**3GPP TSG RAN WG1 Meeting #111 R1-221XXXX**

**Toulouse, France, November 14th – 18th, 2022**

**Source: Moderator (Lenovo)**

**Title: Feature lead summary #1 on multi-cell PUSCH/PDSCH scheduling with a single DCI**

**Agenda item:** **9.9.1**

**Document for:** **Discussion and Decision**

# Introduction

This document summarizes the contributions submitted under the “9.9.1 **Multi-cell PUSCH/PDSCH scheduling with a single DCI**” agenda item of the Rel-18 work item on “Multi-Carrier Enhancements (MCE) for NR”.

The Rel-18 WI Multi-carrier enhancements was agreed during RAN#94-e meeting [1], where one of the objectives is targeted to specify a solution for multi-cell PUSCH/PDSCH scheduling with a single DCI. The detailed objectives in the WID are listed below:

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| **1. Specify a solution for multi-cell PUSCH/PDSCH scheduling (one PDSCH/PUSCH per cell) with a single DCI [RAN1]**   * **Identify the maximum number of cells that can be scheduled simultaneously** * **Consider both intra-band and inter-band CA operation** * **Consider both FR1 and FR2** * ***The single DCI shall be optimized for 3 or more cells for the multi-cell PUSCH/PDSCH scheduling*** |

In this contribution, we summarize the related issues and proposals based on the contributions submitted in RAN1#110 under the agenda item 9.9.1 [1]-[25]. The whole feature lead summary is structured as follows:

From section 2 to 5, the main issues raised by company contributions are divided into 4 parts and each section covers one main issue. In each section, the background and related proposals submitted in this meeting are listed firstly in sub-section X.1, then summary on one or several sub-issues is provided in sub-section X.2 from moderator’s perspective. Based on the above summary, a set of proposals is recommended by moderator followed by one or multiple tables to collect company views for the initial proposals in the first round of e-mail discussion. If present, in each sub-section, the proposals will be updated round by round based on companies’ inputs. As e-mail discussion goes on, more sub-sections may be provided for further e-mail discussion and update.

In section 7, some proposals are selected for discussion in the online/offline sessions.

In Section 9, the agreements made in previous RAN1/RAN meetings are listed for reference.

Companies are highly encouraged to provide views as soon as possible. Moderator will try to update the proposals based on companies’ inputs at least on daily basis.

# Scenarios and basic framework

## Background and submitted proposals

With the agreement achieved in RAN#97 and RAN1 meetings, seems no proposal is submitted for scenarios and basic framework. Some proposals relevant to technical issues have been moved to Section 3 and 4.

Hence, no proposal is provided in this section for time being.

## Moderator summary and proposals based on contributions

Hence, no proposal is provided in this section for time being.

# DCI format design

Based on contributions submitted by companies, below issues are prioritized for discussion in this meeting. Within each sub-section, the summary from moderator’s perspective is listed and followed by draft proposals for further discussion round by round.

## Scheduling possibilities

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| **Huawei:**  *Proposal 1: Monitoring the DCI format 0\_X/1\_X from one scheduling cell and legacy DCI format(s) from the scheduled cell via self-scheduling should be supported.*  **Nokia:**  *Proposal 3.2: For any cell within a set of cells which can be co-scheduled by a DCI format 0\_X/1\_X, RAN1 specification supports monitoring the DCI format 0\_X/1\_X and DCI format 0\_0/1\_0, 0\_1/1\_1, and/or 0\_2/1\_2 (if supported by the UE), if configured from different scheduling cells for the case self-scheduling of DCI formats 0\_0/1\_0, 0\_1/1\_1/0\_2/1\_2.*   * *The DCI format 0\_X/1\_X and the legacy DCI format(s) 0\_0/1\_0/0\_1/1\_1/0\_2/1\_2 can be monitored simultaneously.* * *Note: This does not mean a UE is required to support number of BDs/CCEs beyond the Rel-17 limits (i.e., and ) for PDCCH candidates for each scheduled cell.*     **Vivo:**  *Proposal 1. For a scheduled cell within a set of cells that can be co-scheduled by a DCI format 0\_X/1\_X, the case where different scheduling cells are configured for multi-cell scheduling and single-cell scheduling is not supported in R18.*  **Xiaomi:**  *Proposal 4: Only one scheduling cell can be configured to the UE to monitor both MC-DCI and the legacy DCIs for a scheduled cell in Rel-18.*  **Apple:**  *Proposal 9: RAN1 should discuss if both cross-carrier scheduling and multi-cell scheduling can be configured for a cell*   * *If both cross-carrier scheduling and multi-cell scheduling can be configured for a cell, then the potential UE complexity in terms of BD/CCE counting and search space configuration should be discussed.*   **FGI:**  *Proposal 4: For each scheduled cell, a UE monitors DCI format 0\_X/1\_X on at most one scheduling cell.*  *Proposal 5: For a cell within a set of cells which can be co-scheduled by a DCI format 0\_X/1\_X, support monitoring the DCI format 0\_X/1\_X on one scheduling cell and legacy DCI format(s) on the scheduled cell via self-scheduling.*  **Qualcomm:**  *Proposal 5: Support dynamic indication of scheduling cell(s)*   * *Enable configuration of more than one scheduling cells for a scheduled cell* * *Enable switch/fallback from multi-cell scheduling to legacy self-scheduling dynamically*   + *Extend SSSG switching or BWP switching to enable this*   **Langbo:**  *Proposal 1: For a cell within a set of cells which can be co-scheduled by a DCI format 0\_X/1\_X, monitoring the DCI format 0\_X/1\_X from one scheduling cell and legacy DCI format(s) from another scheduling cell is not supported.* |

### Moderator summary and proposals based on contributions

It is observed by some companies that if multi-cell DCI scheduling and single-cell DCI scheduling are restricted only from a same scheduling cell for each co-scheduled cell, it may lead to high DL control load on the scheduling cell even PDCCH scarcity. Therefore, for a UE, monitoring DCI format 0\_X/1\_X and legacy DCI format(s) from different scheduling cells for a scheduled cell within a set of configured cells scheduled by a DCI format 0\_X/1\_X may be useful for PDCCH load balancing.

Whether to support monitoring DCI format 0\_X/1\_X and legacy DCI format(s) from different cells, companies’ views are summarized as below:

* *Support monitoring DCI format 0\_X/1\_X and legacy DCI format(s) from different cells*
  + *Yes: Huawei, Nokia, FGI*
  + *No: vivo, xiaomi, Langbo*

From moderator’s point of view, supporting monitoring DCI format 0\_X/1\_X and legacy DCI format(s) from different cells seems optimization and not essential to complete this multi-cell scheduling in Rel-18. Considering only 0.5 TU is arranged for November meeting and possible standardization effort, moderator suggest deferring this issue.

