**3GPP TSG RAN WG1 #103-e R1-200XXXX**

**e-Meeting, October 26th – November 13th, 2020**

**Agenda item:** 8.12.1

**Source:** Moderator (CMCC)

**Title:** Summary#1 on mechanisms to support group scheduling for RRC\_CONNECTED UEs for NR MBS

**Document for:** Discussion/decision

# Introduction

The WI NR\_MBS was approved in RAN plenary #86 meeting [1], and the WID was revised in RAN plenary #88 e-meeting [2]. One of the objective is to specify a group scheduling mechanism to allow UEs to receive Broadcast/Multicast service, and this objective also includes specifying necessary enhancements that are required to enable simultaneous operation with unicast reception.

The following email thread for group scheduling is announced by chairman in RAN1#103 e-meeting:

[103-e-NR-MBS-01] Email discussion/approval for mechanisms to support group scheduling for RRC\_CONNECTED UEs– Fei (CMCC)

* 1st check point: 11/5
* 2nd check point: 11/10
* 3rd check point: 11/12

In this contribution, we summarize the related issues and proposals based on the contributions submitted in RAN1#103 e-meeting under the agenda item 8.12.1 [3]-[24]. The following sections are structured as follows.

From section 2 to 8, we categorized the key issues raised by contributions into 7 kinds and each section covers one kind of issues. In each section, we first provide the background and a short summary for the issue in sub-section X.1, then one or several initial proposals related to this issue are recommended by moderator in sub-section X.2, and then in sub-section X.3 one or more tables are provided to collect company views for the initial proposals in the 1st round email discussion, and then in sub-section X.4 the proposals will be updated based on companies’ input. As email discussion goes on, we may add more sub-sections for companies to provide views for the next round email discussions and for moderator to provide further updated proposals.

In section 9, some issues and proposals not belonging to the above 7 kinds are categorized as “other issues”, and they can be low priority and can be discussed based on more progress of previous issues.

In section 10, some proposals will be selected for discussion in the 1st GTW session, and more sections will be added based on discussion for next GTW sessions.

# Issue #1: Frequency resource configuration for multicast

## Background and summary

Considering that frequency resource configuration for broadcast in RRC\_CONNECTED state may be correlated to the frequency resource configuration for broadcast in RRC\_IDLE/INACTIVE which needs more discussions and progresses in RAN2, here we first focus on the frequency resource configuration for multicast, and based on the agreements for multicast, later we can further discuss or extend it to the frequency resource configuration for broadcast.

In RAN1#102-e, it was agreed to define/configure common frequency resource for group-common PDSCH for RRC\_CONNECTED UEs, but there are some FFS points as below.

* FFS: whether to reuse the BWP framework or not
* FFS: the relation between the common frequency resource and UE dedicated BWP, e.g., the common frequency resource is a MBS specific BWP, or the common frequency resource is confined within UE’s dedicated BWP, etc.
* FFS: whether more than one common frequency resource can be configured per UE

Firstly, regarding the relation between the common frequency resource and UE dedicated unicast BWP, based on the contributions submitted in RAN1#103-e, there are basically five options.

* **Option 1**: The common frequency resource for group-common PDSCH is defined as an MBS specific BWP, which may or may not be overlapped with the dedicated unicast BWP(s)
	+ The numerology (SCS and CP) of the MBS specific BWP may or may not be the same as that of the dedicated unicast BWP(s)
	+ The requirements of BWP switch delay when switching between MBS specific BWP and dedicated unicast BWP follow the Rel-15/16 requirements.
* **Option 2A**: The common frequency resource for group common PDSCH is defined as an MBS specific BWP, which is associated with a dedicated unicast BWP. The MBS specific BWP is confined within its associated dedicated unicast BWP and using the same numerology (SCS and CP).
	+ FFS whether there is a BWP switch delay or not when switching between the MBS specific BWP and its associated dedicated unicast BWP, i.e., an LS to RAN4 is needed if this option is selected.
* **Option 2B**: The common frequency resource for group common PDSCH is defined as a new parameter ‘MBS common frequency resource’ which is confined within a dedicated unicast BWP, but it is not defined as a BWP.
	+ The MBS common frequency resource is configured per dedicated unicast BWP
	+ FFS: How to indicate the starting PRB and the length of MBS common frequency resource
* **Option 3**: Support both option 1 and option 2A or 2B.
* **Option 4**: It’s up to network implementation to ensure all UEs in the same MBS group use the same BWP for group-common PDSCH reception based on existing framework for BWP management, e.g., by RRC (re)configuration or BWP switching.

For option 1, the advantage is that it can maximally reuse the RRC signaling of BWP configuration and it can also flexibly support different numerologies for MBS services and unicast services, while the disadvantage is that it cannot support the simultaneous reception of MBS service and unicast service if UE do not support two active BWPs since UE has to switch back and forth between the MBS specific BWP and dedicated unicast BWP to receive MBS service and unicast service.

For option 2A, its motivation and advantage is to maximally reuse the RRC signaling of BWP configuration for MBS, and at the same time to avoid the BWP switch delay when switching between the MBS specific BWP and its associated dedicated unicast BWP. However, even for the case that MBS specific BWP is contained in the associated dedicated unicast BWP, BWP switch delay is not zero when switching between the MBS specific BWP and its associated dedicated unicast BWP according to the current RAN4 spec. In order to achieve zero BWP switch delay, the newly introduced MBS specific BWP is actually a special BWP which is different from the existing Rel-15/16 BWP, new requirements of BWP switch delay (gap=0) may need to be defined by RAN4, but RAN4 is not involved in this objective according to the WID.

For option 2B, the advantage is that UE can simultaneously receive the MBS service on the MBS common frequency resource and unicast service on the associated dedicated unicast BWP without BWP switch delay, but how to indicate the starting PRB and the length of MBS common frequency resource and also how to configure the parameters related to group-common PDCCH / group-common PDSCH need to be discussed further.

In summary, both option 2A and 2B aim to support the simultaneous reception of MBS service and unicast service when UE operates in a dedicated unicast BWP which contains a common frequency resource for group-common PDSCH, regardless of the common frequency resource is a special MBS specific BWP (i.e., Option 2A) or newly defined parameter ‘MBS common frequency resource’ (i.e., Option 2B).

For option 3, it seems some companies think both option 1 and option 2A/2B can be supported for NR MBS.

For option 4, the advantage is no spec impact for common frequency resource configuration, while the disadvantage is that it may be restrictive since RRC (re)configuration will be needed if network want to group the UEs configured with partial overlapped but not exactly the same BWPs into one MBS group. Regardless of option 1/2/3 is agreed or not, it seems still possible to allow network to (re)configure all UEs in the same MBS group with a same BWP for unicast and MBS using option 4. It may be implicitly supported by other companies who proposed other more advanced options (e.g., option 1/2/3), so we can check with companies if option 4 can be first agreed and on top of that down selection can be performed from option 1/2/3.

The supporting companies for different options are summarized in the table below.

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| **Options for common frequency resource** | **Companies** |
| Option 1 | Apple, Convida  |
| Option 2A | ZTE, Qualcomm, Intel, Chengdu TD Tech |
| Option 2B | FUTUREWEI, Huawei, vivo, CATT, Samsung, Lenovo, MTK, Intel, CMCC |
| Option 3 (both Option 1 and Option 2A or 2B) | LG, OPPO, Nokia |
| Option 4 | Ericsson |

Secondly, regarding whether more than one common frequency resource can be configured per UE, 4 companies [Huawei, Nokia, Qualcomm, CMCC] support more than one common frequency resource can be configured per UE, one company [CMCC] proposes to further study whether more than one common frequency resource can be configured per dedicated unicast BWP if above option 2A/2B is supported, and one company [Qualcomm] supports to configure more than one common frequency resource per dedicated unicast BWP.

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| **Proposals for common frequency resource** | **Companies** |
| More than one common frequency resource for group-common PDSCH can be configured per UE | Huawei, Nokia, Qualcomm, CMCC |

## Initial Proposals based on contributions

###  Proposal 1-1

Based on the majority view, the following moderator recommendation is made.

[Moderator’s recommendation]

**Proposal 1-1**: For RRC-CONNECTED UEs, for common frequency resource definition / configuration for group-common PDSCH, support Option 4 as the basis and support one of Option 2A and Option 2B in addition.

* **Option 2A**: The common frequency resource for group common PDSCH is defined as an MBS specific BWP, which is associated with a dedicated unicast BWP. The MBS specific BWP is confined within its associated dedicated unicast BWP and using the same numerology (SCS and CP).
	+ FFS whether there is a BWP switch delay or not when switching between the MBS specific BWP and its associated dedicated unicast BWP, i.e., an LS to RAN4 is needed if this option is selected.
* **Option 2B**: The common frequency resource for group common PDSCH is defined as a new parameter ‘MBS common frequency resource’ which is confined within a dedicated unicast BWP, but it is not defined as a BWP.
	+ The MBS common frequency resource is configured per dedicated unicast BWP
	+ FFS: How to indicate the starting PRB and the length of MBS common frequency resource
* **Option 4**: It’s up to network implementation to ensure all UEs in the same MBS group use the same BWP for group-common PDSCH reception based on existing framework for BWP management, e.g., by RRC (re)configuration or BWP switching.

