosting 등을 통하여 수신 성능을 보상할 수 있다. 아래 option들은 단독으로 혹은 조합을 통해 구현될 수 있다.

Option 1) Measurement 기반 priority

UE는 measurement 및 report 결과에 기반하여 해당 time resource에서의 Rx beam을 설정할 수 있다. 예를 들어, 하나의 symbol에 3개의 CORESET이 중복되고, 각 CORESET의 QCL assumption이 다를 경우, 각 CORESET에 연계된 measurement 결과 중 가장 best measurement 결과에 기반하여 해당 symbol에서의 Rx beam을 설정할 수 있다. 일례로 각 CORESET에서 measurement된 RSRP 중 가장 높은 값을 가진 CORESET에 연계된 Rx beam을 해당 symbol에 적용할 수 있다. (option 1은 UE가 현재 measure한 값에 기반하여 결정될 수도 있고, 가장 최근에 report한 measurement 결과에 기반하여 결정될 수도 있다.)

Option 2) CORESET/SS set index 기반 priority

CORESET index 혹은 SS set index에 priority를 부여하여, 해당 자원에 적용할 Rx beam을 결정할 수 있다. 예를 들어, UE는 CORESET index가 가장 낮은 (혹은 가장 높은) CORESET (혹은 가장 낮은 SS index에 연계된 CORESET)의 TCI state에 근거하여 Rx beam을 설정할 수 있다.

Option 3) Message 기반 priority

UE는 각 CORESET에서 monitoring해야 하는 message의 priority(예를 들어, DCI format, RNTI, BFR 등)에 기반하여 Rx beam을 설정할 수 있다. 예를 들어, SFI, pre-emption등에 관련된 DCI를 monitoring하는 CORESET의 Rx beam이 non-fallback DCI를 monitoring하는 CORESET의 Rx beam에 비하여 높은 priority를 가질 수 있다. 또 다른 예로, RACH/SI update/paging 등 UE의 통신을 유지하기 위해 필요한 정보에 대한 monitoring을 수행하는 CORESET의 Rx beam을 higher priority로 설정할 수 있다.

추가적으로 위에서 제안했듯이, beam failure recovery (혹은 beam management) 등에 관계된

CORESET의 경우, monitoring을 수행해야 하는 slot내의 CORESET priority에 상관없이 항상 highest priority를 부여할 수 있다.

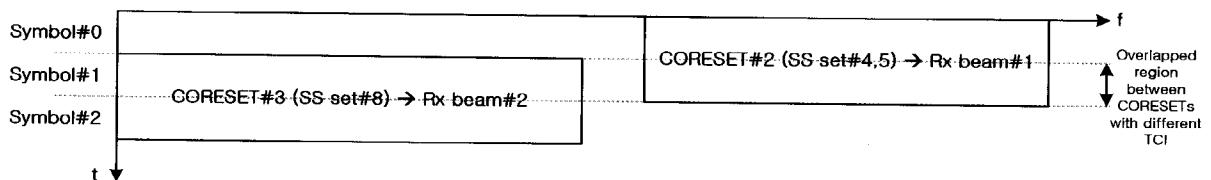
Option 4) Monitoring occasion의 시간 순서에 의한 priority

UE는 slot내에서 각 CORESET의 SS monitoring 순서에 따라 먼저 오는 SS의 beam에 연계된 Rx beam을 적용할 수 있다. 즉, CORESET의 starting symbol index에 따라 각 CORESET의 priority가 결정될 수 있다. 동일한 CORESET이 다수의 SS set에 연계되고, 동일한 starting symbol을 가질 경우, SS set index등의 priority에 기반하여 Rx beam을 결정할 수 있다.

Option 5) CORESET에 연계된 SS set의 개수에 따라 CORESET의 priority가 결정

위에서 언급했듯이, NR에서는 BWP별로 3개의 CORESET과 10개의 search space set이 configure될 수 있으며, 이는 하나의 CORESET에 다수의 search space set이 연계될 수 있음을 의미한다. Option 5는 특정 slot에서 다수의 CORESET에 연계된 다수의 search space set을 monitoring해야 하고, 각 CORESET의 TCI state가 다를 경우, 연계된 search space set의 수가 많은 CORESET의 priority를 높게 부여하는 방법을 의미한다. (이 때, 연계된 search space set의 수는 해당 slot에서 monitoring을 수행하는 search space set으로 한정될 수 있다.)