## Search space configuration, DCI size and BD/CCE budget

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| **Huawei, HiSilicon**  *Proposal 6: Confirm the WA below:*  *“For a set of cells which is configured for multi-cell scheduling,*   * *Existing DCI size budget is maintained on each cell of the set of cells.* * *DCI size of DCI format 0\_X/1\_X is counted on one cell among the set of cells.*   + *FFS which cell DCI size of the DCI format 0\_X/1\_X is counted on.* * *BD/CCE of DCI format 0\_X/1\_X is counted on one cell among the set of cells.*   + *FFS which cell BD/CCE of the DCI format 0\_X/1\_X is counted on.* * *Search space of DCI format 0\_X/1\_X is configured on one cell of the set of cells and associated with the search space of the scheduling cell with the same search space ID.*   + *FFS which cell the SS of the DCI format 0\_X/1\_X is configured on.* * *FFS: How to address Rel-17 BD/CCE limit for any given cell (operating the feature under Rel-17 BD/CCE limit)* * *Note: This does not mean a UE is required to support number of BDs/CCEs beyond the Rel-17 limits (i.e., and ) for PDCCH candidates for each scheduled cell.”*   *Proposal 7: DCI size of DCI format 1\_X/0\_X can be counted on the co-scheduled cell which has minimum number of legacy DCI formats or has minimum number of legacy DCI sizes after alignment.*  *Proposal 8: BD/CCE of DCI format 0\_X/1\_X should be counted on the same cell as which cell the DCI size of DCI format 0\_X/1\_X is counted on.*  *Proposal 9: The SS of the DCI format 0\_X/1\_X should be configured on the same cell as which cell the BD/CCE of DCI format 0\_X/1\_X is counted on.*  *Proposal 10: Accept the proposal 2-6rev1 in R1-2210662:*   * *For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells.* * *The UE can be configured one or multiple sets of cells which are configured for multi-cell scheduling.* * *When multiple sets of cells are configured for multi-cell scheduling, separate n\_CI values are configured for different sets of cells.* * *When multiple sets of cells are configured for multi-cell scheduling, a cell in one set of cells can’t be included in another set of cells.*   **Nokia:**  *Observation 2.1: The ‘set of cells’ for PUSCH scheduling using DCI format 0\_X and PDSCH scheduling using DCI format 1\_X do not need to be the same.*  *Proposal 2.2: Support independent configuration for multi-cell scheduling for DCI format 0\_X and 1\_X with at least the following properties:*   * *Separate configuration of a set of cells for DCI format 0\_X and 1\_X*   + *Note: Any cell with can be scheduled by DCI format 1\_X may or may not be part of a set of cells of a DCI format 0\_X, and vice versa.*   + *Note: The cells of a set of cells for DCI format 0\_X are not expected to be part of more than one set of cells for DCI format 1\_X, and vice versa.* * *Separate configuration of the search space and n\_CI value for a DCI format 0\_X and 1\_X.* * *Separate configuration of the table for indication of the co-scheduled cells for DCI format 0\_X and 1\_X.*   *Proposal 3.3: The DCI size for DCI format 0\_X (or 1\_X) for a set of cells is RRC configured.*  *Proposal 3.4.1: Confirm the RAN1#110bis-e working assumption with the following changes in red:*   |  | | --- | | *Working Assumption*  *For a set of cells which is configured for multi-cell scheduling,*   * *Existing DCI size budget is maintained on each cell of the set of cells.* * *DCI size of DCI format 0\_X/1\_X is counted on one cell among the set of cells.*   + *~~FFS which cell~~ The DCI size of the DCI format 0\_X/1\_X is counted on the cell the search space of the DCI format 0\_X/1\_X is configured on.* * *BD/CCE of DCI format 0\_X/1\_X is counted on one cell among the set of cells.*   + *~~FFS which cell The~~ BD/CCE of the DCI format 0\_X/1\_X is counted on the cell the search space of the DCI format 0\_X/1\_X is configured on.* * *Search space of DCI format 0\_X/1\_X is configured on one cell of the set of cells and associated with the search space of the scheduling cell with the same search space ID.*   + *~~FFS~~ It is up to gNB on which cell the SS of the DCI format 0\_X/1\_X is configured on.* * *UE should not apply any overbooking procedures for any given cell as long as the gNB chosen cell for DCI format 0\_X/1\_X does not exceed the Rel-17 BD/CCE limits. ~~FFS: How to address Rel-17 BD/CCE limit for any given cell (operating the feature under Rel-17 BD/CCE limit~~)* * *Note: This does not mean a UE is required to support number of BDs/CCEs beyond the Rel-17 limits (i.e., and ) for PDCCH candidates for each scheduled cell* |   *Observation 3.4.2: Regarding the n\_CI configurability, as more than one sets of cells would required in case only up to 4 cells can be part of one set of cells the decision on the n\_CI configurability in RAN1#110bis-e Proposal 2-6rev1 should be coupled with the decision on the maximum number of cells and the indication of the co-scheduled cells of RAN1#110bis-e Proposal 3-5rev7 as discussed in Sec. 3.1 with the proposed modifications in red:*   |  | | --- | | *Proposal 3-5rev7:* *·         For a set of cells which is configured for multi-cell scheduling, RAN1 specification supports up to 4 cells within the set of cells.*  *o    A DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the set of cells.*  *·         For multi-cell scheduling, the co-scheduled cells are indicated by an indicator in DCI format 0\_X/1\_X which points to one row of a table defining combinations of co-scheduled cells for the set of cells.*   * *The table is configured by RRC signaling for a set of cells.*  *Proposal 2-6rev1:*  * *For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells.* * *The UE can be configured one or multiple sets of cells which are configured for multi-cell scheduling.* * *When multiple sets of cells are configured for multi-cell scheduling,*    + *separate n\_CI values are configured for different sets of cells*   + *separate tables for co-scheduled cell indication are configured for different sets of cells*   + *separate search spaces are configured for different sets of cells (as the cell configured with the search space cannot be part of more than one configuration of set of cells)*   + *the DCI size of 0\_X (or 1\_X) is the same for all co-scheduled cell combinations for a set of cells, but can be different between different sets of cells* * *When multiple sets of cells are configured for multi-cell scheduling, a cell in one set of cells can’t be included in another set of cells.* |   **Vivo：**  *Proposal 9. DCI size of format 0\_X/1\_X and BD/CCE of DCI format 0\_X/1\_X should be counted on the same cell which is configured with search space of DCI format 0\_X/1\_X, and it is up to gNB which cell is configured with SS of the DCI format 0\_X/1\_X.*  *Proposal 10. For a co-scheduled cell counting the BD/CCE/DCI size of mc-DCI, there is a single DCI size for DCI format 0\_X, there is a single DCI size for DCI format 1\_X.*  *Proposal 11. For a co-scheduled cell counting the BD/CCE/DCI size of mc-DCI, there is only a single n\_CI value for determining the CCE of DCI format 0\_X/1\_X.*  *Proposal 12. From the perspective of the co-scheduled cell counting toward the BD/CCE/DCI size of mc-DCI, mc-DCI and sc-DCI should be configured in different SSs.*  *Proposal 13. From the perspective of the co-scheduled cell counting toward the BD/CCE/DCI size of mc-DCI, a mc-DCI is considered as a unicast DCI, and the total number of mc-DCI and sc-DCI for that scheduled cell should not exceed the legacy restriction of the maximum number of unicast DCI specified in 38.306.*  *Proposal 14. Only one set of cells that are configured for multi-cell scheduling is supported.*  *Proposal 15. If multiple sets of cells which is configured for multi-cell scheduling are supported, the cells in different sets should be orthogonal, and the special cell counting toward the BD/CCE/DCI size of mc-DCI for each set should be different.*  *Proposal 16. From the perspective of a co-scheduled cell counting the BD/CCE/DCI size mc-DCI, it can be configured with one or more BWP with SS for DCI format 0\_X/1\_X.*  **Google:**  *Proposal 1: UE should be able to monitor multiple DCI formats X\_0/X\_1 on multiple scheduling cells simultaneously, and the size of DCI formats X\_0/X\_1 on different scheduling cells should be aligned.*  *Observation 1: It is not clear whether the budget of DCI size, search space, and BD/CCE can be counted on individual cells or have to be counted on the same cell, and how to handle the case if the cell configured/indicated to count the budget is deactivated (e.g., by MAC CE or timer).*  **Fujitsu:**  *Proposal 3: For determining PDCCH candidates for multi-cell scheduling, both the value of and the number of PDCCH candidates per AL are per set of cells that can be scheduled by the DCI format 0\_X/1\_X. The set of cells includes all cells in the table defining combinations of scheduled cells.*  **CATT:**  *Proposal 5:Confirm the working assumption on DCI size, BD/CCE and search space of DCI format 0\_X/1\_X from RAN1#110b-e.*  *Proposal 6: For a set of cells, the BD/CCE and the DCI size of DCI format 0\_X/1\_X should be counted on the same cell, and this cell is the cell configured with the search space of DCI format 0\_X/1\_X.*  *Proposal 7: For a set of cells, the DCI size and BD/CCE of DCI format 0\_X/1\_X can be counted either on one scheduled cell or on scheduling cell, depending on configuring search space of DCI format 0\_X/1\_X on which cell.*  *Proposal 8: For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation should be determined by a value configured for a set of cells.*  *Proposal 14: For a set of cells, the payload size 0\_X is the same for all the co-scheduled cell combinations.*  *Proposal 15: For a set of cells, the payload size 1\_X is the same for all the co-scheduled cell combinations.*  *Proposal 16: The payload size of DCI format 0\_X/1\_X should be configured by a higher layer parameter.*  **Spreadtrum:**  *Proposal 2: A same cell is used for search space and BD/CCE/DCI size counting, which is identified by the configuration of specific search space ID which is used for DCI 0\_X/1\_X on the scheduling cell.*  *Proposal 3: Support the first bullet of Proposal 2-6rev1:*   * *For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells.*   *Proposal 4: Only one size of DCI 0\_X/1\_X on one scheduling cell can be monitored.*  *Proposal 5: The search space configured with DCI format 0\_X/1\_X cannot be configured with legacy DCI formats.*  **Xiaomi:**  *Proposal 5: It is up to gNB’s configuration to maintain the DCI size budget. The dropping rule can be defined if needed to ensure the DCI budget of one or multiple co-scheduled cells is maintained.*  *Proposal 6: It is up to gNB’s configuration to maintain the legacy BD/CCE limits. The dropping rule can be defined if needed.*  *Proposal 7: The BD/CCE is counted on the cell configured with the MC-DCI SS.*  *Proposal 8: For a set of cells which can be scheduled by DCI format 0\_X/1\_X, the payload size of DCI format 0\_X/1\_X is derived by UE based on RRC configuration of co-scheduled cell combinations within the set of cells.*  *Proposal 9: The in the search space equation is determined by a value configured for the set of cells.*  *Proposal 10: The UE can be configured with multiple sets of cells for multi-cell scheduling, without overlapped cells among different sets of cells.*  **Intel:**  *Proposal 6*   * *The multiple cells that can be scheduled by a scheduling cell can be divided into multiple sets of cells*   + *A cell can only belong to one set of cells.* * *For each set of cells, a configuration of the DCI fields can be configured for DCI format 0-X/1-X, which may result in different DCI sizes for the different set of cells*    + *For a set of cells, the DCI size can be determined based on the configured sizes of all the DCI fields*   *Proposal 7*   * *All necessary parameters in the SS set configuration of a SS set with a searchSpaceId for a DCI format of multi-cell scheduling can be configured in the configuration of the scheduling cell, and nrofCandidates if provided in the configuration of the SS set with same searchSpaceId of a scheduled cell, is prioritized in determining the number of PDCCH candidates.* * *The reference cell for SS set configuration can be different for the different configurations of DCI format 0\_X or 1\_X.*   *Proposal 8*   * *One value can be configured to determine the start CCE index of the SS set for the set of cells.* * *The value can be configured to the reference cell for SS set configuration of the SS set.* * *The value can be separately determined for each configuration of the SS set of DCI format 0\_X or 1\_X*   *Proposal 9*   * *The DCI size of DCI format 0\_X/1\_X is counted to the reference cell for the SS set configuration of the DCI format* * *The BD/CCE of DCI format 0\_X/1\_X is counted to the reference cell for the SS set configuration of the DCI format*   *Proposal 10*   * *If the total number of DCI sizes for a cell exceeds the existing DCI size budget per cell, UE can perform DCI size alignment for the cell in the following order:*   + *DCI size alignment as specified in TS 38.212.*   + *The DCI size of the DCI format 0\_X and the DCI format 1\_X can be aligned.*   + *The DCI size of the DCI format 0\_X/1\_X can be further aligned with a DCI format for single-cell scheduling.*   *Proposal 11*   * *For the BD/CCE handling of DCI format 0\_X/1\_X and legacy DCI format(s) on a scheduling cell*   + *Rel-17 PDCCH monitoring limits and can be reused*   + *For the one cell on which the BD/CCE of DCI format 0\_X/1\_X are counted, it is up to gNB implementation to handle the impact of unchanged .*   + *Special handling on BD/CCE counting for is not needed*   **OPPO:**  *Proposal 9: Confirm the working assumption for DCI size counting, BD/CCE counting and search space set configuration for DCI format 0\_X/1\_X.*  *Proposal 10: The cells for DCI size counting, BD/CCE counting and search space set configuration for DCI format 0\_X/1\_X shall be a same cell.*  *Proposal 11: A scaling factor is introduced to explicitly define the capabilities for single-cell scheduling and multi-cell scheduling.*  *Proposal 12: A scaling factor is added into the calculation for .*  *Proposal 13: Restriction for DCI format configuration can be considered to reduce the total number of different DCI size before DCI size alignment.*  *Proposal 14: The n\_CI in the search space equation is determined by a value of cell set.*   * *Different n\_CI values configured for different cell sets*   **China Telecom:**  Proposal 5: For a set of cells which can be scheduled by DCI format 0\_X/1\_X, the payload size of DCI format 0\_X/1\_X is derived by UE based on RRC configuration of the set of cells.  **Lenovo:**  *Proposal 12: For a set of cells which is configured for multi-cell scheduling by DCI format 0\_X, the payload size of the DCI format 0\_X is the same for all the co-scheduled cell combinations within the set of cells.*  *Proposal 13: For a set of cells which is configured for multi-cell scheduling by DCI format 1\_X, the payload size of the DCI format 1\_X is the same for all the co-scheduled cell combinations within the set of cells.