###  Proposal 1-2

Based on the majority view, the following Moderator recommendation is made.

[Moderator’s recommendation]

**Proposal 1-2**: For RRC-CONNECTED UEs, if option 2A or option 2B for common frequency resource is agreed, support more than one common frequency resource for group-common PDSCH can be configured per UE.

## Company Views (1st round of email discussion)

###  Company Views on Proposal 1-1

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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###  Company Views on Proposal 1-2

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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## Updated Proposals (1rd round of email discussion)

###  Updated Proposal 1-1

To be added…

###  Updated Proposal 1-2

To be added…

# Issue #2: Group scheduling mechanism

## Background and summary

In RAN1#102-e, it was agreed to at least support group-common PDCCH with CRC scrambled by a common RNTI to schedule a group-common PDSCH, where the scrambling of the group-common PDSCH is based on the same common RNTI. There was a FFS whether to support UE-specific PDCCH to schedule a PDSCH for MBS.

Firstly, regarding using UE-specific PDCCH to schedule a PDSCH for MBS, based on companies’ contributions, there could be different possibilities, e.g., using UE-specific PDCCH to schedule UE-specific PDSCH (same as legacy unicast transmission) for initial transmission or for retransmission, using UE-specific PDCCH to schedule group-common PDSCH for initial transmission or for retransmission, etc. In order to facilitate of RAN1 discussion, one company proposes to consider the following clarification as RAN1 common understanding only for discussion purpose.

* **PTM transmission scheme 1**: For RRC\_CONNECTED UEs in the same MBS group, use group-common PDCCH with CRC scrambled by group-common RNTI to schedule group-common PDSCH which is scrambled with the same group-common RNTI. This scheme can also be called group-common PDCCH based group scheduling scheme.
* **PTM transmission scheme 2**: For RRC\_CONNECTED UEs in the same MBS group, use UE-specific PDCCH with CRC scrambled by UE-specific RNTI (e.g., C-RNTI) to schedule group-common PDSCH which is scrambled with group-common RNTI. This scheme can also be called UE-specific PDCCH based group scheduling scheme.

From Moderator’s perspective, it may be also beneficial to consider the following clarification for discussion purpose to achieve a common understanding from RAN1 point of view, since many companies use similar terminologies, such as PTP transmission, unicast transmission, etc.

* **PTP transmission:** For RRC\_CONNECTED UEs, use UE-specific PDCCH with CRC scrambled by UE-specific RNTI (e.g., C-RNTI) to schedule UE-specific PDSCH which is scrambled with the same UE-specific RNTI.

Secondly, for initial transmission of MBS service, besides PTM transmission scheme 1 which was agreed in RAN1#102-e, 7 companies [vivo, CATT, Oppo, Nokia, APT, Convida, CMCC] propose to also support PTM transmission scheme 2, but 7 companies [Huawei, ZTE, ETRI, Qualcomm, Ericsson, Lenovo, MTK] propose to not support it.

4 companies [LG, Apple, MTK, Qualcomm] propose to support PTP transmission for initial transmission of MBS service, but considering that dynamic switch between PTP and PTM has been in the scope of WID, and it was also extensively discussed in RAN2#111-e post email discussion (refer to email thread in RAN2 [Post111-e][904][MBS] L2 Architecture (Huawei)), it can be assumed that PTP transmission can be supported for initial transmission for MBS. It seems not necessary to have an additional agreement in RAN1 on this. If more companies suggest to have such an agreement in RAN1, we can add a separate proposal for it later.

One company [CATT] proposes to support sub-group-common PDCCH based group scheduling for initial transmission of MBS service. In this scheme, the whole MBS group can be divided into several sub-groups with small number of UEs, and a Sub-G-RNTI can be used to scramble a group-common PDCCH for a small group scheduling, but all UEs in the MBS group are scheduled with a group-common PDSCH which is scrambled with G-RNTI.

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| **Proposals for initial transmission for MBS** | **Companies** |
| Support PTM transmission scheme 2 for initial transmission for MBS | Support: vivo, CATT, Oppo, Nokia, APT, Convida, CMCCObject: Huawei, ZTE, ETRI, Qualcomm, Ericsson, Lenovo, MTK |
| Support PTP transmission for initial transmission for MBS | LG, Apple, MTK, Qualcomm |
| Support sub-group-common PDCCH based group scheduling for initial transmission for MBS. | CATT |

Thirdly, 8 companies [Huawei, vivo, Apple, Lenovo, MTK, Qualcomm, CMCC, Nokia] propose that, if initial transmission is based on PTM transmission scheme 1, retransmission could use PTP transmission or PTM transmission scheme 1. 2 companies [MTK, CMCC] also proposes to support PTM transmission scheme 2 for retransmission.

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| **Proposals for retransmission for MBS** | **Companies** |
| If initial transmission is based on PTM transmission scheme 1, retransmission can use PTP transmission or PTM transmission scheme 1 | Huawei, vivo, Apple, Lenovo, MTK, Qualcomm, CMCC, Nokia |
| If initial transmission is based on PTM transmission scheme 1, retransmission can use PTM transmission scheme 2 | CMCC |

## Initial Proposals based on contributions

###  Proposal 2-1

 [Moderator’s recommendation]

**Proposal 2-1**: For discussion purpose, consider the following clarification as RAN1 common understanding.

* **PTP transmission**: For RRC\_CONNECTED UEs, use UE-specific PDCCH with CRC scrambled by UE-specific RNTI (e.g., C-RNTI) to schedule UE-specific PDSCH which is scrambled with the same UE-specific RNTI.
* **PTM transmission scheme 1**: For RRC\_CONNECTED UEs in the same MBS group, use group-common PDCCH with CRC scrambled by group-common RNTI to schedule group-common PDSCH which is scrambled with the same group-common RNTI. This scheme can also be called group-common PDCCH based group scheduling scheme.
* **PTM transmission scheme 2**: For RRC\_CONNECTED UEs in the same MBS group, use UE-specific PDCCH with CRC scrambled by UE-specific RNTI (e.g., C-RNTI) to schedule group-common PDSCH which is scrambled with group-common RNTI. This scheme can also be called UE-specific PDCCH based group scheduling scheme.

###  Proposal 2-2

[Moderator’s recommendation]

**Proposal 2-2a**: Support PTM transmission scheme 2 for initial transmission of MBS service in RRC\_CONNECTED state.

**Proposal 2-2b**: Further study whether to support sub-group-common PDCCH based group scheduling for initial transmission of MBS service in RRC\_CONNECTED state.

* FFS: details of sub-group-common PDCCH based group scheduling

###  Proposal 2-3

[Moderator’s recommendation]

**Proposal 2-3**: For RRC\_CONNECTED UEs, if initial transmission of MBS service is based on PTM transmission scheme 1, at least support retransmission can use PTP transmission or PTM transmission scheme 1.

* FFS: whether to support PTM transmission scheme 2 for retransmission.
* FFS: How to indicate the association between PTM scheme 1 and PTP transmitting the same TB.
* FFS: If multiple retransmission schemes are supported, then can different retransmission schemes be supported simultaneously for different subgroups of UEs in the same MBS group?

## Company Views (1st round of email discussion)

###  Company views on Proposal 2-1

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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###  Company views on Proposal 2-2

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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###  Company views on Proposal 2-3

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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## Updated Proposals (1rd round of email discussion)

To be added…

# Issue #3: CORESET and Search Space configuration

## Background and summary

Regarding the CORESET configuration for PTM transmission scheme 1 (group-common PDCCH based group scheduling), 6 companies [Huawei, Lenovo, Intel, Qualcomm, CMCC, Nokia] propose that the CORESET should be configured within the common frequency resource for group-common PDSCH. The concrete definition and clarification of common frequency resource is up to the discussion for issue#1 in section 2, but regardless which definition is adopted, it is natural to have this proposal.

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| **Proposals for CORESET configuration**  | **Companies** |
| The CORESET for group-common PDCCH should be configured within the common frequency resource for group-common PDSCH | Huawei, Lenovo, Intel, Qualcomm, CMCC, Nokia |

Regarding the search space set type for PTM transmission scheme 1, companies’ views are diverged. Two companies [ZTE, Intel] think both existing CSS type(s) and a new defined CSS type can be considered, one company [CMCC] proposes to use USS, one company [Qualcomm] considers CSS and/or USS can be used, and one company [Nokia] proposes to discuss first on whether a new SS set type is required to be introduced specifically for multicast or not, and how to handle the SS monitoring prioritization between multicast and unicast.

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| **Options for search space set type** | **Companies** |
| Option 1: define a new search space set type specific for MBS | ZTE, Intel |
| Option 2: reuse the existing CSS type(s) in Rel-15/16 with possible modifications | ZTE, Intel, Qualcomm, Nokia |
| Option 3: reuse the existing USS in Rel-15/16 in Rel-15/16 with possible modifications | CMCC, Qualcomm |

## Initial Proposals based on contributions

###  Proposal 3-1

[Moderator’s recommendation]

**Proposal 3-1**: For PTM transmission scheme 1, the CORESET for group-common PDCCH is configured within the common frequency resource for group-common PDSCH.