위에서는 특정 time resource에서 서로 다른 TCI state를 갖는 CORESET 들이 중복되어 configure 될 경우, 어떤 TCI state에 기반하여 Rx beam을 설정할 지에 대하여 제안하였다. 본 발명에서는 추가적으로 하나의 CORESET내에서 다른 CORESET과 중복된 time resource와 해당 CORESET만 존재하는 time resource가 모두 존재할 경우, 각 영역에 대한 Rx beam 설정방법을 제안한다. [그림 3-1]은 서로 다른 TCI state가 configure된 서로 다른 2 CORESETs이 time domain에서 partially overlap되는 경우에 대한 예를 나타낸다. 그림에서 알 수 있듯이, 각 CORESET에 대한 monitoring을 수행할 때 UE가 적용해야 하는 Rx beam이 서로 다르고, 2개의 CORESET이 overlap될 경우, 위에서 제안한 priority rule에 의해 UE가 적용해야 하는 Rx beam (혹은 UE가 가정해야 하는 TCI state)가 결정될 수 있다. 예를 들어, 그림에서 CORESET#2의 priority가 높다면 UE는 중복된 영역에서 Rx beam#1을 적용할 수 있다. 그러나 이 경우, CORESET#3의 symbol#2에서 어떤 Rx beam을 사용하여 수신할 지가 결정되어야 한다. 이를 위해 본 발명에서는 아래의 option을 제안하며, 아래 option들은 단독으로 혹은 조합을 통해 구현될 수 있다.



[그림 3-1]

추가로 아래의 option들은 각 slot별 CORESET의 set별로 수행될 수 있다. 예를 들어, 각 set은 time domain에서 partially or fully overlap된 CORESET들로 구성될 수 있으며, 하나의 slot내에 존재하는 모든 CORESET이 하나의 set을 구성할 수도 있다.

Option 1) 각 time resource 별로 priority에 따라 Rx beam 설정

각 time resource (e.g., OFDM symbol)에서 가장 priority가 높은 CORESET의 TCI state에 근거하여

해당 time resource에서의 Rx beam을 설정할 수 있다. 이 경우, 동일한 CORESET내에서 서로 다른 Rx beam으로 인해 인접 symbol간 동일한 precoding을 가정할 수 없는 경우가 발생할 수 있으며, 해당 CORESET에서는 time domain REG bundling이 적용되지 않는다고 가정할 수 있다. 혹은 동일한 Rx beam을 사용하는 time resource내에서만 time domain bundling이 적용된다고 가정할 수 있다.

Option 2) 중복된 CORESET 중 highest priority를 갖는 CORESET에 대한 Rx beam을 중복 영역을 포함하는 다수의 CORESET에 적용

Option 2는 동일한 time resource를 포함하는 CORESET들에 대하여, 해당 CORESET 중 가장 높은 priority를 갖는 CORESET의 TCI state에 근거하여 중복된 CORESET 전체에 대한 Rx beam을 설정할 수 있다. 이는 time domain에서 (예를 들어, symbol level) 중복되지 않는 CORESET들은 각 CORESET의 TCI state에 근거하여 Rx beam을 설정함을 의미하기도 한다.

Option 3) 하나의 slot에서 서로 다른 TCI state를 갖는 CORESET이 다수 존재할 경우, 위에서 제안한 priority rule에 의해 highest priority로 결정된 CORESET의 TCI state를 해당 slot 전체에 적용할 수 있다. 이는 서로 다른 TCI state를 configure받은 서로 다른 CORESET을 동일 slot에서 monitoring할 경우, priority가 낮은 CORESET은 해당 slot에 한하여 Rx beam을 변경(즉, configuration과 다른 TCI state를 가정)할 수 있음을 의미할 수 있다.

Option 4) UE는 서로 다른 TCI state가 설정된 CORESET이 time domain에서 partially or fully overlap될 경우, highest priority를 갖는 CORESET에 속한 SS sets의 candidate에 대해서만 monitoring을 수행하도록 가정할 수 있다. 또한 이는 time domain에서 overlap되지 않는 CORESET에 대한 monitoring은 configuration에 따라 수행함을 포함할 수도 있다. 혹은 해당 slot 중 서로 다른 Rx beam을 가정해야 하는 CORESET이 overlap할 경우, 해당 slot 전체에서 가장 priority가 높은 CORESET에 대한 monitoring만을 수행하는 것으로 해석될 수도 있다.