*  *Proposal 19: For a set of cells which is configured for multi-cell scheduling, it is up to gNB to select one cell to configure search space of DCI format 0\_X/1\_X on it.*  *Proposal 20: For a set of cells which is configured for multi-cell scheduling, both DCI size and BD/CCE of DCI format 0\_X/1\_X are counted only on the cell configured with search space for monitoring the DCI format 0\_X/1\_X within the set of cells.*  *Proposal 21: For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells.*  *Proposal 22: When multiple sets of cells for respective multi-cell scheduling are configured for a UE, separate n\_CI values are configured for different sets of cells.*  *Proposal 23: When multiple sets of cells for respective multi-cell scheduling are configured for a UE, a cell in one set of cells can’t be included in another set of cells.*  **CMCC:**  *Proposal 4. The DCI payload size of a DCI format 0\_X/1\_X can be derived by UE based on RRC configuration of co-scheduled cell combinations within the set of cells.*   * *The payload size of DCI format 0\_X should be same for all the co-scheduled cell combinations within the set of cells.* * *The payload size of DCI format 1\_X should be same for all the co-scheduled cell combinations within the set of cells.*   *Proposal 5. To determine the CCEs for each configured aggregation level of PDCCH candidates for multi-cell scheduling,*   * *The same n\_CI value for calculating CCE indexes of PDCCH candidates can be configured for the combinations of co-scheduled cells within the set of configured cells.* * *One or multiple sets of cells can be configured for multi-cell scheduling. When multiple sets of cells are configured for multi-cell scheduling, separate n\_CI values are configured for different sets of cells.*   *Proposal 6. For a set of cells which is configured for multi-cell scheduling, existing DCI size budget is maintained and DCI size of DCI format 0\_X/1\_X is counted only on one scheduled cell among the set of cells.*   * *The scheduled cell can be configured based on gNB implementation or pre-defined rules.*   *Proposal 7. For a set of cells which is configured for multi-cell scheduling, BD/CCE numbers of monitoring DCI format 0\_X/1\_X are counted only on one scheduled cell among the set of cells.*   * *The scheduled cell can be configured based on gNB implementation to ensure the legacy BD/CCE budget is maintained.*   **Apple:**  *Proposal 2: Confirm the following working assumption:*  *Working Assumption*  *For a set of cells which is configured for multi-cell scheduling,*   * *Existing DCI size budget is maintained on each cell of the set of cells.* * *DCI size of DCI format 0\_X/1\_X is counted on one cell among the set of cells.*   + *FFS which cell DCI size of the DCI format 0\_X/1\_X is counted on.* * *BD/CCE of DCI format 0\_X/1\_X is counted on one cell among the set of cells.*   + *FFS which cell BD/CCE of the DCI format 0\_X/1\_X is counted on.* * *Search space of DCI format 0\_X/1\_X is configured on one cell of the set of cells and associated with the search space of the scheduling cell with the same search space ID.*   + *FFS which cell the SS of the DCI format 0\_X/1\_X is configured on.* * *FFS: How to address Rel-17 BD/CCE limit for any given cell (operating the feature under Rel-17 BD/CCE limit)* * *Note: This does not mean a UE is required to support number of BDs/CCEs beyond the Rel-17 limits (i.e., and ) for PDCCH candidates for each scheduled cell.*   *Proposal 3: For DCI size counting, BD/CCE counting and search space configuration of DCI format 0\_X/1\_X, same cell is selected/configured from the set of cells that can be co-scheduled by DCI format 0\_X/1\_X.*  *Proposal 4: For DCI size counting, BD/CCE counting and search space configuration of DCI format 0\_X/1\_X, pre-defined rule(s) can be applied to determine the selection of one cell from the set of co-scheduled cells:*   * *If the scheduling cell is one of the co-schedulable cells, then the DCI size counting, BD/CCE counting and search space configuration of DCI format 0\_X/1\_X is done one the scheduling cell* * *FFS: other pre-defined rules to determine the cell in case when scheduling cell is not one of the co-schedulable cells*   *Proposal 5: For BD/CCE limit for a given cell, BD/CCE budget will be shared for monitoring both legacy DCI formats as well as DCI format 0\_X/1\_X on the cell that is selected/configured for BD/CCE counting*   * *UE is not expected to go beyond the per cell limit for the selected/configured cell*   *Proposal 7: For a set of cells which can be scheduled by DCI format 0\_X/1\_X*   * *The payload size 0\_X is the same for all the co-scheduled cell combinations.* * *The payload size 1\_X is the same for all the co-scheduled cell combinations.*   *Proposal 8: For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells.*   * *The UE can be configured one or multiple sets of cells which are configured for multi-cell scheduling.*    + *When multiple sets of cells are configured for multi-cell scheduling, separate n\_CI values are configured for different sets of cells.*   + *When multiple sets of cells are configured for multi-cell scheduling, a cell in one set of cells can’t be included in another set of cells.*   **FGI:**  *Proposal 6: Consider the following alternatives for counting DCI size.*   * *The cell on which a DCI size of the DCI format 0\_X/1\_X is counted is explicitly configured.* * *The cell on which a DCI size of the DCI format 0\_X/1\_X is counted is the cell with smallest serving cell index in the set of cells excluding PCell.*   *Proposal 7: Consider the following alternatives for counting BD/CCE.*   * *The cell on which a BD/CCE of the DCI format 0\_X/1\_X is counted is explicitly configured.* * *The cell on which a BD/CCE of the DCI format 0\_X/1\_X is counted is the cell with smallest serving cell index in the set of cells excluding PCell.*   *Proposal 8: Different n\_CI can be configured for different sets of co-scheduled cells within the set of cells.*  **NTT DOCOMO:**  *Proposal 3: For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells.*   * *The n\_CI is configured via RRC signaling.* * *When multiple sets of cells are configured for multi-cell scheduling, separate n\_CI values are configured for different sets of cells.*   *Proposal 4: For multi-cell scheduling, the SS set for a DCI format 0\_X/1\_X should be configured on the cell that BD/CCE/DCI size for the DCI format 0\_X/1\_X is counted.*  *Proposal 7: For a set of cells which can be scheduled by DCI format 0\_X/1\_X, the payload size of DCI format 0\_X/1\_X is derived by UE based on RRC configuration of co-scheduled cell combinations within the set of cells.*   * *The payload size 0\_X is the same for all the co-scheduled cell combinations included in a set of cells.* * *The payload size 1\_X is the same for all the co-scheduled cell combinations included in a set of cells.*   *Proposal 8: Following steps should be added to the DCI size alignment procedure.*   * *Step 4D: Align the payload size of DCI format 0\_X and 1\_X*    + *Align the payload size of DCI format 0\_X and DCI format 1\_X for a same set of cells with zero padding, if necessary.*   + *Align the payload size of DCI format 0\_X/1\_X among multiple sets of cells with zero padding, if necessary.* * *Step 4E: Align the payload size of DCI format 0\_0/1\_0 and DCI format 0\_2/1\_2 with zero padding, if necessary.*   **Samsung:**  *Proposal 4: A UE can be configured:*   * *Separate search space sets to monitor PDCCH for MC-DCI formats and SC-DCI formats;* * *Separate search space sets to monitor PDCCH for DL DCI format 1\_X and UL DCI format 0\_X.*   *Proposal 5: The size of the MC-DCI format, for a given scheduling cell, is based on the maximum number of co-scheduled cells and the corresponding configurations of MC-DCI format fields across different “sets of cells configured for multi-cell scheduling”.*   * *The size of DL MC-DCI format 1\_X can be different from the size of UL MC\_DCI format 0\_X.*   *Proposal 6: For the “3+1” limit on UE budget for DCI sizes, the UE counts the size of one or both of DCI format 0\_X and DCI format 1\_X on a “reference” cell.*   * *When DCI formats 0\_X and 1\_X have different sizes, the UE counts the size of DCI format 0\_X on a first “reference” cell and counts the size of DCI format 1\_X on a second “reference” cell;* * *The UE determines the (first and second) “reference” cell(s) for counting the sizes of DCI formats 0\_X/1\_X per gNB configuration.* * *DCI size alignment procedures of [TS 38.212] can be extended, for the “reference” cell(s), to incorporate the DCI formats 0\_X/1\_X.*   *Proposal 7: For configuration of search space set and counting of PDCCH candidates and non-overlapping CCEs for multi-cell scheduling:*   * *gNB configures the “linked” search space sets for DCI format 0\_X/1\_X on a “reference” cell (other than the scheduling cell);* * *The UE counts the BDs/CCEs for DCI format 0\_X/1\_X on the “reference” that has the corresponding “linked” search space set;* * *Separate “reference” cells for DCI format 0\_X and for DCI format 1\_X can be configured;* * *Separate “reference” cells for different “sets” of co-scheduled cells can be configured (corresponding to different n\_CI values);* * *The configuration of “reference” cell(s) for counting the size of DCI format 0\_X or DCI format 1\_X is separate than the configuration of “reference” cell(s) for counting corresponding BDs/CCEs.*   *Proposal 8: A UE configured with multi-cell scheduling applies the Rel-17 PDCCH monitoring limits.*   * *For any co-scheduled cell other than “reference” cell(s) for BD/CCE counting, Rel-17 limits for PDCCH monitoring and PDCCH counting rules apply;* * *For each “reference” cell for BD/CCE counting, a total number of configured BD/CCEs for both DCI format 0\_X/1\_X and legacy SC-DCI formats does not exceed the Rel-17 limits.*   *Proposal 9:* *When a search space set for DCI format 0\_X/1\_X is not on an active DL BWP of the “reference” cell or when the “reference” cell is deactivated or has a dormant active DL BWP, the UE does not monitor PDCCH for DCI format 0\_X/1\_X for the corresponding “set of cells configured for multi-cell scheduling” and calculation of PDCCH monitoring limits is as in Rel-17.*  *Proposal 10: Confirm the below WA from RAN1#110bis-e with the following revisions.*  *Working Assumption (RAN1#110bis-e)*  *For a set of cells which is configured for multi-cell scheduling,*   * *Existing DCI size budget is maintained on each cell of the set of cells.* * *When DCI formats 0\_X and 1\_X have a same size,* *DCI size of DCI format 0\_X/1\_X is counted on one cell among the sets of cells.*   + *When DCI formats 0\_X and 1\_X have different sizes, DCI sizes of DCI formats 0\_X/1\_X can be counted on two cells among the sets of cells.*   + *The gNB explicitly configures the one cell or the two cells.*   + *The DCI size of the DCI format 0\_X/1\_X for different “sets of cells configured for multi-cell scheduling” can be counted on the same one cell or two cells.*   + *For the one cell or two cells, Rel-17 procedures for DCI size alignment are extended to incorporate DCI format 0\_X/1\_X.*   + *~~FFS which cell~~* *~~DCI size of the DCI format 0\_X/1\_X is counted on.~~* * *When DCI formats 0\_X and 1\_X have a same size,* *BD/CCE of DCI format 0\_X/1\_X is counted on one cell among the set of cells.*   + *When DCI formats 0\_X and 1\_X have different sizes, BD/CCE of DCI formats 0\_X/1\_X can be counted on two cells among the set of cells.*   + *The UE counts the BD/CCE of the DCI format 0\_X/1\_X on the same one cell or two cells on which the “linked” search space set(s) of the DCI format 0\_X/1\_X are configured.*   + *~~FFS which cell BD/CCE of the DCI format 0\_X/1\_X is counted on.~~* * *When DCI formats 0\_X and 1\_X have a same size, Search space set of DCI format 0\_X/1\_X is configured on one cell of the set of cells and associated with the search space set of the scheduling cell with the same search space set ID.*   + *When DCI formats 0\_X and 1\_X have different sizes, separate Search space sets of DCI formats 0\_X and of DCI format 1\_X are configured on two cells of the set of cells, respectively, and associated with the search space sets of the scheduling cell with the same search space set IDs, respectively.*   + *It is up to gNB on which one cell or two cells (other than the scheduling cell) to configure the “linked” search space set(s) of DCI format 0\_X/1\_X.*   + *The configuration of the one or two cells for the “linked” search space set(s) of DCI formats 0\_X/1\_X is separate from the configuration of the one or two cells for counting the size(s) of DCI formats 0\_X/1\_X.*   + *~~FFS which cell the SS of the DCI format 0\_X/1\_X is configured on.~~* * *~~FFS: How~~ to address Rel-17 BD/CCE limit for any given cell (operating the feature under Rel-17 BD/CCE limit):*   + *For any cell, in the sets of cells, other than the one or two cell(s) for BD/CCE counting for DCI format 0\_X/1\_X, Rel-17 limits for PDCCH monitoring and PDCCH counting rules apply.*   + *For the one or two cell(s) for BD/CCE counting for DCI format 0\_X/1\_X, a total number of configured BD/CCEs for both DCI format 0\_X/1\_X and legacy single-cell scheduling DCI formats does not exceed the Rel-17 limits.* * *Note: This does not mean a UE is required to support number of BDs/CCEs beyond the Rel-17 limits (i.e., and ) for PDCCH candidates for each scheduled cell.* * *Note 2: When a search space set for DCI format 0\_X/1\_X is not configured on an active DL BWP of the one or two cell(s) for BD/CCE counting of DCI format 0\_X/1\_X, or when the one or two cell(s) are deactivated or have a dormant active DL BWP, the UE does not monitor PDCCH for DCI format 0\_X/1\_X for the corresponding set of cells.*   *Observation 1: Multi-cell scheduling impacts either PDCCH counting rules or PDCCH monitoring limits, but there is no need to impact both.*  *Observation 2: No additional specification impact is needed for multi-cell scheduling when UE is configured cross-carrier scheduling from SCell to PCell.*  **Qualcomm:**  *Proposal 1:*   * *For a DCI format 0\_X/1\_X for a set of cells configured for multi-cell scheduling,*    + *The cell on which search space set(s) of DCI format 0\_X/1\_X is/are configured, from the set of cells, is:*     - *The scheduling cell for the set of cells, if the scheduling cell is in the set of cells*     - *Any one cell from the set of cells, if the scheduling cell is not in the set of cells*   + *The cell on which the DCI size and BD/CCE of DCI format 0\_X/1\_X are counted, from the set of cells, is the same cell on which the search space set(s) of DCI format 0\_X/1\_X is/are configured*   *Proposal 2:*   * *On the cell where BD/CCE for a DCI format 0\_X/1\_X for a set of cells is counted, the maximum number of blind decodes and maximum number of non-overlapping CCEs per slot are given by and , respectively* * *Introduce a split ratio for BD/CCE between DCI format 0\_X/1\_X and legacy DCI formats counted on the same cell. The UE reports supported max value(s) of the split ratio*    + *On the cell where the BD/CCE for the DCI format 0\_X/1\_X is counted,*      - * *max number of BDs for the DCI format 0\_X/1\_X is , and*       * *max number of non-overlapping CCEs for the DCI format 0\_X/1\_X is*       * *max number of BDs for the legacy DCI formats is , and*       * *max number of non-overlapping CCEs for the legacy DCI formats is*   + *On any other cells in the set,*      - * *the max number of BDs is*       * *the max number of non-overlapped CCEs is*   *Proposal 3:*   * *On the cell where the size of the DCI format 0\_X/1\_X for the set of cells is counted,*    + *Max number of different DCI sizes with C-RNTI is 3.