* FFS: number of CORESET(s) for group-common PDCCH within the common frequency resource for group-common PDSCH

###  Proposal 3-2

[Moderator’s recommendation]

**Proposal 3-2a**: For search space set of group-common PDCCH of multicast in RRC\_CONNECTED state, the CCE indexes are common for different UEs in the same MBS group.

**Proposal 3-2b**: For search space set of group-common PDCCH of multicast in RRC\_CONNECTED state, down select from the following options for the monitoring priority of search space set

* Option 1: The monitoring priority of search space set for multicast is the same as existing Rel-15/16 CSS
* Option 2: The monitoring priority of search space set for multicast is the same as existing Rel-15/16 USS
* Option 3: The monitoring priority of search space set for multicast can be between the existing Rel-15/16 CSS and existing Rel-15/16 USS

**Proposal 3-2c**: For search space set of group-common PDCCH of multicast in RRC\_CONNECTED state, down select from the following options.

* Option 1: Define a new search space type specific for multicast
* Option 2: Reuse the existing CSS type(s) in Rel-15/16
	+ FFS: whether modifications are needed for multicast
* Option 3: Reuse the existing USS in Rel-15/16 with necessary modifications for MBS
	+ FFS: detailed modifications

## Company Views (1st round of email discussion)

###  Company views on Proposal 3-1

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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###  Company views on Proposal 3-2

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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## Updated Proposals (1rd round of email discussion)

To be added…

# Issue #4: DCI and Blind Decoding related issues

## Background and summary

Regarding the number of BDs/CCEs, 3 companies [CATT, Nokia, CMCC] propose to keep the same maximum number of monitored PDCCH candidates and non-overlapped CCEs per slot per serving cell as in Rel-15 when Rel-17 MBS functionality is enabled. One company [Qualcomm] proposes to consider the group-common PDCCH monitoring for multicast as a virtual CC to count the number of BDs/CCEs, which is similar to the method used for multi-DCI based multi-TRP in Rel-16.

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| **Options for number of BDs/CCEs** | **Company** |
| Option 1: Keep the BDs/CCEs limits per slot per serving cell defined in Rel-15 for Rel-17 MBS  | CATT, Nokia, CMCC |
| Option 2: Consider the group-common PDCCH monitoring for multicast as a virtual CC to count the number of BDs/CCEs, which is similar to the method used for multi-DCI based multi-TRP in Rel-16 | Qualcomm |

Regarding the DCI size budget, two companies [Nokia, CMCC] propose to maintain the “3+1” DCI size budget defined in Rel-15 when Rel-17 MBS functionality is enabled. When considering the “3+1” DCI size budget rule for group-common PDCCH based group scheduling, one company [Nokia] proposes to count G-RNTI as “other RNTI” and another company [Intel] proposes to count G-RNTI as “C-RNTI”.

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| **Options for DCI size budge** | **Company** |
| Option 1: Keep the “3+1” DCI size budget defined in Rel-15 for Rel-17 MBS  | Nokia, CMCC |
| Option 2: The DCI size budget defined in Rel-15 can be increased for Rel-17 MBS  |  |

Regarding the DCI format, companies’ views are also diverged. Basically there are two options in high level, that is, whether to reuse the existing DCI format(s) with possible modifications or to define a new DCI format for MBS.

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| **Options for DCI format** | **Company** |
| Option 1: reuse the existing DCI format(s) in Rel-15/16 with possible modifications for group-common PDCCH for Rel-17 MBS | Huawei (format 1\_0/1\_1/1\_2), ZTE (format 1\_0), Intel (format 1\_0), CMCC (format 1\_0/1\_1/1\_2), Qualcomm (format 1\_0/1\_1, FFS 1\_2) |
| Option 2: define a new DCI format for group-common PDCCH for Rel-17 | Oppo, Intel |

Regarding the FDRA field in the DCI format for group-common PDCCH, 4 companies [Huawei, Lenovo, Intel, CMCC] propose that, for PTM transmission scheme 1, the FDRA field of group-common PDCCH is interpreted based on the common frequency resource for group-common PDSCH.

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| **Options for FDRA field** | **Company** |
| For PTM transmission scheme 1, the FDRA field of group-common PDCCH is interpreted based on the common frequency resource for group-common PDSCH. | Huawei, Lenovo, Intel, CMCC, Nokia |

## Initial Proposals based on contributions

###  Proposal 4-1

[Moderator’s recommendation]

**Proposal 4-1:** Down select from the two options for BDs/CCEs limit for Rel-17 MBS

* Option 1: Keep the maximum number of monitored PDCCH candidates and non-overlapped CCEs per slot per serving cell defined in Rel-15 for Rel-17 MBS.
* Option 2: Consider the group-common PDCCH monitoring for multicast as a virtual CC to count the number of BDs/CCEs, which is similar to the method used for multi-DCI based multi-TRP in Rel-16.

###  Proposal 4-2

[Moderator’s recommendation]

**Proposal 4-2:** Keep the “3+1” DCI size budget defined in Rel-15 for Rel-17 MBS.

* FFS: Whether the G-RNTI is counted as “C-RNTI” or as “other RNTI” when considering the “3+1” DCI size budget rule for group-common PDCCH based group scheduling.
* FFS: DCI size alignment procedure for group-common PDCCH

###  Proposal 4-3

[Moderator’s recommendation]

**Proposal 4-3:** For PTM transmission scheme 1, if Option 2A or Option 2B for common frequency resource for group-common PDSCH is agreed, the FDRA field of group-common PDCCH is interpreted based on the common frequency resource.

## Company Views (1st round of email discussion)

###  Company views on Proposal 4-1

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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###  Company views on Proposal 4-2

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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###  Company views on Proposal 4-3

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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## Updated Proposals (1rd round of email discussion)

To be added…

# Issue #5: Simultaneous operation with unicast reception

## Background and summary

In RAN1#102-e, it was agreed at least to support FDM between unicast PDSCH and group-common PDSCH in a slot based on UE capability for RRC\_CONNECTED UEs. There is still a FFS for TDM and SDM. In addition, there may be some ambiguities need to be further clarified, e.g., whether to support FDM between multiple group-common PDSCHs in a slot, whether to support FDM between one or multiple TDMed unicast PDSCHs and multiple group-common PDSCHs, etc.

In RAN1#103-e, 7 companies [Huawei, vivo, Nokia, Intel, Qualcomm, Ericsson, CMCC] propose to also support TDM between at least one unicast PDSCH and at least one group-common PDSCH in a slot based on UE capability for RRC\_CONNECTED UEs, but one company [Apple] proposes to support it without capability signaling.

One company proposes to support TDM between multiple TDMed unicast PDSCHs and one group-common PDSCH in a slot based on UE capability. Although other companies did not clearly mention this, moderator thinks it may be also the thinking of some of other companies.

One company proposes to support TDM among multiple group-common PDSCHs in a slot based on UE capability, and further discuss whether to support FDM among multiple group-common PDSCHs in a slot.

One company proposes to support both FDM and TDM between multiple TDMed unicast PDSCHs and multiple TDMed group-common PDSCHs in a slot based on UE capability.

One company proposes to support inter-slot TDM between unicast PDSCH and group-common PDSCH in different slots as a core MBS functionality (mandatory).

Two companies [Huawei, Intel] propose to support SDM between at least one unicast PDSCH and at least one group-common PDSCH in a slot based on UE capability for RRC\_CONNECTED UEs, but two companies [Ericsson, CMCC] propose not to support this.

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| **Proposals for simultaneous operation with unicast reception** | **Company** |
| TDM between one unicast PDSCH and one group-common PDSCH in a slot | Huawei, vivo, Nokia, Intel, Qualcomm, Ericsson, CMCC, Apple |
| TDM between multiple TDMed unicast PDSCHs and one group-common PDSCH in a slot | CMCC |
| TDM among multiple group-common PDSCHs in a slot | CMCC |
| TDM between multiple TDMed unicast PDSCHs and multiple TDMed group-common PDSCHs | CMCC |
| FDM between multiple TDMed unicast PDSCHs and multiple TDMed group-common PDSCHs | CMCC |
| Inter-slot TDM between unicast PDSCH and group-common PDSCH in different slots as a core MBS functionality (mandatory) | Ericsson |
| SDM between at least one unicast PDSCH and at least one group-common PDSCH in a slot | Support: Huawei, [Intel]Object: Ericsson, CMCC, Qualcomm |

One company [BBC] proposes that due consideration should be given to the potential support of Broadcast/Multicast and Unicast Superposition Transmission in NR based on UE capability to improve the system’s spectral efficiency.

One company [Oppo] proposes to define some dropping rule for the case that UE is scheduled with unicast PDSCH and group-common PDSCH in one slot but UE has no capability to receive them simultaneously.

One company [Intel] proposes to at least support PDSCH mapping type A for group-common PDSCH, and FFS for PDSCH mapping type B.

## Initial Proposals based on contributions

###  Proposal 5-1

[Moderator’s recommendation]

**Proposal 5-1a**: Support TDM between one unicast PDSCH and one group-common PDSCH in a slot based on UE capability for RRC\_CONNECTED UEs.

**Proposal 5-1b**: Down select from the following cases for simultaneous reception of unicast PDSCH and group-common PDSCH in a slot based on UE capability for RRC\_CONNECTED UEs.