Option 4는 BFR CORESET/SS set을 monitoring해야 하고, 해당 BFR CORESET에서의 TCI state가 기존의 CORESET (즉, BFR 이전에 monitoring을 수행하도록 configure된 CORESETs/SS sets)과 다를 경우, 해당 slot에서는 BFR CORESET에 대한 monitoring만을 수행하는 경우를 포함할 수 있다. (또한 이는 기존의 CORESET과 BFR CORESET이 동일 slot에서 monitoring되고, 기존 CORESET 중 BFR CORESET과 동일한 Rx beam을 사용하는 CORESET이 존재할 경우, 해당 CORESET에 대해서는 monitoring을 수행하는 경우도 포함할 수도 있다.)

<2018-05-11 추가>

● **QCL assumption of a CORESET without tci-StatesPDCCH**

According to a current RRC specification (i.e., TS38.331), an information element "ControlResourceSet" is provided for each CORESET, and a parameter "tci-StatesPDCCH" in the IE can be configured for providing QCL relationships between the DL RS/SSB and the CORESET. However, the "tci-StatesPDCCH" is optional parameter. It means that the parameter may not be configured for some CORESETs. So, a default QCL assumption should be needed to determine Rx beam for PDCCH reception in the TCI-less CORESET. For a default QCL assumption, we propose that, for a CORESET which doesn't include "tci-StatesPDCCH", a UE assumes that a QCL from latest RACH procedure is applied to the CORESET.

In the case of BFR-CORESET (for beam failure recovery procedure), according to the previous agreement from the email discussion in MIMO session, a UE assumes that the dedicated CORESET is spatial QCL'ed with DL RS of the UE-identified candidate beam in the beam failure recovery request. From the PDCCH perspective, this agreement can be interpreted as follows; implicit spatial QCL update (regardless of CORESET configuration) via beam recovery procedure and/or beam management procedure is assumed for a BFR-CORESET.

Other than BFR-CORESET, it needs to clarify which CORESET(s) would not be associated with TCI states. At least, we consider that CORESET #0 (by PBCH) and #1 (by RMSI) would not be associated with TCI states. For other CORESETs, generally for USS operation, it is desirable to configure TCI states.

Some clarification whether this RACH procedure can include contention-free as well is necessary. In our view, contention-free may be based on CSI-RS without associated SSB and QCL associated with the CSI-RS may not be stable for CORESET#0 and/or #1. So, at least for CORESET#0 and/or #1, it is safer to change QCL information based on the recent contention-based RACH procedure.

위의 내용에 따르면 tci-StatesPDCCH가 configure되지 않은 CORESET은 가장 최근에 수행한 RACH procedure로부터 도출한 QCL assumption을 적용할 수 있다. 본 발명에서는 좀 더 구체적으로 QCL assumption을 도출하는 방법을 추가로 제안한다. 아래에서 contention based RACH

는 SSB를 기반으로 (measurement 결과에 기인한) best SSB에 연계된 자원에서의 RACH procedure를 수행함을 의미할 수 있으며, contention free RACH procedure는 gNB의 signaling에 의해 CSI-RS port (혹은 SSB) 등에 연계된 자원에서 RACH procedure를 수행하는 경우를 의미할 수 있다. Contention free RACH procedure는 network configuration에 기반하기 때문에 measurement와 무관하게 signaling되거나, network이 UE의 measurement report를 기반으로 signaling할 수도 있다. 또한 CSI-RS port의 경우, SSB와의 연계를 signaling하거나 하지 않을 수 있다. 즉, contention free RACH procedure는 SSB와의 연계성 및 measurement 결과의 반영 등을 확신할 수 없는 경우가 발생할 수 있다. 이는 SSB와 연계되어 CORESET 및 search space set이 설정될 수 있는 CORESET#0, #1 등의 동작에서 성능을 저하시키는 요인으로 작용할 수 있다. 예를 들어, UE는 잘못된 Tx beam에 대한 가정을 기반으로 Rx beam을 설정하는 경우가 발생할 수 있다.