*   + *Step 1: All the existing steps of DCI size alignment procedure for legacy DCI formats are performed on this cell.*   + *Step 2: If the total number of different DCI sizes with C-RNTI for legacy DCI formats is 2, the DCI formats 0\_X and 1\_X are size-matched (if necessary).*   + *Step 3: If the total number of different DCI sizes with C-RNTI for legacy DCI formats is 3,*      - * *Step 3-1: the DCI formats 0\_X and 1\_X are size-matched (if necessary)*       * *Step 3-2: the DCI format 0\_X/1\_X and legacy DCI format (e.g., 0\_1/1\_1) are size-matched (if necessary)* * *On any other cells in the set,*    + *The UE reports a value of N as the max number of different DCI sizes with C-RNTI for legacy DCI formats on the cell, where N = {1 or 2 or 3}*   + *Network shall ensure that the UE does not monitor PDCCH with more than N DCI sizes with C-RNTI for legacy DCI formats.*   *Proposal 4:*   * *Adopt FL proposal 2-6rev1 with a further clarification, i,e:*   + *For monitoring PDCCH candidates for DCI format 0\_X/1\_X for a set of cells for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells.*      - * *The n\_CI value for a set of cells is the common value for monitoring PDCCH candidates for DCI format 0\_X and DCI format 1\_X for the same set of cells.*   + *The UE can be configured one or multiple sets of cells which are configured for multi-cell scheduling.*      - * *When multiple sets of cells are configured for multi-cell scheduling, separate n\_CI values are configured for different sets of cells, and the UE monitors DCI format 0\_X/1\_X for the corresponding set of cells using the corresponding n\_CI value.*       * *When multiple sets of cells are configured for multi-cell scheduling, a cell in one set of cells can’t be included in another set of cells.*   *Observation:*   * *No specification change is necessary regarding search space sharing.* * *Any potential impact on UE capability should be discussed in UE feature session.*   **Ericsson:**  *Proposal 2: For each set,* *size of mc-DCI (0\_X/1\_X) is explicitly configured by higher layers.*  *Proposal 3: Support independent configuration of mc-DCI for PUSCH and PDSCH, including different sets of cells for PUSCH and PDSCH.*  *Proposal 4: DCI size of DCI format 0\_X/1\_X is counted on the cell amongst the set of cells which has the lowest cell index, and which is not a scheduling cell for the DCI 0\_X/1\_X.*  *Proposal 5: When a scheduling cell is configured to carry DCI format 1\_X/0\_X for more than one set of configured co-schedulable cells, a set index field is included in the DCI format 1\_X/0\_X for the scheduling cell.*  *Observation 1: For a scheduled cell, it should be possible to configure a same number of BD/CCEs for monitoring scheduling DCI formats (including 0\_X/1\_X and legacy DCI formats) as the case of legacy cross-carrier scheduling.*  *Observation 2: Duplicate counting of a BD/CCE attempt for a mc-DCI format should be avoided when counting BD/CCE across co-scheduled cells for comparison against the aggregate limits and .*  *Proposal 6: BD/CCE counting for mc-DCI is based on the legacy Rel-15/16/17 BD/CCE counting mechanism with the following update*   * *a BD/CCE attempt for a mc-DCI format is counted only once for comparison against aggregate and limits in numerology buckets.*   *Proposal 7: For a set of cells which is configured for multi-cell scheduling, if the primary cell belongs to the set and is a scheduling cell for the set, USS sets corresponding to DCI 0\_X/1\_X for the set can be dropped in search space overbooking procedure.*  *Proposal 8: Search space of DCI format 0\_X/1\_X is configured on the cell amongst the set of cells which has the lowest cell index.*   * *Note: When cell with lowest cell index within a set is same as the scheduling cell, the corresponding search space on scheduling cell for DCI format 0\_X/1\_X has the full search space configuration.*   *Proposal 9: For monitoring DCI 0\_X/1\_X PDCCH candidates for a set of cells, the n\_CI to be used in the search space equation is explicitly configured for the set of cells.*  **Langbo:**  *Proposal 2: Confirm the working assumption made on DCI size, BD/CCE counting and search space configuration.*  *Proposal 3: DCI format 0\_X/1\_X is configured in a search space on the scheduling cell while the number of candidates for DCI format 0\_X/1\_X monitoring is configured in a search space on a cell in the set of co-scheduled cells. The cell on which the search space is configured for determination of the number of candidates per AL is up to the network. No more than one search space across the set of cells with the same search space ID as the search space on the scheduling cell is expected.*  *Proposal 4: For a set of cells that can be potentially co-scheduled by a DCI format 0\_X/1\_X, the n\_CI in the search space equation for each cell combination in the set of cells is determined by a same value configured for the set of cells.*  *Proposal 5: The n\_CI value configured for a cell on which the BD/CCE of DCI format 0\_X/1\_X is counted is used as the n\_CI value for the set of cells.*  *Proposal 6: Multiple sets of potentially co-scheduled cells configured with a same scheduling cell is not supported.*  *Proposal 7: A set of co-scheduled cells are counted together as a single cell for and calculation when the scheduling cell of the set of co-scheduled cells is configured with only DCI format 0\_X/1\_X.*  **MediaTek:**  *Proposal 1: To address the “FFS: How to address Rel-17 BD/CCE limit for any given cell” in the agreed working assumption of RAN1 #110-bis-e:*   * *A UE applies Rel-17 PDCCH monitoring limits (i.e., same and as in Rel-17) in a slot and DCI size limit (i.e., “3+1” per scheduled cell)* *regardless of monitoring legacy DCI formats or* *DCI formats 0\_X/1\_X or both in the slot.* * *Legacy DCI size budget is maintained per scheduled cell* *regardless of UE is configured with DCI formats 0\_X/1\_X or not.* * *BD/CCE is counted on the scheduled cell as in legacy regardless of UE is configured with DCI formats 0\_X/1\_X or not.*   *Proposal 2:* *For a multi-cell scheduling DCI, use a pre-defined rule to determine which cell should* *the corresponding DCI size and BD/CCE counted on. For example:*   * *The corresponding DCI size and BD/CCE is counted on the co-scheduled cell with the lowest ServCellIndex* * *The corresponding DCI size and BD/CCE is counted on the co-scheduled cell with the highest ServCellIndex*   *Proposal 3: Or, for a* *multi-cell scheduling DCI, use a RRC configured or pre-defined table to define which cell should* *the corresponding DCI size and BD/CCE counted on. For example:*   |  |  | | --- | --- | | *Scheduled cells combination for one multi-cell scheduling DCI* | *Which cell to count the corresponding DCI size and BD/CCE* | | *Cell 1, Cell 2, Cell 3, Cell 4* | *Cell 1* | | *Cell 2, Cell 3* | *Cell 2* | | *Cell 2, Cell 3, Cell 4* | *Cell 3* | | *Cell 1, Cell 3* | *Cell 3* |   *Proposal 4: For a multi-cell scheduling DCI, its search space is configured under the cell which the corresponding DCI size and BD/CCE is counted on.*  *Proposal 5: RAN1 to agree on* *Proposal 2-8rev2 on payload size of 0\_X/1\_X in the moderator summary during RAN1 #110-bis-e [2].*  *Proposal 6: For scheduled cells indication in the multi-carrier scheduling DCI, introduce a bitmap as below:*   * *Bitmap size = number of configured scheduled cells for this scheduling cell (Ex. 4 🡪 bc1bc2bc3bc4)* * *Each bit corresponds to one of the configured scheduled cells, with MSB to LSB of the bitmap corresponding to the first to last configured scheduled cells in ascending order of ServCellIndex* * *Number of 1’s in the bitmap <= maximum number of cells that can be scheduled simultaneously (Ex. 3)*   *Proposal 7: RAN1 to agree on Proposal 6 or agree on Proposal 3-5rev7 with the FFS being kept in the moderator summary during RAN1 #110-bis-e [2].*  *Proposal 8: Use the CCE index formula in 38.213 10.1 to stagger the DCI with different set of scheduled cells, where nCI is replaced by the set index where one set contains a group of cells. One example is shown below:*   |  |  |  | | --- | --- | --- | | *Scheduled cells combination for one multi-cell scheduling DCI* | *Which cell to count the corresponding DCI size and BD/CCE* | *nCI (set index)* | | *Cell 1, Cell 2, Cell 3, Cell 4* | *Cell 1* | *0* | | *Cell 2, Cell 3* | *Cell 2* | *1* | | *Cell 2, Cell 3, Cell 4* | *Cell 3* | *2* | | *Cell 1, Cell 3* | *Cell 3* | *3* |   *Proposal 9: RAN1 to agree on Proposal 8 or agree on Proposal 2-6rev1* *in the moderator summary during RAN1 #110-bis-e [2].*  **LGE:**  *Proposal #4: Support the following Proposal 2-8rev2 in FL summary at RAN1#110bis-e.*   * *For a set of cells which can be scheduled by DCI format 0\_X/1\_X, the payload size of DCI format 0\_X/1\_X is derived by UE based on RRC configuration of co-scheduled cell combinations within the set of cells.*   + *The payload size 0\_X is the same for all the co-scheduled cell combinations.*   + *The payload size 1\_X is the same for all the co-scheduled cell combinations.*   *Proposal #9: It is up to gNB’s configuration on which cell SS (i.e., PDCCH candidates) of the DCI format 0\_X/1\_X is configured.*  *Proposal #10: Clarify whether the one cell configured with SS of the DCI format 0\_X/1\_X is configured separately per SS ID or commonly for all the SS IDs.*   * *It is reasonable to configure the SS of DCI 0\_X/1\_X separately per SS ID in order to avoid unnecessary BD limitation on the DCI 0\_X/1\_X in a slot configured with multiple SS IDs.*   *Proposal #11: Clarify how to specifically perform SS configuration and SS ID linking for the DCI format 0\_X/1\_X, based on the following two approaches according to whether or not to follow the existing SS linking structure applied for cross-CC scheduling.*   * *Alt 1 : Number of PDCCH candidates is determined by the SS configuration on a scheduled cell while DCI format (e.g. DCI 0\_X/1\_X or legacy DCI) is determined by the SS configuration on scheduling cell (same as the existing SS linking for CCS).* * *Alt 2: DCI format 0\_X/1\_X as well as the number of corresponding PDCCH candidates are determined by the SS configuration on a scheduled cell (differently from the existing SS linking for CCS) while legacy DCI format and the number of corresponding PDCCH candidates are determined based on the existing SS linking for CCS.*   *Proposal #12: For the PDCCH candidates of DCI format 0\_X/1\_X configured on a cell (for a SS ID), the corresponding BD/CCE is counted on the same cell (for the same SS ID).*  *Proposal #13: Support BD/CCE counting for the DCI format 0\_X/1\_X on all the cells configured for multi-cell scheduling (on top of BD/CCE counting for the DCI 0\_X/1\_X on one among the cells based on the working assumption) as UE capability, with consideration of UE implementation burden/complexity required for SS sharing-like PDCCH processing.*  *Proposal #14: The DCI size of DCI format 0\_X/1\_X is counted on one cell among the cells on which SS of the DCI 0\_X/1\_X is configured (and the corresponding BD/CCE is counted).*   * *The one cell on which the DCI size of DCI 0\_X/1\_X is counted can be determined based on RRC configuration or predefined rule.*   *Proposal #15: Consider how to specifically perform DCI size alignment for the cell on which the DCI size of DCI format 0\_X/1\_X is counted, including the following aspects.*   * *The ordering of alignment between DCI format 0\_X/1\_X and legacy DCI format* * *Handling of up to 4 different DCI formats including the DCI 0\_X/1\_X.*   *Proposal #16: Support the following Proposal 2-6rev1 in FL summary at RAN1#110bis-e, with addition of the last sub-bullet with FFS (in red) as below.*   * *For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells.* * *The UE can be configured one or multiple sets of cells which are configured for multi-cell scheduling.*   + *When multiple sets of cells are configured for multi-cell scheduling, separate n\_CI values are configured for different sets of cells.*   + *When multiple sets of cells are configured for multi-cell scheduling, a cell in one set of cells can’t be included in another set of cells.*   + *FFS whether/how to allow multiple sets of cells configured for multi-cell scheduling for a same scheduling cell*   **ITRI:**  *Proposal 1: For a set of cells which is configured for multi-cell scheduling,*   * *DCI size of the DCI format 0\_X/1\_X is counted on a cell when the DCI format 0\_X/1\_X is monitored according to a search space of the cell.* * *BD/CCE of DCI format 0\_X/1\_X is counted on a cell when the DCI format 0\_X/1\_X is monitored according to a search space of the cell.* * *SS of the DCI format 0\_X/1\_X can be configured on any of the set of cells.*   *Proposal 2: For a set of cells which can be scheduled by DCI format 0\_X/1\_X, the payload size of DCI format 0\_X/1\_X is derived by UE based on RRC configuration of co-scheduled cell combinations within the set of cells.*   * *The payload size of DCI format 0\_X is the same for all the co-scheduled cell combinations.* * *The payload size of DCI format 1\_X is the same for all the co-scheduled cell combinations.* * *FFS: if total length of DCI field in the DCI format 0\_X/1\_X is larger than the payload size of DCI format 0\_X/1\_X.*   **NEC:**  *Proposal 2: For the cell among the set of cells counting DCI size of DCI format 0\_X/1\_X, align size of format 0\_X/1\_X after alignment of DCI format 0\_1/1\_1 on that cell.*  **ZTE:**  *Proposal 8: The DCI size should be determined based on the RRC configuration of the fields in the DCI and equal to the largest payload size among all the combinations of co-scheduled cells configured by the network.*  *Proposal 9: The cell on which DCI size and BD/CCE of the DCI format 0\_X/1\_X is counted can be configured on one cell of set of cells if the scheduling cell is one cell of the set of scheduled cells.*  *Proposal 10: Based on the working assumption, the USS of MC-DCI configured on the scheduling cell is dropped by UE if the scheduling cell is not included in the set of scheduled cells.*  *Proposal 11: The cell on which DCI size and BD/CCE of the DCI format 0\_X/1\_X is counted is the cell configured with USS of the DCI format 0\_X/1\_X if the scheduling cell is not included in the set of scheduled cells.*  *Proposal 12: For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by the legacy CIF value of the cell configured with the USS of DCI format 0\_X/1\_X.*  *Proposal 13: DCI size budget maintenance for a scheduling cell which is also a scheduled cell can be achieved by following.*   * *The whole DCI size budget (i.e., 4 DCI sizes) can be used for DCI formats with CRC scrambled by C-RNTI*   *Proposal 14: Whether the cell in the set of scheduled cells for multi-cell scheduling without any USS configured is counted as one cell for M\_total\_μ/C\_total\_μ calculation should be determined.* |