* Case 1: support TDM between multiple TDMed unicast PDSCHs and one group-common PDSCH in a slot
* Case 2: support TDM among multiple group-common PDSCHs in a slot
* Case 3: support TDM between multiple TDMed unicast PDSCHs and multiple TDMed group-common PDSCHs in a slot
* Case 4: support FDM between multiple TDMed unicast PDSCHs and multiple TDMed group-common PDSCHs in a slot
* Case 5: support FDM among multiple group-common PDSCHs in a slot
* FFS: maximum number of PDSCHs in a slot simultaneous received per UE

**Proposal 5-1c**: For RRC\_CONNECTED UEs, support inter-slot TDM between unicast PDSCH and group-common PDSCH in different slots as a core MBS functionality (mandatory).

**Proposal 5-1d**: Not to support SDM between unicast PDSCH and group-common PDSCH in a slot for RRC\_CONNECTED.

## Company Views (1st round of email discussion)

###  Company views on Proposal 5-1

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
|  |  |

## Updated Proposals (1rd round of email discussion)

To be added…

# Issue #6: SPS for NR MBS

## Background and summary

7 companies [vivo, CATT, Samsung, ZTE, Intel, Qualcomm, Chengdu TD Tech] propose to support SPS group-common PDSCH for MBS for RRC\_CONNECTED UEs. One company [ZTE] proposes to use UE-specific PDCCH for SPS group-common PDSCH activation/deactivation, one company [Qualcomm] proposes to use group-common PDCCH for SPS group-common PDSCH activation/deactivation.

|  |  |
| --- | --- |
| **Proposal for SPS group-common PDSCH** | **Company** |
| Support SPS group-common PDSCH for MBS for RRC\_CONNECTED UEs | vivo, CATT, Samsung, ZTE, Intel, Qualcomm, Chengdu TD Tech, Nokia |

## Initial Proposals based on contributions

### Proposal 6-1

[Moderator’s recommendation]

**Proposal 6-1**: Support SPS group-common PDSCH for MBS for RRC\_CONNECTED UEs

* FFS: use group-common PDCCH or UE-specific PDCCH for SPS group-common PDSCH activation/deactivation
* FFS: whether to support more than one SPS group-common PDSCH configuration per UE
* FFS: whether and how uplink feedback could be configured

## Company Views (1st round of email discussion)

###  Company views on Proposal 6-1

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
|  |  |

## Updated Proposals (1rd round of email discussion)

To be added…

# Issue #7: Multi-beam operation

## Background and summary

5 companies [CATT, LG, Sony, ZTE, Chengdu TD Tech] mentioned the multi-beam operation for MBS in RRC\_CONNECTED state, basically, there are two high-level options. One option is beam sweeping operation with all beams in the cell which is suitable for the case that network is not aware of the preferred beams of the MBS UEs, e.g., when the group-common PDCCH / group-common PDSCH are targeted to be received by both RRC\_IDLE/INACTVE UEs and RRC\_CONNECTED UEs. The other option is beam sweeping with partial beams in the cell which is suitable for the case that network is aware of the preferred beams of the MBS UEs, e.g., when the group-common PDCCH / group-common PDSCH are targeted to be received by only RRC\_CONNECTED UEs.

|  |  |
| --- | --- |
| **Options for multi-beam operation** | **Company** |
| Option 1: Beam sweeping operation with all beams in the cell for RRC\_CONNECTED UEs | CATT, LG, Sony, ZTE, Chengdu TD Tech |
| Option 2: Beam sweeping operation with partial beams in the cell for RRC\_CONNECTED UEs | LG, Sony, ZTE |

There are some other detailed proposals regarding multi-beam operation which are only raised by one company as listed below.

|  |  |
| --- | --- |
| **Detailed proposals for multi-beam operation** | **Company** |
| Regarding Rel-17 NR MBS, define association between PDCCH MOs and SSBs or CSI-RSs for group common PDCCH transmission. | ZTE |
| Consider beam sweeping mechanism for NR Rel-15 SIBx transmission as the starting point for Rel-17 broadcast. | ZTE |
| Support configuration of multiple CORESETs in search space set for group scheduling of a MBS control TB on PDSCH with multiple beams/TRPs e.g. via system information or UE dedicated signaling, if MCCH-like logical channel is supported by RAN2 | LG |
| Support configuration of multiple CORESETs in search space set for group scheduling of a MBS data TB on PDSCH with multiple beams/TRPs e.g. via MCCH signaling or UE dedicated signaling, if MTCH-like logical channel is supported by RAN2. | LG |
| The UE shall report preference of beam(s) in which its interested MBS services can be provided. | Sony |

## Initial Proposals based on contributions

###  Proposal 7-1

[Moderator’s recommendation]

**Proposal 7-1**: Consider whether to support the following multi-beam operations for group-common PDCCH / group-common PDSCH of MBS for RRC\_CONNECTED UEs.

* Beam sweeping with all SSB beams in the cell
* Beam sweeping with partial SSB/CSI-RS beams in the cell

## Company Views (1st round of email discussion)

###  Company views on Proposal 7-1

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
|  |  |

## Updated Proposals (1rd round of email discussion)

To be added…

# Issue #8: Other issues (Low priority)

## Background and summary

There are some other issues and proposals which are raised by one or two companies as listed below. These proposals can be low priority and can be discussed based on more progress of previous issues.

|  |  |
| --- | --- |
| **Proposals** | **Company** |
| **Proposal 8-1:** A UE can be configured with multiple group common RNTIs for PDSCH scrambling for different Broadcast/Multicast services.* FFS: whether UE is expected to receive all the PDSCHs scrambled with these group common RNTIs
 | vivo |
| **Proposal 8-2**: The configurable number of maximum HARQ process number is kept unchanged for UE supporting MBS reception, and * the total number of HARQ processes for initial transmissions are shared and split between unicast and MBS;
* the HARQ process number for retransmission is kept the same as for initial transmission.
 | Huawei |
| **Proposal 8-3**: Consider supporting DRX/WUS for NR MBS for power saving. The detailed design is FFS. | CATT |
| **Proposal 8-4**: Further discuss whether to support CA for Rel-17 MBS, e.g., UE receive MBS services on SCell. | CMCC, LG |
| **Proposal 8-5**: Study whether the same basic broadcast mechanism is applied for RRC\_CONNECTED UEs and RRC\_IDLE/RRC\_INACTIVE UEs. | ZTE |

## Company Views (1st round of email discussion)

Companies can provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
|  |  |

## Updated Proposals (1rd round of email discussion)

To be added…

# Proposals for 1st GTW session

To be added…

# References

1. RP-193248 New WID proposal: NR Multicast and Broadcast Services
2. RP-201038 Revised WID: Core part: NR multicast and broadcast services
3. R1-2007556 Group scheduling for MC/BC services FUTUREWEI
4. R1-2007562 Resource configuration and group scheduling for RRC\_CONNECTED UEs Huawei, HiSilicon
5. R1-2007637 Group scheduling for RRC\_CONNECTED UEs CHENGDU TD TECH LTD.
6. R1-2007691 Discussion on mechanisms to support group scheduling for RRC\_CONNECTED UEs vivo
7. R1-2007835 Discussion on group scheduling mechanism for RRC\_CONNECTED UEs in MBS CATT
8. R1-2008034 Discussion on group scheduling mechanisms CMCC
9. R1-2008064 Support of group scheduling for RRC\_CONNECTED UEs LG Electronics
10. R1-2008192 On mechanisms to support group scheduling for RRC\_CONNECTED UEs Samsung
11. R1-2008242 Group scheduling for NR Multicast and Broadcast Services OPPO
12. R1-2008375 Considerations on MBMS group scheduling for RRC\_CONNECTED UEs Sony
13. R1-2008449 Discussion on group scheduling mechanism for RRC\_connected UEs Apple
14. R1-2008826 Mechanisms to Support Group Scheduling for RRC\_CONNECTED UEs ZTE
15. R1-2008833 Discussion on mechanisms to support group scheduling for RRC\_CONNECTED UEs ETRI
16. R1-2008882 Group Scheduling Mechanisms to Support 5G Multicast / Broadcast Services for RRC\_CONNECTED UEs Nokia, Nokia Shanghai Bell
17. R1-2008926 Discussion on group scheduling mechanism for NR MBS Lenovo, Motorola Mobility
18. R1-2008961 Discussion on NR MBS group scheduling for RRC\_CONNECTED UEs MediaTek Inc.
19. R1-2009000 Group Scheduling for NR-MBS Intel Corporation
20. R1-2009055 Discussion on mechanisms to support group scheduling for RRC\_CONNECTED UEs Asia Pacific Telecom co. Ltd
21. R1-2009165 On group scheduling mechanism for NR multicast and broadcast Convida Wireless
22. R1-2009238 On Optimal Multiplexing for Simultaneous Operation of Broadcast/Multicast and Unicast Services BBC
23. R1-2009274 Views on group scheduling for Multicast RRC\_CONNECTED UEs Qualcomm Incorporated
24. R1-2009305 Mechanisms to support group scheduling for RRC\_CONNECTED Ues Ericsson

# Appendix 1: Agreements in previous meetings

**RAN1#102-e**

Agreements:

For RRC\_CONNECTED UEs, HARQ-ACK feedback is supported for multicast and no additional evaluation is needed to justify this.