1. UE는 RACH procedure의 type (즉, contention based/contention free RACH procedure)과 상관없이 가장 최근에 수행한 RACH procedure에서 도출한 QCL assumption을 TCI-less CORESET에 적용할 수 있다.
2. UE는 TCI-less CORESET의 QCL assumption은 가장 최근에 수행한 contention based RACH procedure에서 도출한 결과만을 적용할 수 있다. 이는 실제로 가장 최근에 수행한 RACH procedure가 contention free 방식일 경우, 해당 결과를 무시하고 가장 최근에 수행한 contention based RACH procedure에서 도출한 QCL assumption을 해당 CORESET에 적용함을 의미할 수 있다.
3. CORESET별로 서로 다른 RACH procedure의 QCL assumption을 사용할 수도 있다. 예를 들어, CORESET#0 (and/or #1)은 가장 최근에 수행한 contention based RACH procedure로부터 도출한 QCL assumption을 적용하고, 나머지 CORESET은 contention 여부와 상관없이 가장 최근에 수행한 RACH procedure로부터 QCL assumption을 도출할 수 있다. 또 다른 예로, CSS가 configure된 CORESET은 가장 최근에 수행한 contention based RACH procedure로부터 도출한 QCL assumption을 적용하고, USS가 configure된 CORESET은 contention 여부와 상관없이 가장 최근에 수행한 RACH procedure로부터 QCL assumption을 도출할 수 있다. (이 때 CSS와 USS가 모두 configure된 CORESET의 가장 최근에 수행한 contention based RACH procedure로부터 도출한 QCL assumption을 적용할 수도 있다.)
4. 위에서 제안한 방식들에서 contention free RACH procedure라고 할지라도 연계된 SSB가 indicate되거나, implicit하게 연계된 SSB를 알 수 있을 경우, 해당 contention free RACH procedure로부터 도출한 QCL assumption을 TCI-less CORESET에 적용할 수도 있다.

추가적으로 본 발명에서는 TCI-less CORESET에 대하여 어떤 RACH procedure type으로부터 QCL assumption을 도출하는지를 network이 higher layer signaling 등을 통하여 UE에게 알릴 것을 제안한다. 이는 contention free RACH procedure에서 주어지는 CSI-RS port에 연계된 SSB 정보를 UE에게 알리는 방법도 포함될 수 있다.

● **QCL assumption between overlapped CORESETs in time domain**

According to previous agreements, each CORESET has own QCL assumption, and different

CORESETs can be overlapped on time and/or frequency domain. It means that CORESETs with different QCL assumptions can be overlapped on a same symbol. Because a UE determines an Rx beam used for monitoring each CORESET by considering TCI state of each CORESET, if multiple CORESETs with different QCL assumptions overlaps on time domain resources (e.g., OFDM symbol), a UE should support multiple Rx beams or select one Rx beam (or TCI state) by a certain selection rule. In current release, a UE which can use multiple Rx beams are not considered so far, so we can consider following options for solving the problem;

Option 1) Monitoring skip of lower prioritized CORESET

The CORESET selection rule can be applied when CORESETs with different spatial QCLs are overlapped on time resources, and a UE can skip monitoring candidates included in non-selected CORESET. The priority of each CORESET can be determined by, for example, CORESET ID, the number of SS sets associated with a CORESET, associated search space type, etc. This option is simple, but PDCCH transmission/reception opportunity cannot be guaranteed in some resources.

Option 2) Representative spatial QCL for overlapped CORESETs

This option is to list overlapped CORESETs using the priority rule as in Option 1). Instead of dropping lower priority CORESET(s), change of QCL state can be considered on lower priority CORESET(s). In other words, we propose that same spatial QCL is assumed on overlapped CORESETs, and the representative QCL can be selected by using CORESET priority as mentioned in option 1. In other words, QCL assumption for overlapped CORESET(s) follow the highest priority CORESET's QCL. This option can provide more PDCCH transmission/reception opportunity, but the PDCCH performance of CORESET with lower priority may be decreased because of mismatch between Tx beam and Rx beam.

Option 3) No overlap between CORESETs with different spatial QCLs

A UE can assume that the network doesn't schedule overlapped CORESETs with different spatial QCLs. However, it is not sure that the overlap can always be avoided by scheduling.

● **Candidate mapping in Case 2**

Search space of Case 1 and Case 2

In last meeting, it was agreed that the number of CCEs for channel estimation per slot of Case 2 is same with Case 1 (i.e., for both cases, {56, 56, 48, 32} CCEs for SCS {15kHz, 30kHz, 60kHz, 120kHz}). Regarding the agreement, it seems that either Case 1 or Case 2 can be configured to a UE. In other words, it is ambiguous whether a UE can be configured to monitor Case 1 and Case 2 SS sets in a slot. In our understanding, there is no reason to prohibit such configuration. For example, common information can be transmitted on shared resources (i.e., slot based scheduling) between eMBB and URLLC, and service-specific data can be transmitted by slot based scheduling (for eMBB) and non-slot based scheduling (for URLLC). In this case, URLLC UEs can receive both scheduling types, i.e., Case 1 and Case 2. In order to clarify previous agreements, we propose as follows;

Proposal 1: A UE can be configured to monitor both Case 1 and Case 2 search space sets, and both SS sets can be monitored in a slot.