### Moderator summary and proposals based on contributions

* On DCI size and BD/CCE counting as well as SS configuration of DCI format 0\_X/1\_X

Regarding DCI size budget and BD/CCE counting as well as SS configuration for multi-cell scheduling DCI, these issues have been extensively discussed in RAN1#110bis-e meeting and merged with one proposal for multiple rounds of formulation. Finally, a working assumption as below is made in RAN1#110bis-e meeting.

|  |
| --- |
| **Working Assumption**  For a set of cells which is configured for multi-cell scheduling,   * Existing DCI size budget is maintained on each cell of the set of cells. * DCI size of DCI format 0\_X/1\_X is counted on one cell among the set of cells.   + FFS which cell DCI size of the DCI format 0\_X/1\_X is counted on. * BD/CCE of DCI format 0\_X/1\_X is counted on one cell among the set of cells.   + FFS which cell BD/CCE of the DCI format 0\_X/1\_X is counted on. * Search space of DCI format 0\_X/1\_X is configured on one cell of the set of cells and associated with the search space of the scheduling cell with the same search space ID.   + FFS which cell the SS of the DCI format 0\_X/1\_X is configured on. * FFS: How to address Rel-17 BD/CCE limit for any given cell (operating the feature under Rel-17 BD/CCE limit) * Note: This does not mean a UE is required to support number of BDs/CCEs beyond the Rel-17 limits (i.e., and ) for PDCCH candidates for each scheduled cell. |

For RAN1#111 meeting, 6 companies [Huawei, Nokia, CATT, OPPO, Apple, Langbo] suggest confirming the working assumption.

Regarding the cell on which the DCI size of the DCI format 0\_X/1\_X is counted and the cell on which the BD/CCE of the DCI format 0\_X/1\_X is counted, 14 companies [Huawei, Nokia, vivo, CATT, Spreadtrum, xiaomi, Intel, OPPO, Lenovo, Apple, NTT DOCOMO, Qualcomm, MediaTek, LG] propose both DCI size of DCI format 0\_X/1\_X and BD/CCE of DCI format 0\_X/1\_X are counted on same cell.

Regarding how to determine the cell on which DCI size/BD/CCE of the DCI format 0\_X/1\_X is counted, companies’ preferences are summarized as below:

* The cell has minimum number of legacy DCI formats or has minimum number of legacy DCI sizes
* *Supported by Huawei,*
* The cell on which DCI size and BD/CCE of the DCI format 0\_X/1\_X is counted is the cell where the SS of the DCI format 0\_X/1\_X is configured
* *Supported by Nokia, vivo, CATT, Spreadtrum, xiaomi, OPPO, Lenovo, NTT DOCOMO, Qualcomm (if scheduling cell is not in the set of cells), LG, ITRI, ZTE (if the scheduling cell is not included in the set of scheduled cells)*
* The cell is explicitly configured.
* *Supported by CMCC, Apple, FGI, Samsung*
* The cell has the lowest/highest cell index among co-scheduled cells or configured per co-scheduled cell combination
* *Supported by MediaTek,*
* The cell has the lowest cell index, and is not a scheduling cell for the DCI 0\_X/1\_X
* *Supported by Ericsson,*

From moderator’s point of view, for the cell where the BD/CCE budget is counted, it can be decided by gNB to select a cell which has minimum BD/CCE budget of legacy DCI formats or even no legacy DCI formats. Anyway, it is up to gNB to select the cell, which is similar to select the cell where the DCI size of DCI format 0\_X/1\_X is counted. It makes more sense to select same cell from the set of cells for counting the DCI size and BD/CCE budget of the DCI format 0\_X/1\_X. Furthermore, regarding SS configuration, it is fully up to gNB to select one cell for configuring the SS of DCI format 0\_X/1\_X. As mentioned above, both DCI size and BD/CCE of DCI format 0\_X/1\_X can be counted on a same cell. One way to indicate the cell to UE is to configure the SS of DCI format 0\_X/1\_X only on a single cell of the set of cells, which implicitly indicates the UE that the cell is used for counting the DCI size and BD/CCE budget of DCI format 0\_X/1\_X. No additional signaling is required to indicate which cell is used to count BD/CCE and DCI size.

Hence, moderator suggests Proposal 2-1 for confirming the working assumption with update on the cell determined for DCI size and BD/CCE budget counting as the cell with SS configured.

* On payload size determination of DCI format 0\_X/1\_X

For a set of cells configured for multi-cell scheduling using a DCI format 0\_X/1\_X, the payload size of DCI format 0\_X should be same for all the co-scheduled cell combinations within the set of cells and the payload size of DCI format 1\_X should be same for all the co-scheduled cell combinations within the set of cells.

Regarding payload size determination of DCI format 0\_X/1\_X, below proposal has been discussed in previous RAN1 meeting and captured in final FL summary.

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| --- |
| Proposal 2-8rev2:  * For a set of cells which can be scheduled by DCI format 0\_X/1\_X, the payload size of DCI format 0\_X/1\_X is derived by UE based on RRC configuration of co-scheduled cell combinations within the set of cells.   + The payload size 0\_X is the same for all the co-scheduled cell combinations.   + The payload size 1\_X is the same for all the co-scheduled cell combinations. |

For RAN1#111 meeting, companies’ preferences on payload size determination of DCI format 0\_X/1\_X are summarized as below:

* DCI size of DCI format 0\_X/1\_X is configured by RRC.
* *Supported by Nokia, CATT, Ericsson,*
* DCI size of DCI format 0\_X/1\_X is derived by UE.
* *Supported by xiaomi, China Telecom, CMCC, MediaTek, NTT DOCOMO, LGE, ITRI, ZTE*

From the moderator’s point of view, Proposal 2-8rev2 in previous RAN1 meeting reflects majority companies’ views and it makes more sense to determine the payload size of DCI format 0\_X/1\_X based on RRC configured fields and equal to the largest payload size among the co-scheduled cell combinations included in a set of cells scheduled by DCI format 0\_X/1\_X. Hence, similar proposal is provided in Proposal 2-2 for triggering the discussion.

* On multiple sets of cells configured for multi-cell scheduling

For multi-cell scheduling, if a UE can be configured with at most one set of cells for multi-cell scheduling, the maximum number of cells within the set of cells should be increased, e.g., up to 8. Otherwise, legacy DCI formats have to be used by gNB for the remaining cells within the same PUCCH group via one-to-one scheduling way. In that sense, the remaining cells can’t enjoy the benefit of co-scheduling and PDCCH capacity may be a problem for the scheduling cell especially for PCell. If maximum number of cells per set is 4, then multiple sets of cells need to be configured for respective multi-cell scheduling for more flexibility in Rel-18 CA framework.