* + FFS: The detailed HARQ-ACK feedback solutions, e.g., ACK/NACK based, NACK-only based.
	+ FFS: HARQ-ACK feedback can be optionally disabled and/or enabled.

Agreements:

For RRC\_CONNECTED UEs, at least support group-common PDCCH with CRC scrambled by a common RNTI to schedule a group-common PDSCH, where the scrambling of the group-common PDSCH is based on the same common RNTI.

o   FFS: whether to support UE-specific PDCCH to schedule a PDSCH for MBS.

Agreements:

* For RRC\_CONNECTED UEs, define/configure common frequency resource for group-common PDSCH.
	+ FFS: whether to reuse the BWP framework or not
	+ FFS: the relation between the common frequency resource and UE dedicated BWP, e.g., the common frequency resource is a MBS specific BWP, or the common frequency resource is confined within UE’s dedicated BWP, etc.
	+ FFS: whether more than one common frequency resource can be configured per UE

Agreements:

* For RRC\_CONNECTED UEs, at least support FDM between unicast PDSCH and group-common PDSCH in a slot based on UE capability.
	+ FFS: TDM or SDM in a slot.

Agreements:

* For RRC\_CONNECTED UEs, at least support slot-level repetition for group-common PDSCH.
	+ FFS: whether enhancement is needed

Agreements:

* For RRC\_CONNECTED UEs, existing CSI feedback can be used for multicast transmission.
	+ FFS: whether enhancement is needed

# Appendix 2: Summary of proposals

|  |  |  |
| --- | --- | --- |
| **Tdoc** | **Source** | **Proposals** |
| [3]R1-2007556 | FUTUREWEI | Proposal 1: Support common frequency resource for MBS to be confined within UE’s dedicated BWP. Proposal 2: Support simultaneous reception of NR unicast TB and MBS TBs in the UE dedicated BWP.Proposal 3: New DCI fields are needed for group scheduling MBS. FFS if a new DCI format is needed or if existing DCI format(s) can be modifiedProposal 4: Both downlink resource allocation schemes type 0 and type 1 are supported for MBS. Proposal 5: * Define common PUCCH resource for MBS HARQ feedback.
	+ This common PUCCH resource is in addition to any PUCCH resource that NR unicast may have.
	+ The common PUCCH resource is indexed based on the HARQ process number.
	+ The common-RNTI scrambled DCI PRI field indicate orthogonal PUCCH resources per HARQ process ID to transmit UL feedback.

Observation 1: The DCI field PDSCH-to-HARQ\_feedback timing indicator can reuse the DCI format 1\_0 or DCI format 1\_1 method of indicating as long as it enables indicating multiple PDSCHs that may be scheduled in the slot |
| [4]R1-2007562 | Huawei, HiSilicon | Proposal 1：UE-specific PDCCH scheduling group-common PDSCH for MBS is not necessary. Proposal 2: Group-common PDCCH and UE-specific PDCCH can both be supported for scheduling retransmission of MBS. Proposal 3: A common sub-band for MBS configured within dedicated unicast BWPs of UEs of the group is more proper in terms of less restriction and without BWP switching for receiving both unicast and MBS. Proposal 4: More than one common frequency resources can be configured per UE with each confined within dedicated unicast BWP. Proposal 5: For a common sub-band for MBS configured within dedicated unicast BWP and a group-common PDCCH based scheduling:* The CORESET and search space is configured within the common sub-band;
* The configurations for the CORESET and search space are kept the same for all UEs of the group.

Proposal 6: DCI formats 1\_0, 1\_1 and 1\_2 can be used for scheduling MBS with necessary modifications, and new DCI format is not needed:* For a common sub-band for MBS configured within dedicated unicast BWP and a group-common PDCCH based scheduling, the FDRA field in DCI is dimensioned per the common sub-band.

Proposal 7: DCI size alignment for monitoring DCI for MBS scheduling needs to be determined including whether the DCI size budget is kept or can be extended. Proposal 8: The configurable number of maximum HARQ process number is kept unchanged for UE supporting MBS reception, and * the total number of HARQ processes for initial transmissions are shared and split between unicast and MBS;
* the HARQ process number for retransmission is kept the same as for initial transmission.

Proposal 9: For RRC\_CONNECTED UEs, support TDM and SDM between unicast PDSCH and group-common PDSCH in a slot based on UE capability. |
| [5]R1-2007637 | CHENGDU TD TECH LTD | Proposal 1: Pre-configure at least one MBS dedicated BWP with each MBS dedicated BWP providing the radio resource for the MBS.Proposal 2: Preconfigure at least one general BWP for each MBS dedicated BWP with each general BWP containing the MBS dedicated BWPProposal3: gNB should support to pre-configure the same MBS dedicated BWPs and the same general BWPs for each MBS dedicated BWP for all NR cells controlled by the gNB.Proposal 4: gNB pre-configures at least one CORESET and SS group on each MBS dedicated BWPProposal 5: gNB should support to pre-configure the same CORESET and SS groups on each MBS dedicated BWP for all NR cellsProposal 6: Support more than one SC-MTCHs for the PTM bearer of an MBSProposal 7: G-RNTI and SPS G-RNTI are configured for an MBS.Proposal 8: For a P-RB of the PTM bearer, the following items need to be supported.1. Configure the SPS PDSCH resource to transmit the data of a P-RB of the PTM bearer periodically
2. PDCCH with CRC scrambled with SPS G-RNTI is used to activate/de-activate the SPS PDSCH resource.
3. SPS G-RNTI is used in the bit scrambling of the PDSCH carrying a P-RB of the PTM bearer.

Proposal 9: For all the NP-RBs of the PTM bearer, the following items need to be supported.1. The dynamic scheduling is used to transmit the data of all the NP-RBs of the PTM bearer with the SC-MTCHs of all the NP-RBs multiplexed onto one DL-SCH.
2. Each time the PTM bearer is scheduled, the PDCCH and PDSCH resource is allocated. The PDCCH with CRC scrambled with G-RNTI is transmitted with the allocated PDCCH resource. The PDSCH with G-RNTI used in the bit scrambling is transmitted with the allocated PDSCH resource
3. Each time the PTM bearer is scheduled, one TB is generated and repeatedly transmitted N1 times in each beam coverage area where at least one RRC\_CONNECTED UE is located.

Proposal 10: Support the group scheduling method for B2=B and/or B2=B1.Proposal 11: For a RRC\_CONNECTED UE, support the DTCHs of the UE’s PTP bearer and the DTCHs of the UE’s unicast services are multiplexed onto one DL-SCH.Proposal 12: For a RRC\_CONNECTED UE, support the DTCHs of the UE’s PTP bearer are multiplexed onto one DL-SCH which is independent from the DL-SCH of the UE’s unicast services. |
| [6]R1-2007691 | vivo | Observation 1: The retransmission scheme with dynamically selected C-RNTI/g-RNTI brings about 6.23% and 1.11% gain in term of RU compared to the g-RNTI only and C-RNTI retransmission scheme respectively.Observation 2: For the cell spectral efficiency, the performances of the three kinds of MBS HARQ retransmission schemes are similar.Proposal 1: For RRC\_CONNECTED UEs, when defining/configuring common frequency resource for group-common PDSCH, it is suggested to define an MBS common frequency resource confined within UE’s active BWP.Proposal 2: For RRC\_CONNECTED UEs, support TDM between unicast PDSCH and group-common PDSCH in a slot based on UE capability.Proposal 3: A UE can be configured with multiple common RNTIs for PDSCH scrambling for different Broadcast/Multicast services.Proposal 4: For RRC\_CONNECTED UEs, support UE-specific PDCCH with CRC scrambled by a UE-specific RNTI to schedule a group-common PDSCH, where the scrambling of the group-common PDSCH is scrambled by a common RNTI.Proposal 5: The following two modes are supported for MBS service scheduling.* Dynamic scheduling PDSCH for Broadcast/Multicast service
* Semi-persistent scheduling PDSCH for Broadcast/Multicast service.

Proposal 6: For the retransmission of group common PDSCH for MBS service, either UE-specific PDSCH or group common PDSCH can be used. |
| [7]R1-2007835 | CATT | Proposal 1: UE-specific PDCCH and sub-group-common PDCCH group scheduling is supported in NR MBS.Proposal 2: Reusing current BWP framework for MBS common frequency resource definition/configuration.Proposal 3: The common frequency resource is confined with UEs’ dedicated BWPs.Proposal 4: SPS can be supported for NR MBS by reusing the Rel-16 SPS mechanism.Proposal 5: In NR MBS system, both options of PDCCH monitoring occasion method can be considered.* Option 1: PDCCH MOs in one period are for different SSBs for scheduling the same PDSCH.
* Option 2: PDCCH MOs in one period are for the same SSB for scheduling different PDSCHs.