Proposal 2: For Rel.15 December 2017 version, maximum number of CCEs for channel estimation per slot per UE per CC is {56, 56, 48, 32} CCEs for SCS {15kHz, 30kHz, 60kHz, 120kHz} regardless of CORESET/SS configurations. → 이는 BD limit에도 동일한 적용될 수 있다.

Candidate mapping in Case 2

Generally, the required number of BDs/CCEs of Case 2 is much larger than Case 1, if the configured number of BDs/CCEs in a SS set configuration is almost same between Case 1 and 2. . In terms of CCE counting for Case 2 search space set, it is necessary to multiply the required CCEs for each monitoring occasion by the number of monitoring occasion in a slot. With this the necessary CCEs/BDs increases proportionally with the number of monitoring occasion. Thus, if search space set level channel estimation/BD budget handling is also used for Case 2, it may be possible that the entire monitoring occasion of Case 2 is dropped particularly when the number of monitoring occasion is high. This can have impact, for example, on URLLC support. To mitigate this impact, we can consider further candidate selection on monitoring occasion basis (e.g., some monitoring occasions are dropped). However, we don't have enough time to discuss this issue, so we propose as follows;

Proposal 1: In Rel-15, SS set-level PDCCH mapping within a slot is used for BD/CE complexity handling even for Case 2.

● **BFR CORESET/SS set**

The BFR CORESET and associated SS set are configured for beam failure recovery procedure. This CORESET/SS set is activated by beam failure recovery procedure, and a UE is not expected to monitor PDCCH candidates in the CORESET before beam failure recovery procedure (e.g., PRACH transmission) and after new CORESET/SS set configuration(s) or TCI update. On the other hands, it is not sure whether PDCCH monitoring in existing CORESETs (i.e., CORESETs which are configured to monitor before BFR procedure) is performed during monitoring window of BFR CORESET. In our view, as some common information (such as SFI, system information, paging ...) may not be monitored in the BFR CORESET, it is desirable that a UE can monitor PDCCH candidates in the existing CORESETs even during monitoring window of BFR CORESET.

Proposal 2: A UE may continue monitoring on other active CORESETs (than BFR-CORESET) during BFR procedure.

It is expected that TCI state of a CORESET (if configured) will be updated only via explicit configuration. Thus, during BFR procedure, the UE may monitor a CORESET with outdated TCI state. When BFR-CORESET and other CORESET(s) are monitored on the same time resource with potentially different QCL/TCI information (and thus potentially lead different Rx beam), some

handling is necessary. A simple solution is that a UE can skip monitoring old CORESET, if BFR CORESET overlaps with old CORESET in time domain. This is to prioritize BFR-CORESET in case of collision.

Another issue is whether to count CCEs/BDs for BFR-SS under UE's channel estimation/BD limit. If it is not accounted, it may be that the total number of required CCEs can be much higher than what UE can support during BFR, we propose to count CCEs/BDs of BFR-SS as well when monitored. If this is assumed, some clarification is necessary. According to previous agreement, CSS has a higher priority compared to USS for PDCCH mapping, and it is assumed that the number of BDs/CCEs for CSSs doesn't exceed each limit. But, in a slot configured to monitor BFR CORESET, the number of BDs/CCEs for BFR CORESET should be considered to PDCCH mapping rule. In order to solve this problem, BFR CORESET/SS set should have highest priority (regardless of SS type) on PDCCH mapping rule, and existing PDCCH mapping rule can be applied to other SS sets. If this is applied, unless it is ensured that the sum of CCEs of CSS and BFR-SS does not exceed UE's limit, CSS(s) may need to be dropped when BFR-SS is monitored. Not to incur too much configuration flexibility, we propose to drop CSS(s) based on SS set index when BFR-SS is monitored.

Proposal 3: If BFR CORESET overlaps with other CORESET(s) in time domain, a UE is not required to monitor PDCCH candidates in other CORESET(s) at least in case QCL information is different between BFR-CORESET and other CORESET(s).

Proposal 4: The BFR CORESET/SS set has highest priority (regardless of SS type) for PDCCH candidate mapping rule when monitored. CSS(s) associated with other CORESET(s) may be dropped based on SS set index when BFR SS is monitored.

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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	UT18-0378_ADS.pdf	2237135	no	8
			c8532e344b5c56ea3cc0e434652aa6f0f855a5de		
Warnings:					
Information:					
2	Specification - Not in English	UT18378_SPEC.pdf	1615093	no	16
			a86a1a7015f97a49a7b3cc204d6878bc479a59a8		
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	29552	no	2
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