During RAN1#110bis-e meeting, this issue has been fully discussed with n\_CI determination and below proposal is captured in final FL summary.

|  |
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| Proposal 2-6rev1:  * For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells. * The UE can be configured one or multiple sets of cells which are configured for multi-cell scheduling. * When multiple sets of cells are configured for multi-cell scheduling, separate n\_CI values are configured for different sets of cells. * When multiple sets of cells are configured for multi-cell scheduling, a cell in one set of cells can’t be included in another set of cells. |

For RAN1#111 meeting, 9 companies [Huawei, Nokia, xiaomi, Intel, Lenovo, CMCC, Apple, FGI, NTT DOCOMO] support multiple sets of cells can be configured for UE for multi-cell scheduling, while one company [vivo] prefer only one set of cells that is configured for multi-cell scheduling is supported, and if multiple sets of cells which is configured for multi-cell scheduling are supported, the cells in different sets should be orthogonal, and the special cell counting toward the BD/CCE/DCI size of mc-DCI for each set should be different. Moderator thinks it is reasonable that one cell in one set of cells can’t be included in another set of cells and separate cells for counting BD/CCE/DCI size of DCI format 0\_X/1\_X for different sets of cells. One company [Langbo] propose multiple sets of potentially co-scheduled cells configured with a same scheduling cell is not supported.

From moderator’s point of view, if maximum number of cells per set is 4, then multiple sets of cells need to be configured for respective multi-cell scheduling for more flexibility in Rel-18 CA framework. Separate configuration for each set of cells should be reasonable way to go.

Hence, a similar proposal as previous RAN1 meeting on multiple sets of cells and n\_CI value determination is provided for further discussion with some necessary additions.

* On n\_CI value determination for monitoring DCI format 0\_X/1\_X

An open issue is about determining the CCEs for monitoring the multi-cell scheduling DCI. In legacy cross-carrier scheduling, for a scheduled cell, the CCEs for each configured aggregation level of PDCCH candidates are determined based on below equation, where is the CIF value configured by *CrossCarrierSchedulingConfig*.



For Rel-18 multi-cell scheduling, one issue is how to determine the value of n\_CIfor co-scheduled cells. Several options are provided, e.g., the n\_CI is determined by a value configured for the co-scheduled cells, the n\_CI is determined for each combination of co-scheduled cells.

During RAN1#110bis-e meeting, this issue has been fully discussed with n\_CI determination and below proposal is captured in final FL summary.

|  |
| --- |
| Proposal 2-6rev1:  * For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells. * The UE can be configured one or multiple sets of cells which are configured for multi-cell scheduling. * When multiple sets of cells are configured for multi-cell scheduling, separate n\_CI values are configured for different sets of cells. * When multiple sets of cells are configured for multi-cell scheduling, a cell in one set of cells can’t be included in another set of cells. |

For RAN1#111 meeting, companies’ views on monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling are summarized as below:

* *The n\_CI in the search space equation is determined by a value configured for the set of cells* 
  + *Supported by 19 companies [Huawei, Nokia, vivo, Fujitsu, CATT, Spreadtrum, xiaomi, Intel, OPPO, Lenovo, CMCC, Apple, FGI, NTT DOCOMO, Qualcomm, Ericsson, Langbo, MediaTek, LG]*

Hence, moderator provides Proposal 2-3 for triggering the discussion.

### 1st round of discussions

#### Proposal 2-1:

* Confirm the RAN1#110bis-e working assumption with the following changes:

**Working Assumption**

For a set of cells which is configured for multi-cell scheduling,

* Existing DCI size budget is maintained on each cell of the set of cells.
* DCI size of DCI format 0\_X/1\_X is counted on one cell among the set of cells.
  + DCI size of the DCI format 0\_X/1\_X is counted on the cell the search space of the DCI format 0\_X/1\_X is configured on.
* BD/CCE of DCI format 0\_X/1\_X is counted on one cell among the set of cells.
  + BD/CCE of the DCI format 0\_X/1\_X is counted on the cell the search space of the DCI format 0\_X/1\_X is configured on.
* Search space of DCI format 0\_X/1\_X is configured on one cell of the set of cells and associated with the search space of the scheduling cell with the same search space ID.
  + It is up to gNB on which cell the SS of the DCI format 0\_X/1\_X is configured on.
* FFS: How to address Rel-17 BD/CCE limit for any given cell (operating the feature under Rel-17 BD/CCE limit)
* Note: This does not mean a UE is required to support number of BDs/CCEs beyond the Rel-17 limits (i.e., and ) for PDCCH candidates for each scheduled cell.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Spreadtrum | The proposal seems to say the BD/CCE/DCI size should be counted on one scheduled cell. However, there is always the SS configured on the scheduling cell, so SS are on both of scheduling and scheduled cell. There is misunderstanding for the cell the search space of the DCI format 0\_X/1\_X is configured on especially the scheduling cell is also in the set of cell. Thus, It needs to separate the scheduling cell and scheduled cell clearly. The change can be:  For a set of cells which is configured for multi-cell scheduling,   * Existing DCI size budget is maintained on each cell of the set of cells. * The cell on which the search space of DCI format 0\_X/1\_X is configured is   + the scheduling cell, when the search space is only on the scheduling cell and the scheduling cell is in the set of cells, or   + the scheduled cell, when the search space is on one scheduled cell and the scheduling cell, and associated with the search space of the scheduling cell with the same search space ID.   + It is up to gNB on which cell the SS of the DCI format 0\_X/1\_X is configured on. * DCI size of DCI format 0\_X/1\_X is counted on one cell among the set of cells.   + DCI size of the DCI format 0\_X/1\_X is counted on the cell the search space of the DCI format 0\_X/1\_X is configured on * BD/CCE of DCI format 0\_X/1\_X is counted on one cell among the set of cells.   + BD/CCE of the DCI format 0\_X/1\_X is counted on the cell the search space of the DCI format 0\_X/1\_X is configured on. * FFS: How to address Rel-17 BD/CCE limit for any given cell (operating the feature under Rel-17 BD/CCE limit) * Note: This does not mean a UE is required to support number of BDs/CCEs beyond the Rel-17 limits (i.e., and ) for PDCCH candidates for each scheduled cell. |
| Qualcomm | Similar comment as Spreadtrum – “Search space of DCI format 0\_X/1\_X is configured on one cell of the set of cells and associated with the search space of the scheduling cell with the same search space ID” is not clear.  Our understanding/interpretation of the working assumption is that, if the scheduling cell is one of the set of cells, the SS set for DCI format 0\_X/1\_X is configured on the scheduling cell; otherwise, it is any one of the set of cells. In other words, if the scheduling cell is one of the set of cells, it is NOT up to gNB. Therefore, the sub-bullet should be deleted.   * Search space of DCI format 0\_X/1\_X is configured on one cell of the set of cells and associated with the search space of the scheduling cell with the same search space ID.   + ~~It is up to gNB on which cell the SS of the DCI format 0\_X/1\_X is configured on.~~ |
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#### Proposal 2-2:

* For a set of cells which is configured for multi-cell scheduling, the payload size of DCI format 0\_X/1\_X is derived by UE based on RRC configuration of co-scheduled cell combinations within the set of cells.
* The payload size of DCI format 0\_X is the same for all the co-scheduled cell combinations of the set of cells.
* The payload size of DCI format 1\_X is the same for all the co-scheduled cell combinations of the set of cells.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| Spreadtrum | One more FFS can be added.   * FFS the payload size determination, e.g. the maximum bits number among all the co-scheduled cell combinations, or each field is aligned for all the co-scheduled cell combinations |
| Qualcomm | Since this is the last meeting, we must complete the discussion without any FFS. However, as Spreadtrum pointed out, the Proposal 2-2 is incomplete. We also prefer to conclude the field size determination.  The proposal 2-2 is unclear. The main bullet looks to say “The payload size can change depending on actually co-scheduled cells within the set of cells” while the sub-bullets look to say “The payload size is fixed based on RRC configuration”.  Firstly, we believe the payload size of the DCI 0\_X/1\_X for a set of cells has to be fixed by RRC configuration and does not change regardless of which cells in the set are actually scheduled. We assume this is the common understanding.  Secondly, we also consider that the bitwidths of any fields of the DCI 0\_X/1\_X (and also interpretation of any fields) for a set of cells has to be fixed by RRC configuration and does not change regardless of which cells in the set area actually scheduled. We understand there are some proposals on “dynamic interpretation of DCI fields depending on actually co-scheduled cells”. However, such solution has never been discussed/investigated until today, and we do not see the complete solution for such design. We believe it is impossible to complete it. Having said that, we propose to update the proposal as follows. Proposal 2-2:  * For a set of cells which is configured for multi-cell scheduling, the payload size and the bitwidths of all the fields of DCI format 0\_X/1\_X is derived by UE based on RRC configuration of ~~co-scheduled cell combinations within~~ the set of cells. * The payload size and the bitwidths of all the fields of DCI format 0\_X is the same for any ~~all the~~ co-scheduled cell combinations of the set of cells. * The payload size and the bitwidths of all the fields of DCI format 1\_X is the same for any ~~all the~~ co-scheduled cell combinations of the set of cells.   Note that if we agree to support multiple sets of cells for multi-cell scheduling by different DCI format 0\_X/1\_X associated with different n\_CI values (Proposal 2-3), the payload size and bitwidths of the fields of different DCI formats 0\_X (or different DCI formats 1\_X) for different sets of cells can be of course different. This has no specification impact. |
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#### Proposal 2-3:

* For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells.
* A UE can be configured one or multiple sets of cells for multi-cell scheduling.
* When multiple sets of cells are configured for multi-cell scheduling,
  + a cell in one set of cells can’t be included in another set of cells.
  + separate n\_CI values are configured for different sets of cells.
  + separate tables for co-scheduled cell combination indication are configured for different sets of cells.
  + separate search space configuration of DCI format 0\_X/1\_X are configured for different sets of cells.
  + separate cells for DCI size and BD/CCE counting of DCI format 0\_X/1\_X are determined for different sets of cells.
  + separate DCI size of DCI format 0\_X is determined for different sets of cells.
  + separate DCI size of DCI format 1\_X is determined for different sets of cells.

Companies are encouraged to provide comments in the table below.

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| --- | --- |
| **Company** | **Comment** |
| Spreadtrum | For the first bullet, the n\_CI valude is always configured. Such as if there is only one set of cell on the scheduling cell, the n\_CI can use a default value, e.g 0. It is useless to configure.  For the second bullet, we ask for one clarification. These multiple sets of cells are on one scheduling cell or different scheduling cells. If they are on separate scheduling cells, the separate n\_CI is also useless. We never have a chance to discuss whether it is supportive to have more than one scheduling cells for multi-cell schedule within one PUCCH group. |
| Qualcomm | In general OK for us, but we prefer to decouple the discussion on “table for co-scheduled cell combination indication”. Regarding “separate search space configuration”, it is not clear whether this intends to say different search space IDs have to be assigned, or just RRC configuration for search space set is provided separately for separate sets. We prefer to delete it. Proposal 2-3:  * For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells. * A UE can be configured one or multiple sets of cells for multi-cell scheduling. * When multiple sets of cells are configured for multi-cell scheduling,   + a cell in one set of cells can’t be included in another set of cells.   + separate n\_CI values are configured for different sets of cells.   + ~~separate tables for co-scheduled cell combination indication are configured for different sets of cells.~~   + ~~separate search space configuration of DCI format 0\_X/1\_X are configured for different sets of cells.~~   + separate cells for DCI size and BD/CCE counting of DCI format 0\_X/1\_X are determined for different sets of cells.   + separate DCI size of DCI format 0\_X is determined for different sets of cells.   + separate DCI size of DCI format 1\_X is determined for different sets of cells. |
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# DCI field design

Based on contributions submitted by companies, below issues are prioritized for discussion in this meeting. Within each sub-section, the summary from moderator’s perspective is listed and followed by draft proposals for further discussion round by round.