Proposal 6: The maximum number of monitored PDCCH candidates per slot is not increased based on Rel-15 when PDCCH candidates for MBS are considered in the monitoring.Proposal 7: Rel-15 mechanism on how to allocate the PDCCH candidates in CSS/USS can be a baseline to determine the monitoring priority, when PDCCHs for MBS are added for blind decoding.Proposal 8: DRX/WUS can be supported for NR MBS for power saving. The detailed design is FFS. |
| [8]R1-2008034 | CMCC | Proposal 1. For RRC\_CONNECTED UEs, define following two PTM schemes only for discussion purpose.* PTM scheme 1: For PTM transmission for UEs in the same MBS group, use group-common PDCCH with CRC scrambled by group-common RNTI to schedule group-common PDSCH which is scrambled with the same group-common RNTI. This scheme can also be called group-common PDCCH based group scheduling scheme.
* PTM scheme 2: For PTM transmission for UEs in the same MBS group, use UE-specific PDCCH with CRC scrambled by UE-specific RNTI (e.g., C-RNTI) to schedule group-common PDSCH which is scrambled with group-common RNTI. This scheme can also be called UE-specific PDCCH based group scheduling scheme.

Proposal 2. For RRC\_CONNECTED UEs, the configured common frequency resource for group-common PDSCH is confined within UE’s dedicated BWP, and the common frequency resource is configured per DL BWP.Proposal 3. For RRC\_CONNECTED UEs and PTM scheme 1, if the common frequency resource is configured for the group-common PDSCH, the CORESET for the group-common PDCCH should be configured in the common frequency resource, and the FRDA field of group-common PDCCH is determined based on the common frequency resource instead of UE’s active DL BWP.Proposal 4. For PTM scheme 1, dedicated physical layer parameters for group-common PDSCH e.g., TDRA table, DMRS configuration, etc., can be configured under the configuration of common frequency resource.Proposal 5. Further discuss whether more than one common frequency resource can be configured per DL BWP.Proposal 6. For PTM scheme 1, USS is preferred for group-common PDCCH monitoring, but group-common RNTI value can be used in  for CCE indexes calculation to guarantee UEs in the same MBS group receiving the same PDCCH.Proposal 7. For PTM scheme 1, both fallback DCI format 1\_0 and non-fallback DCI format 1\_1/1\_2 could be considered with new interpretations.Proposal 8. Keep the “3+1” DCI size budget as in Rel-15/16 when PTM transmission is enabled. Proposal 9. For PTM scheme 1, decide whether the DCI size associated with group-common RNTI (G-RNTI) should be counted in the DCI size budget associated with C-RNTI or counted in the DCI size budget associated with all RNTIs.Proposal 10. For PTM scheme 1, keep the same maximum number of monitored PDCCH candidates and non-overlapped CCEs per slot per serving cell as in Rel-15 when R17 NR MBS is enabled.Proposal 11. For RRC\_CONNECTED UEs, support PTM scheme 2 for NR MBS, i.e., UE-specific PDCCH with CRC scrambled by UE-specific RNTI to schedule group-common PDSCH scrambled with group-common RNTI.Proposal 12. The common frequency resource for group-common PDSCH can be optionally configured for PTM scheme 2. If type 0 frequency domain resource allocation is used, the RBG size and RBG numbering for FDRA indication in the UE-specific DCI are determined based on the size of common frequency resource instead of UE’s active BWP.Proposal 13. For PTM scheme 2, dedicated physical layer parameters for group-common PDSCH e.g., TDRA table, DMRS configuration, etc., can be configured under the configuration of common frequency resource.Proposal 14. For PTM scheme 2, non-fallback DCI format 1\_1/1\_2 could be considered, and one additional DCI field is defined to differentiate that the scheduled PDSCH’s scrambling initialization is based on UE-specific RNTI or group-common RNTI.Proposal 15. For PTM scheme 2, keep the same maximum number of monitored PDCCH candidates and non-overlapped CCEs per slot per serving cell as in Rel-15 when R17 NR MBS is enabled.Proposal 16. For NR MBS, if the initial transmission is based on PTM scheme 1, support that the re-transmission can be based on PTM scheme 1, PTM scheme 2 or PTP.Proposal 17. For NR MBS, if the initial transmission is based on PTM scheme 2, support that the re-transmission can be based on PTM scheme 2 or PTP.Proposal 18. For RRC\_CONNECTED UEs, support TDM between unicast PDSCH and group-common PDSCH in a slot based on UE capability.Proposal 19. For RRC\_CONNECTED UEs, support TDM between multiple group-common PDSCHs in a slot based on UE capability.Proposal 20. For RRC\_CONNECTED UEs, support TDM or FDM between unicast PDSCH(s) and multiple TDMed group-common PDSCHs in a slot based on UE capability.Proposal 21. Further discuss whether to support FDM between multiple group-common PDSCHs in a slot for RRC\_CONNECTED UEs.Proposal 22. Further discuss the PDSCH prioritization rule when PTM PDSCH is partially or fully overlapped in time in non-overlapping PRBs with another SI-RNTI PDSCH in one slot.Proposal 23. Further discuss whether to consider the two typical CA cases in section 4.1 for R17 NR MBS. |
| [9]R1-2008064 | LG Electronics | Proposal 1: Support all the following scenarios for UE specific scheduling as well as group scheduling in reception of a MBS TB in RRC\_CONNECTED UEs.* Scenario 1: Group scheduling of a MBS TB with Group RNTI
	+ Scenario 1A: Group scheduling of a MBS TB within UE’s active BWP
	+ Scenario 1B: Group scheduling of a MBS TB in a BWP not overlapped with UE’s active BWP within UE’s serving cell
	+ Scenario 1C: Group scheduling of a MBS TB in a cell other than UE’s serving cell

NOTE: Group scheduling of a MBS TB with Group RNTI in Scenario 1A/B/C is defined as follows:* + DCI(s) with Group RNTI schedules PDSCH transmission(s) of the TB with one or more beams.
	+ Each of UEs in the group selects a beam and receives at least one PDCCH/PDSCH transmission possibly received by other UE(s) in the group.
* Scenario 2: Unicast scheduling of a MBS TB with UE’s C-RNTI in UE’s active BWP
	+ DCI(s) with UE’s C-RNTI schedules UE’s own PDSCH transmission(s) of the TB with at least a beam selected for the UE.
	+ Each of UEs in the group receives UE’s own PDCCH/PDSCH transmission of the TB.

Proposal 2: PDCCH/PDSCH transmissions of a MBS TB can be repeated in time and/or frequency resources with all beams/TRPs, e.g. if idle/inactive UEs as well as connected UEs receive the TB.Proposal 3: Support configuration of multiple CORESETs in search space set for group scheduling of a MBS control TB on PDSCH with multiple beams/TRPs e.g. via system information or UE dedicated signaling, if MCCH-like logical channel is supported by RAN2.Proposal 4: Support configuration of multiple CORESETs in search space set for group scheduling of a MBS data TB on PDSCH with multiple beams/TRPs e.g. via MCCH signaling or UE dedicated signaling, if MTCH-like logical channel is supported by RAN2.Proposal 5: PDCCH/PDSCH transmissions of a MBS TB can be repeated in time and/or frequency resources only with multiple selective beams/TRPs (i.e. not all beams/TRPs), e.g. if only connected UEs receive the TB. |
| [10]R1-2008192 | Samsung | Proposal 1: Configure MBS PDSCH reception parameters for UE-specific BWPs.Proposal 2: Supports SPS for multicast.Proposal 3: Consider whether a same BWP or different BWPs are used for unicast and MBS PDSCH transmissions for determining support of FDM between multicast PDSCH and unicast PDSCH.Observation 1: Whether a UE monitors PDCCH for scheduling MBS PDSCH receptions according to CSS or according to USS can be determined after a decision whether the UE also monitors PDCCH for scheduling unicast PDSCH/PUSCH in the same DL BWP or whether MBS PDSCH receptions from multiple TRPs are supported. |
| [11]R1-2008242 | OPPO | Proposal 1: Support to use overlapping part of active BWP of multiple UEs as the common frequency resource for group-common PDSCH.Proposal 2: Support to use dedicated MBS BWP as the common frequency resource for group-common PDSCH.Proposal 3: Support to use UE specific PDCCH to schedule group common PDSCH.Proposal 4: A new DL DCI format should be defined for the scheduling of group-common PDSCH.Proposal 5: Group scheduling design for MBS should take Case 1 and Case 2 above into account.Proposal 6: In case of gNB schedule unicast PDSCH and group-common PDSCH in one slot but UE has no capability to receive them simultaneously, some dropping rule should be defined. |
| [12]R1-2008375 | Sony | Proposal 1: Support the use of beam(s) for NR\_MBS contents delivery.Proposal 2: The network shall configure beam location and periodicity for NR\_MBS contents delivery.Proposal 3: The UE shall report preference of NR\_MBS content and beam(s) in which the NR\_MBS content can be provided.Proposal 4: Configure multiple beam sweeping resources for same NR\_MBS session(s) delivery. |
| [13]R1-2008449 | Apple | Observation 1: For Rel-15 paging mechanism, different UEs are separated into different POs. While for Rel-15 SIBx mechanism, different SI messages are separated into different SI-windows.Proposal 1: MBS specific BWP is configured for common frequency resource for group-common PDSCH.Observation: The UE behavior should be defined if it doesn’t receive the group common PDSCH correctly, in other words, UE receives the group common PDSCH re-transmission or receives the re-transmission via the unicast PDSCH.Proposal 2: Support dynamic indication of MBS PDSCH re-transmission via PTM or PTP.Proposal 3: Support joint indication of MBS PDSCH re-transmission and PTM and PTP switching.Proposal 4: Support UE-specific PDCCH to schedule a PDSCH for MBS.Proposal 5: TDM reception of unicast PDSCH and group-common PDSCH in a slot is supported without capability signalling. |
| [14]R1-2008826 | ZTE | Proposal 1: Rel-17 NR MBS can consider partial beam sweep in order to reduce the resource overhead.Proposal 2: Rel-17 NR MBS can consider introducing a MBS specific BWP for better flexibility.* The MBS specific BWP is confined within UE’s unicast BWP, and the SCS and CP are the same as unicast BWP.