## DCI field types

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| **Huawei, HiSilicon**  *Proposal 2: Fields in multi-cell scheduling DCI 1\_X are advised to classify as follows:*   * *Type-1A: Enhanced Type 3 codebook indicator, SCell dormancy indication, PUCCH Cell indicator.* * *Type-1C: PDCCH monitoring adaptation indication.* * *Type-2: Modulation and coding scheme, HARQ process number.* * *Type-3: Remaining fields that have not been explicitly precluded*   *Proposal 3: Fields in multi-cell scheduling DCI 0\_X are advised to classify as follows:*   * *Type-1A: Invalid symbol pattern indicator, SCell dormancy indication, PUCCH Cell indicator.* * *Type-1C: PDCCH monitoring adaptation indication.* * *Type-2: Modulation and coding scheme, HARQ process number.* * *Type-3: Remaining fields that have not been explicitly precluded.*   *Proposal 4: TDRA table should be configured for one set of cells configured for multi-cell scheduling instead of the actually co-scheduled cells.*  **NOKIA:**  *Proposal 4.1: RAN1 to discuss if the RRC parameters for DCI format 0\_1/1\_1 scheduling or the Rel-16 RRC parameters for DCI format 0\_2/1\_2 are reused for DCI formats 0\_X/1\_X operation, or if alternatively new separate configurations for DCI formats 0\_X/1\_X are introduced.*  *Proposal 4.2: The TDRA table for DCI format 0\_X (or 1\_X) is defined as follows:*   * *The gNB configures a table with up to 64 entries / 6 bits* * *The table contains entries for all the cells of the set of cells and the table is independent of the indicated co-scheduled cell combination* * *The table row entry for a specific cell of set of cells is a pointer to the row number of the UL / DL BWP specific TDRA configured tables of pusch-TimeDomainAllocationList / pdsch-TimeDomainAllocationList*   *Proposal 4.3: The baseline multi-cell DCI configuration is to be done as part of the PhysicalCellGroupConfig configuration.*  *Proposal 4.4: Adopt the following DCI field types for DCI format 1\_X assuming also monitoring for single cell DCI is supported:*   |  |  |  | | --- | --- | --- | | DCI FIELDS OF FORMAT 1\_X | FIELD TYPE | COMMENTS | | Identifier for DCI formats | Type 1A | Agreed at RAN1#110 | | Indicator of co-scheduled cells | Type 1B | Agreed in RAN1#110bis-e as Type 1.  The assumption is this field would Points to Code point in a RRC configured table (see proposal 4.1) | | Bandwidth part indicator | Type 1A | This field could also be omitted if it is assumed that the multi cell scheduling is always scheduling the active BWP of the co-scheduled cells. | | Frequency domain resource assignment | Type 3 | Type 1 resource allocation with larger granularity (as supported for DCI format 1\_2) can be considered.  Separate RRC configuration for DCI format 1\_X (as done for DCI format 1\_2). | | Time domain resource assignment | Type 1B | Agreed at RAN1#110bis-e to have a single field | | VRB-to-PRB mapping | Type 3 |  | | PRB bundling size indicator | Type 3 |  | | Rate matching indicator | Type 3 |  | | ZP CSI-RS trigger | Type 2 | Separate field since a UE is not expected to receive more than one DCI with non-zero CSI request field per slot per cell. A UE is not expected to receive DCI with non-zero CSI request field within a cell group in a slot overlapping with any slot receiving DCI with non-zero CSI request field in the same cell  group. | | TB1: Modulation and coding scheme | Type 3 | Common could be useful e.g. for intra-band operation, whereas for inter-band operation clearly separate DCI field would be needed.  We don’t see a need to introduce additional enhancements such as delta MCS or similar. | | TB1: New data indicator | Type 2 | Agreed at RAN1#110 | | TB1: Redundancy version | Type 2 | Agreed at RAN1#110 | | TB2: Modulation and coding scheme | Type 3 |  | | TB2: New data indicator | Type 2 | Agreed at RAN1#110 | | TB2: Redundancy version | Type 2 | Agreed at RAN1#110 | | HARQ process number | Type 2 |  | | Downlink assignment index | Type 1A | Agreed at RAN1#110 | | TPC command for scheduled PUCCH | Type 1A | Agreed at RAN1#110 | | PUCCH resource indicator | Type 1A | Agreed at RAN1#110 | | PDSCH-to-HARQ timing indicator | Type 1A | Agreed at RAN1#110 | | One shot HARQ ACK request | Type 1A | Agreed at RAN1#110  Separately RRC configured from DCI formats 0\_1 / 0\_2 | | Enhanced Type 3 codebook indicator | Type 1A | Only a single k1 value can be indicated à only a single enh. Type 3 HARQ-ACK CB can be triggered  Separately RRC configured from DCI formats 0\_1 / 0\_2 | | HARQ-ACK retransmission indicator | Type 1A | Only a single k1 value can be indicated à only a HARQ-ACK CB can be triggered for re-transmission  Separately RRC configured from DCI formats 0\_1 / 0\_2 | | Antenna port(s) | Type 3 |  | | Transmission configuration indication | Type 3 |  | | SRS request | Type 3 |  | | DMRS sequence initialization | Type 2 |  | | Priority indicator | Type 1A | Agreed in RAN1#110bis-e as Type 1.  Should be 1A, applicable for all scheduled cells | | PDCCH monitoring adaptation indication | Type 1C | Refers to the scheduling cell only | | PUCCH Cell indicator | Type 1A | Same as k1, PRI, TPC for PUCCH, … |   *Proposal 4.5: Adopt the following DCI field types for DCI format 0\_X assuming also monitoring for single cell DCI is supported:*   |  |  |  | | --- | --- | --- | | DCI FIELDS OF FORMAT 0\_X | FIELD TYPE | COMMENTS | | Identifier for DCI formats | Type 1A | Agreed at RAN1#110 | | Indicator of co-scheduled cells | Type 1B | Agreed in RAN1#110bis-e as Type 1.  The assumption is this field would Points to Code point in a RRC configured table (see proposal 4.1) | | Frequency domain resource assignment | Type 3 | Type 1 resource allocation with larger granularity (as supported for DCI format 0\_2) can be considered.  Separate RRC configuration for DCI format 0\_X (as done for DCI format 0\_2). | | Time domain resource assignment | Type 1B | Agreed at RAN1#110bis-e to have a single field | | Frequency hopping flag | Type 3 |  | | Modulation and coding scheme | Type 3 | Common could be useful e.g. for intra-band operation, whereas for inter-band operation clearly separate DCI field would be needed.  We don’t see a need to introduce additional enhancements such as delta MCS or similar. | | New data indicator | Type 2 | Agreed at RAN1#110 | | Redundancy version | Type 2 | Agreed at RAN1#110 | | HARQ process number | Type 2 |  | | Downlink assignment index | Type 1A | Agreed at RAN1#110  Note: Assumption here would be, that only a single HARQ-ACK codebook (and single PHY priority) is to be multiplexed on the set of scheduled PUSCHs. | | TPC command for scheduled PUSCH | Type 1C | Interpretation is that this TPC command is applicable to the UL of the scheduling cell only. If the scheduling cell cannot be scheduled by the multi-cell DCI, the TPC field is not present. | | SRS resource indicator | Type 1C | Interpretation is that the SRI is applicable to the UL of the scheduling cell only | | Precoding information and number of layers | Type 3 | Common (e.g. for intra-band UL CA) or cell specific depending on the scenario. | | Antenna ports | Type 3 | Common (e.g. for intra-band UL CA) or cell specific depending on the scenario. | | SRS request | Type 1C | Interpretation is that the SRS request is applicable to PUSCH of the first scheduled cell only | | SRS offset indicator | Type 1C | Interpretation is that the CSI request is applicable to PUSCH of the first scheduled cell | | CSI request | Type 1C | Agreed at RAN1#110bis-e as Type 1. Should be Type 1B | | PTRS-DMRS association | Type 3 |  | | beta\_offset indicator | Type 1A | Agreed at RAN1#110bis-e as Type 1. Should be Type 1A - same as the DAI | | DMRS sequence initialization | Type 1A |  | | UL-SCH indicator | Type 1C | Agreed at RAN1#110bis-e as Type 1. Should be Type 1C – applicable only to a single scheduled cell (as for multi-PUSCH) | | Open-loop power control parameter set indication | Type 1A | To be aligned with PHY priority indicator definition (same PHY priority, same OL TPC parameter sets). | | Priority indicator | Type 1A | Agreed at RAN1#110bis-e as Type 1.  Should be Type 1A – applicable to all the cells | | Invalid symbol pattern indicator | Type 1A |  | | PDCCH monitoring adaptation indication | Type 1C | Applies to the scheduling cell only. |   **Vivo:**  *Proposal 6. DCI format 0\_X/1\_X includes - Type-2 fields include:  - MCS - Type-3 field:   - FDRA  - VRB/PRB  - PRB bundling  - Rate matching  - SRS  - DMRS initialization*  *Proposal 7. The scheduling granularity of FDRA can be scaled or determined according to the BW of all the scheduled cells to reduce DCI size.*  *Proposal 8. The size of a field applying to a combination of co-scheduled cells scheduled by a DCI format 0\_X/1\_X is determined based on the configuration of the corresponding co-scheduled cell(s), and/or the configuration of the scheduling cell. If multiple sizes for DCI format 0\_X/1\_X are obtained for different combinations after determining each field size, the DCI format 0\_X/1\_X with a smaller size should be zero-padded to align to the largest DCI format 0\_X/1\_X size among all the DCI format 0\_X/1\_X.*  **Fujitsu:**  *Proposal 1: For CSI request by DCI format 0\_X, consider the following two options. Option 1 is preferred for flexibility.*   * *Option 1: DCI format 0\_X can schedule one or more cells when triggering CSI report. The triggered CSI report is transmitted on the schedule cell with lowest serving cell identifier.* * *Option 2: DCI format 0\_X can schedule only one cells when triggering CSI report. The triggered CSI report is transmitted on the scheduled cell.*   **CATT:**  *Proposal 9: The ChannelAccess-CPext can be involved in the DCI format 0\_X/1\_X and defined as Type-1 field.*  *Proposal 10: For TDRA table configured for multi-cell scheduling, each row includes N {SLIV, mapping type, scheduling offset K0 (or K2)}, where N is number of the set of cells.*  *Proposal 11: For DCI format 0\_X/1\_X, the fields of MCS can be indicated by a reference MCS and (N-1) offset MCS via joint indication to indicate MCS for the co-scheduled cells, where N is the maximum number of co-scheduled cells.*  *Proposal 12: The bitwidth of each NDI for a co-scheduled cell and each RV for a co-scheduled cell is 1 bit and 2 bits for each cell, respectively.*  *Proposal 13: The following fields are suggested to be designed as type-3 field:*   * *The fields in DCI format 0\_X: FDRA, frequency hopping flag, SRS indicator, precoding and layers, antenna port and PTRS-DMRS can be designed as Type-3 field.* * *The fields in DCI format 1\_X: FDRA, VRB-to-PRB, PRB bundling size, rate matching indicator, antenna port and TCI state can be designed as Type-3 field.*   **Spreadtrum:**  *Proposal 6: According to sub-group Type-3*   * *One cell in the configuration cells for co-scheduling always belongs to a same sub-group, for all the fields that is configured as sub-group type.* * *Type-1A/1C can be used for each sub-field of sub-group Type-3, while Type-B cannot* * *Size of bits in sub-group Type-3 depend on the maximum bit length of all cells in the cell group*   *Proposal 7: The TDRA table can contain the time domain resource allocation information for each cells within the set of cells which is configured for multi-cell scheduling.*  *Proposal 8: The indication for TDRA can refer to one row of TDRA table of the single-scheduling DCI for each scheduled cells.