Proposal 3: Regarding Rel-17 NR MBS* Define a Type x-PDCCH CSS set for the group common PDCCH.
* Define association between PDCCH MOs and SSBs or CSI-RSs for group common PDCCH transmission.

Proposal 4: DCI format 1\_0 scrambled with the G-RNTI can be used for MBS group scheduling under group common PDCCH. Proposal 5: Current mechanism can be reused for determining the size of DCI format 1\_0 for MBS group scheduling under group common PDCCH.* DCI size is determined according to CORESET0 if CORESET0 is configured; otherwise, the DCI size will be determined according to initial DL BWP.

Proposal 6: UE-specific PDCCH based group scheduling is NOT supported for MBS transmission.Proposal 7: SPS that is activated/deactivated by UE-specific PDCCH can be considered for multicast service transmission. Proposal 8: The same basic broadcast mechanism is applied for RRC\_CONNECTED UEs and RRC\_IDLE/RRC\_INACTIVE UEs.Proposal 9: Consider beam sweeping mechanism for NR Rel-15 SIBx transmission as the starting point for Rel-17 broadcast.Proposal 10: NR MBS UEs support reporting its interested broadcast service under RRC\_CONNECTED state. Proposal 11: RAN1 further studies whether to support HARQ-ACK for broadcast service for UEs under RRC\_CONNECTED state. |
| [15]R1-2008833 | ETRI | Proposal1: UE-specific PDCCH is not considered in Rel-17.Proposal2: BWP framework is required to be reused for MBS.Proposal3: Trade-off between two alternatives: the common frequency resource is a MBS specific BWP or the common frequency resource is confined within UE’s dedicated BWP should be considered together with other related issues. |
| [16]R1-2008882 | Nokia, Nokia Shanghai Bell | Observation-1: Having a UE specific PDCCH that can schedule UEs to use a group common PDSCH is desirable for the following reasons:1. In scenarios where there is a low density of users receiving multicast traffic with high data rates and requiring uplink feedback, gNB will have the flexibility to choose the appropriate control channel signalling mechanism2. Enables the support of seamless mobility and switching from multicast-to-unicast 3. Enables simultaneous BWP switching and scheduling of MBS PDSCH resources using the same DCIObservation-2: In order to support both signalling options to access the same group common PDSCH, new signalling mechanisms will be required to allow the network to configure and modify on a dynamic basis these connections.Observation-3: For Option-1, it is not clear whether the unicast traffic can be scheduled in the MBS BWP or not.Observation-4: For Option-1, if the unicast is considered not part of MBS BWP, there is the drawback of limiting the overall capacity that is available for MBS and unicast.Observation-5: For Option-1, if the unicast is considered not part of MBS BWP, it does not support multiplexing of unicast / multicast reception.Observation-6: Option-2 does not fully avoid the BWP switching for multicast reception, but UEs would not be required to switch BWPs for receiving unicast and multicast traffic simultaneously.Observation-7: Option-1 can be seen as a special case of configuration when Option-2 is supported.Observation-8: From UE power savings perspective, it is not beneficial to configure a large dedicated BWP to a UE in the MBS group.Observation-9: Multiple common frequency resources can be configured per UE based on gNB implementation – even though the motivations for doing so are not clear, with the maximum limit dependent on UE capabilities and available system resources.Observation-10: For slot based FDM multiplexing of unicast and multicast traffic, the network will need to optimize the active BWP bandwidth to account for the expected combined unicast and multicast traffic capacity and to minimize power consumed when there is no/less traffic.Observation-11: Slot based FDM multiplexing of unicast and multicast traffic, may need to be suspended temporarily if the active BWP needs to be reconfigured/changed.Proposal-1: For RRC\_CONNECTED UEs, support UE-specific PDCCH with CRC scrambled by a C-RNTI to schedule a group-common PDSCH, where the scrambling of the group-common PDSCH is based on a common RNTI.Proposal-2: The same group-common PDSCH for PTM transmission can be accessed either by:• A set of UEs using the same group-common PDCCH with CRC scrambled by a common RNTI• A set of UEs, where each UE uses a UE-specific PDCCH with CRC scrambled by a C-RNTI • A mix of the UEs, where some of them use UE-specific PDCCH and others use group-common PDCCH Proposal-3: The network can dynamically modify the signalling used to configure a UE to access a group-common PDSCH.Proposal-4: BWP framework should be re-used at Rel-17 MBS.Proposal-5: For RRC\_CONNECTED UEs Option-2 shall be supported • Option-1 is a special case of Option-2 and thus implicitly also supported.• BWP where MBS data is provided must support multiplexing with unicast.Proposal-6: Need to discuss on how to handle the SS monitoring prioritization between multicast and unicast.Proposal-7: RAN1 should discuss whether a new SS set type specific for MBS is needed or not.Proposal-8: Propose to have the SS configuration and UE monitoring for 5G NR multicast to depend on the multicast service types, i.e. high-priority multicast services are configured in CSS and low-priority multicast services are configured in USS if no new SS set type introduced specifically for MBS.Proposal-9: Propose to maintain the maximum supported CORESET/SS sets numbers and BD/CCE limits defined in Rel-15 for Rel-17 MBS.Proposal-10: Propose to count G-RNTI as “other RNTI” when considering the (3+1) DCI size budget rule defined in Rel-15 NR.Proposal-11: Propose to consider the RNTI prioritization between C-RNTI and G-RNTI in a configured SS set.Proposal-12: Further discuss whether a New DCI format with G-RNTI is needed or not when the issue of common frequency resource with BWP operation is clarified.Proposal-13: For RRC\_CONNECTED UEs, support Type-B based TDM between unicast PDSCH and group-common PDSCH in a slot subject to UE capability. |
| [17]R1-2008926 | Lenovo, Motorola Mobility | Proposal 1: Using a UE-specific DCI to schedule a group-common PDSCH for MBS is not supported. Proposal 2: Using a UE-specific DCI to schedule a UE-specific PDSCH for MBS is supported for MBS retransmission. Proposal 3: A common frequency region confined with each UE’s dedicated BWP is defined/configured for MBS.Proposal 4: The group-common DCI and scheduled group-common PDSCH are transmitted within the common frequency region.Proposal 5: RB numbering within the common frequency region is with reference to the lowest RB of the common frequency region.Proposal 6: The number of bits for frequency domain resource assignment indicator in DCI is determined based on the bandwidth of the common frequency region. |
| [18]R1-2008961 | MediaTek Inc. | Observation 1: UE-specific PDCCH based group scheduling can be configured when the number of UEs in one MBS group are relatively small.Observation 2: UE-specific PDCCH based group scheduling can reuse R15/R16 unicast as much as possible.Observation 3: UE-specific PDSCH associated with a G-RNTI in UE-specific PDCCH based group scheduling can increase the system time delay for latency sensitive services and need more PUCCH resources in one feedback window to feed back timely.Observation 4: gNB doesn’t need to know which UE report NACK when both the initial transmission and retransmission adopt the group common scheduling.Observation 5: From gNB’s perspective, initial transmission (PTM) and retransmission (PTP) have different HARQ process.Observation 6: The common NACK feedback mode is not suitable for case 2’s group scheduling.Observation 7: case 3’s group scheduling mechanism is similar to unicast.Proposal 1: The MBS common frequency resource is confined with UE’s active BWP for group-common PDCCH based group scheduling.Proposal 2: The group-common PDCCH based group scheduling can be used for initial transmission and retransmission.Proposal 3: UE-specific PDSCH associated with a C-RNTI should be supported in UE-specific PDCCH based group scheduling.Proposal 4: Case 1 with common NACK mode should be supported when there are many UEs in one MBS group.Proposal 5: The initial transmission (PTM) DCI and retransmission (PTP) DCI should be configured the same HP ID.Proposal 6: case 2 with ACK/NACK mode should be supported when the UEs in the same MBS group are relatively small.Proposal 7: case 2 with separate NACK mode should be supported for reducing UE’s power consumption.Proposal 8: The UE-specific PDCCH based group scheduling should be supported for initial (re)transmission when the UEs in one MBS group is smaller (e.g., N<3). |
| [19]R1-2009000 | Intel Corporation | 1. The common frequency resource for receiving group common PDSCH should be contained within the active BWPs of the UEs in the group. The CORESET for the group-common PDCCH carrying the scheduling DCI should be contained within the defined MBS frequency resource.
2. BWP framework need not be fully re-used and special frequency resource or a special BWP can be configured which includes at least a configuration of subcarrier spacing (SCS), cyclic prefix (CP), starting PRB index via an offset to the common resource block (CRB) #0, and a number of PRBs on the CRB grid.
3. The FDRA field of the DCI should be dimensioned on the basis of the common frequency resource for the MBS group-common PDSCH reception.
4. Define a new RNTI, namely SC-RNTI for scrambling the CRC of DCI scheduling a PDSCH mapped to the MCCH containing multicast configuration information. Define a new RNTI, namely the SC-N-RNTI for scrambling the CRC of the DCI notifying a change in the multicast configuration. Define a new group RNTI, namely G-RNTI for scrambling the CRC of DCI scheduling a PDSCH carrying the multicast data corresponding to MTCH.
5. For groupcast, search space configuration for monitoring DCI scheduling multicast PDSCH can have the following options:
	* Re-use NR Type 3 CSS configuration while additionally supporting monitoring of DCI with CRC scrambled by SC-RNTI, SC-N-RNTI and G-RNTI
	* Alternately, define new NR CSS Type 4 for monitoring multicast DCI with CRC scrambled by SC-RNTI, SC-N-RNTI and G-RNTI
6. For RRC\_CONNECTED UEs groupcast PDCCH can also be monitored in USS
7. NR MBS uses PDSCH Mapping Type A with DM-RS Type 1 as a baseline. PDSCH Mapping Type B and use of Type 2 DM-RS are not precluded.
8. RRC\_CONNECTED UEs may be able to receive both multicast and unicast transmissions within a slot in a TDM manner. Simultaneous reception of unicast and multicast transmissions by a UE on orthogonal DM-RS ports is not precluded.
9. *DCI Format for scheduling NR MBS transmissions:*
	* *As a baseline DCI format 1\_0 (fallback DCI) can be re-used*
	* *If needed, a compact DCI format for multicast scheduling can be defined*
10. *The group-common DCI format for MBS transmission is included in the scheduling DCI size budget of 3 for UEs and UEs can perform size alignment for other DCI formats if MBS DCI size exceeds other scheduling DCI in its active BWP.*
11. *DL semi-persistent scheduling can be used for NR multicast PDSCH transmission*
12. *For NR MBS support of multi-layer MIMO transmission with rank adaptation is not precluded*
13. *For groupcast transmission, all UEs within the group share the same DM-RS port(s). Additionally, multiplexing UEs receiving unicast transmission on remaining orthogonal DM-RS ports is not precluded*
14. *Advanced transmission schemes like multiuser superposition transmission (MUST) for improving group spectral efficiency are not precluded*
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| [20]R1-2009055 | Asia Pacific Telecom co. Ltd | Observation 1: UE-specific feedback mechanism cannot be easily supported if a group-common PDCCH is used to schedule a group-common PDSCH. Nevertheless, having UE-specific feedback mechanism is beneficial because the network can fully understand the channel condition of each UE. Observation 2: In the case where UE-specific PDCCH schedules a group-common PDSCH, the feedback mechanism of PTP transmission, i.e., UE specific feedback, could be easily adopted.Proposal 1: Using UE-specific PDCCH to schedule group-common PDSCH could be supported by NR MBS for RRC\_CONNECTED UEs. |
| [21]R1-2009165 | Convida Wireless | Proposal 1: UE-specific PDCCH can be supported to schedule the PDSCH for MBS in addition to the group-common PDCCH for RRC\_CONNECTED UEs in NR MBS.Proposal 2: Dedicated MBS BWP should be supported for RRC\_CONNECTED UEs in NR MBS. |
| [22]R1-2009238 | BBC | Observation 1: Orthogonal TDM and/or FDM multiplexing in the time-frequency OFDMA grid for simultaneous operation of broadcast/multicast and unicast services, as considered for NR MBS, is a suboptimal transmission approach in terms of maximum sum-rate.Observation 2: A two-layered broadcast/multicast and unicast superposition transmission (BMUST) is optimal in terms of the maximum sum-rate supported. Hence, BMUST can be more spectral efficient than orthogonal TDM/FDM multiplexing.Observation 3: System level simulations confirm that BMUST provides the best average spectral efficiency performance against other orthogonal multiplexing schemes such as FDM, unicast-only and multicast-only for any number of UEs.Observation 4: With 20 UEs, the average spectral efficiency gain of BMUST against FDM is 40% and 45% in the simulated rural and urban environments, respectively.Observation 5: While multicast-only provides the best 5th percentile UE spectral efficiency in the considered scenarios, BMUST provides similar performance to multicast-only, especially as the number of UEs increases.Observation 6: In the case of simultaneous operation of broadcast/multicast and unicast services in a slot, both information streams contribute to the UE’s data rate and both information streams would need to be decoded regardless of the multiplexing scheme, i.e., FDM, TDM or BMUST.Observation 7: For BMUST, the receiver has the additional complexity for the operations required to reencode and subtract the broadcast/multicast stream from the main received signal.Observation 8: The link level results with realistic channel estimation and imperfect interference cancellation show that BMUST can provide significant gains in terms of increased spectral efficiency against orthogonal multiplexing.Recommendation: Due consideration should be given to the potential support of Broadcast/Multicast and Unicast Superposition Transmission in NR based on UE capability to improve the system’s spectral efficiency. |
| [23]R1-2009274 | Qualcomm Incorporated | Observation 1: Most of the parameters related to PDCCH/PDSCH reception are configured per BWP. Reusing the BPW signalling to define the common frequency resource for MBS allows for flexible configuration for GC-PDCCH and GC-PDSCH.Proposal 1: For RRC\_CONNECTED UEs, one or more Multicast BWPs can be configured per UE for GC-PDCCH/GC-PDSCH reception.* A Multicast BWP is configured to be associated with a dedicated DL BWP if it is fully contained in the dedicated DL BWP and using the same numerology.
* UE can monitor a Multicast BWP if its associated dedicated DL BWP is active.

Proposal 3: For RRC\_CONNECTED UEs, CSS and/or USS for GC-PDCCH can be configured per Multicast BWP.* Reuse legacy priority rules for mapping CSS and USS sets for GC-PDCCH.

Proposal 4: For RRC\_CONNECTED UEs, at least DCI format 1\_0 and 1\_1 can be used for GC-PDCCH.* FFS DCI size alignment for GC-PDCCH and unicast PDCCH with same DCI format.

Proposal 5: For RRC\_CONNECTED UEs, consider the GC-PDCCH monitoring for multicast as a virtual CC to count the number of BDs/CCEs.Proposal 6: For RRC\_CONNECTED UEs, common parameters for GC-PDSCH are configured per Multicast BWP.Proposal 7: For RRC\_CONNECTED UEs, support dynamic GC-PDSCH and SPS GC-PDSCH configuration per Multicast BWP. * GC-PDCCH is used for SPS GC-PDSCH activation/deactivation.
* FFS: more than one SPS GC-PDSCH.

Proposal 8: UE-specific PDCCH can be used to schedule PDSCH for multicast retransmission.* UE-specific PDCCH schedules multicast retransmission with HARQ process ID associated with that of GC-PDSCH scheduled by GC-PDCCH.

Proposal 9: Consider separate UE capabilities for FDM only, TDM only, or FDM+TDM for unicast PDSCH and GC-PDSCH in a slot.Proposal 10: Further discuss the potential RAN1 impact related with the configuration of G-RNTI(s) and the interaction between G-RNTI and C-RNTI for PDSCH reception, including:* Aspects related to simultaneous reception of G-RNTI(s) and C-RNTI
* Aspects related to simultaneous reception of multiple G-RNTIs.
* Aspects related to retransmission of packets between G-RNTI(s) and C-RNTI.

Proposal 11: For RRC\_CONNECTED UEs, the configuration for NR multicast reception is received by unicast RRC signalling. |
| [24]R1-2009305 | Ericsson | Observation 1 The existing BWP framework can be used, i.e. with no specification impact, for the reception of MBS and unicast.Observation 2 BWP switching for MBS UEs while in RRC Connected will require RRC reconfiguration of all MBS UEs at the same time, which is costly from the point of view of radio resources and latency.Observation 3 Fall back to default/initial BWP mechanisms can be used to switch to the MBS bandwidth, at the condition on the no activity on all the active BWPs for the MBS UEs.1. Limit scheduling of G-RNTI based PDCCH to G-RNTI based PDSCH, i.e., i.e. not support C-RNTI-based PDCCH for such scheduling in Rel.17.
2. The existing framework for BWP management is sufficient for ensuring all UEs in MBS share the same BWP during common PDSCH transmission. The common BWP is either an MBS specific bandwidth part or the initial bandwidth part. Transmission over a common frequency resource within each UE dedicated BWP is not supported.
3. For RRC\_CONNECTED UEs, support inter-slot TDM between unicast PDSCH and group-common PDSCH in different slots as a core MBS functionality.
4. For RRC\_CONNECTED UEs, at least support intra-slot TDM of unicast PDSCH and group-common PDSCH in a slot subject to UE capability.
5. For RRC\_CONNECTED UEs, SDM of unicast PDSCH and group-common PDSCH is not pursued in rel17.
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