*  *Proposal 9: The undecided fields in DCI format 1\_X are with the below type classification:*   * *Type-1 fields include below:*   + *Carrier indicator co-scheduled cells (Type-1B)*   + *Time domain resource assignment (Type-1B)*   + *Priority indicator (Type-1A if exist)*   + *Enhanced Type 3 codebook indicator (Type-1A)*   + *PDCCH monitoring adaptation indication (Type-1C)* * *Type-3 fields include below:*   + *Frequency resource related*     - *Frequency domain resource assignment*     - *VRB-to-PRB mapping*     - *Rate matching indicator*   + *MIMO related:*     - *PRB bundling size indicator*     - *ZP CSI-RS trigger*     - *Antenna port(s)*     - *TCI*     - *SRS request*     - *CSI request*     - *DMRS sequence initialization*     - *SRS offset indicator*   + *Modulation and coding scheme TB1 and TB2*   + *HARQ process number* * *Fields not needed or supported for multi-carrier scheduling include below:*   + *Bandwidth part indicator*   + *HARQ-ACK retransmission indicator*   + *Minimum applicable scheduling offset indicator*   + *SCell dormancy indication*   *Proposal 10: The fields in DCI format 0\_X are with the below type classification:*   * *Type-1 fields include below:*   + *Carrier indicator o/Indicator/bitmap of co-scheduled cells (Type-1B)*   + *Time domain resource assignment (Type-1B)*   + *Priority indicator (Type-1A if exist)*   + *PDCCH monitoring adaptation indication (Type-1C)*   + *beta offset indicator (Type-1B)*   + *CSI request(Type-1C)*   + *UL-SCH indicator(Type-1C)* * *Type-2 fields include below:*   + *TPC command for scheduled PUSCH (Type2)* * *Type-3 fields include below:*   + *Frequency resource related*     - *Frequency domain resource assignment*     - *Frequency hopping flag*   + *MIMO related:*     - *SRS resource indicator*     - *Precoding information and number of layers*     - *Antenna port(s)*     - *SRS request*     - *SRS offset indicator*     - *CSI request*     - *PTRS-DMRS association*     - *DMRS sequence initialization*   + *Modulation and coding scheme*   + *HARQ process number*   + *beta offset indicator* * *Fields not needed or supported for multi-carrier scheduling include below:*   + *DFI flag*   + *Bandwidth part indicator*   + *SRS resource set indicator*   + *Invalid symbol pattern indicator*   + *Minimum applicable scheduling offset indicator*   + *SCell dormancy indication*   + *Open-loop power control parameter set indication*   **Xiaomi:**  *Proposal 11: The DCI fields in DCI format 1\_X can be categorized as:*   * *Type 1: Minimum applicable scheduling offset indicator, SCell dormancy indication, PDCCH monitoring adaptation indication, PUCCH Cell indicator, and indicator of co-scheduled cells* * *Type 2: Modulation and coding scheme, HARQ process number, ChannelAccess-CPext, and Frequency domain resource assignment (could also be a type 3)* * *Type 3: all other fields* * *Omitted: Bandwidth part indicator (could also be type 3)*   *Proposal 12: The DCI fields in DCI format 1\_X can be categorized as:*   * *Type 1: Minimum applicable scheduling offset indicator, SCell dormancy indication, PDCCH monitoring adaptation indication, PUCCH Cell indicator, and indicator of co-scheduled cells* * *Type 2: Modulation and coding scheme, HARQ process number, ChannelAccess-CPext, and Frequency domain resource assignment (could also be a type 3)* * *Type 3: all other fields* * *Omitted: Bandwidth part indicator (could also be type 3)*   **Intel:**  *Proposal 1: Support Type-3 DCI field for multi-cell scheduling:*   * *Type-3 field: Common or separate to each of the co-scheduled cells, or separate to each sub-group, dependent on explicit configuration.*   *Proposal 2: Type-1 DCI field for multi-cell scheduling at least includes*   * *HARQ process number* * *DMRS sequence initialization* * *Rate matching indicator* * *ZP CSI-RS trigger* * *VRB-to-PRB mapping* * *SRS request*   *Proposal 4: For TDRA table, each entry includes N {SLIV, mapping type, scheduling offset K0 (or K2)}, where N is number of configured cells for multi-cell scheduling.*   * *If the number of co-scheduled cells is less than N, UE determines the {SLIV, mapping type, scheduling offset K0 (or K2)} based on the indicated carrier index within the N configured cells.* * *{SLIV, mapping type, scheduling offset K0 (or K2)} for multi-cell scheduling is determined based on the TDRA table from single-cell scheduling.*   *Proposal 5: Type-3 DCI field for multi-cell scheduling at least includes*   * *Modulation and coding scheme* * *Frequency domain resource assignment*   **OPPO:**  *Proposal 3: Joint TDRA table defined per cell set is adopted.*  *Proposal 4: The same frequency domain resource allocation type from {Type-0 only, Type-1 only, dynamic switch} shall be configured for all cells potentially scheduled by one DCI, and the same type-0 or type-1 FDRA type should be used for all cells actually scheduled by one DCI.*  *Proposal 5: FDRA field is a shared DCI field (type-1 as agreed in RAN1 #109/#110). The bit size of this single FDRA field is determined by the maximum size of FDRA indication required across all the potentially scheduled cells.*  *Proposal 6: MCS indication is separated field for each scheduled PDSCH/PUSCH.*  *Proposal 7: HARQ process number field is a common indication for scheduled cells.*  *Proposal 8: The DCI field for power control can be separated per scheduled cell.*  **China Telecom:**  *Proposal 1: The following are considered for the design of frequency domain resource assignment field:*   * *The field is Type-1 field being configured as Type-1A field or Type-1B field.* * *Same resource allocation type for each of the cells to be co-scheduled.* * *When it is configured as Type-1B field:*   + *Larger RBG size based on the total bandwidth of all the BWPs of the cells to be co-scheduled, and one RBG mapped to a single cell for resource allocation type 0.*   + *Joint indication of the respective RIV for each of the cells to be co-scheduled, and configured resource allocation granularity for resource allocation type 1.*   *Proposal 2: For bandwidth part indicator field, when it is configured to indicate different BWPs for the cells to be co-scheduled, for only one cell the initial BWP is supported to be indicated by the field.*  Proposal 4: In DCI format 0-X/1-X, the bits containing separate scheduling information of a type 2 or 3 field are mapped to cells or sub-groups of cells that can be co-scheduled according to the ServCellIndex increasing order, and the bits of the same field containing scheduling information for the different cells or sub-groups of cells are consecutive.  **Lenovo:**  *Proposal 4: BWP indicator in DCI format 0\_X/1\_X is separate for each of co-scheduled cells.*  *Proposal 5: Frequency domain resource allocations for co-scheduled cells are joint indicated by FDRA field in DCI format 0\_X/1\_X by pointing to one FDRA combination from a RRC configured list.*  *Proposal 6: VRB-to-PRB mapping, PRB bundling size indicator, and rate matching indicator in DCI format 0\_X/1\_X are shared or separate to co-scheduled cells dependent on RRC configuration.*  *Proposal 7: Separate MCS fields are included in DCI format 0\_X/1\_X.*  *Proposal 8: Separate HARQ process numbers are included in DCI format 0\_X/1\_X.*  *Proposal 9: ZP CSI-RS trigger, Antenna port(s), TCI, SRS request, and DMRS sequence initialization in DCI format 0\_X/1\_X are shared or separate to co-scheduled cells dependent on RRC configuration.*  *Proposal 10: Single ChannelAccess-CPext is included in DCI format 0\_X/1\_X indicating same channel access information for co-scheduled cells.*  *Proposal 11: PDCCH monitoring adaptation indication, PUCCH Cell indicator, Minimum applicable scheduling offset indicator, and SCell dormancy indication are excluded from DCI format 0\_X/1\_X.*  **CMCC:**  *Proposal 8. FDRA field can be configured as Type-1 field to reduce DCI size, and the following designing can be considered.*   * *The FDRA field size can be determined by the minimum BWP size among BWPs of all co-scheduled cells.* * *For resource allocation type 0, the common indication for bitmap and RBG size is used for all co-scheduled cells, and UE interprets the indication respectively to each scheduled cell with scaling factor K.* * *For resource allocation type 1, the common indication of RIV is used for all co-scheduled cells, and the UE can interpret the indication respectively with the scaling factor K.*   *Proposal 9. The fields in DCI format 1\_X can be classified as the following:*   * *Type-1 fields include below:* * *Type-1A fields:* * *Identifier for DCI formats* * *Downlink assignment index* * *TPC for scheduled PUCCH* * *PUCCH resource indicator* * *PDSCH-to-HARQ\_feedback timing indicator* * *One-shot HARQ-ACK request* * *Priority indicator* * *Indicator of co-scheduled cells* * *Type-1B fields:* * *Frequency domain resource assignment* * *Type-2 fields include below:* * *Modulation and coding scheme* * *New data indicator* * *Redundancy version* * *HARQ process number* * *Type-3 fields include below:* * *Bandwidth part indicator* * *Time domain resource assignment* * *VRB-to-PRB mapping* * *PRB bundling size indicator* * *Rate matching indicator* * *ZP CSI-RS trigger* * *Antenna port(s)* * *Transmission configuration indication* * *SRS request* * *DMRS sequence initialization*   **Apple:**  *Proposal 6: For indication time domain resource allocation for multiple cells by single joint TDRA field in DCI format 0\_X/1\_X, UE should be configured with a new table, where each row of the new table indicates the row index to the legacy TDRA table for each of the co-scheduled cell, as illustrated in the table.*   * *Joint TDRA field in the DCI format 0\_X/1\_X indicates the index of the new proposed table* * *New proposed table can be configured only on the scheduling cell* * *New proposed table can also be used to indicate which cells are configured*   + *If no row index to TDRA table is indicated for a cell, then it can imply that the cell is not scheduled*   **FGI:**  *Proposal 1: Adopt the type classification of DCI fields for DCI format 1\_X in Table 1 and DCI format 0\_X in Table 2.*  *Proposal 2: The HARQ process number field jointly indicates HARQ process numbers for each scheduled cell.*  *Proposal 3: RAN1 is suggested to consider more than one TDRA tables are configured for a set of cells and each TDRA table is associated with a cell in the set of cells. The TDRA field indicates a row of each TDRA table.*  **CAICT:**  *Proposal 1: Further enhancements are considered to overcome the scheduling restriction if CRC bit filed is designed as a type-1 field and unique RNTI is used.*  *Proposal 2: CRC bit filed in DCI format 0\_X/1\_X is considered as Type-1B field. Multiple predefined RNTIs are used to discriminate different scheduling modes of the scheduled PDSCH/PUSCH by DCI format 0\_X/1\_X.*  **NTT DOCOMO:**  *Proposal 5: ChannelAccess-CPext should be specified as the Type-1 field.*  *Proposal 6: The DCI fields in DCI format 0\_X/1\_X are Type-3 unless it is agreed as Type-1 or 2 field.*  **Samsung:**  *Proposal 11: When a DCI format 0\_X1/1\_X is used for scheduling a single cell, the UE interprets the DCI format 0\_X1/1\_X based on the same fields as for a SC-DCI format (e.g., DCI format 0\_1/1\_1).*   * *Fields corresponding to fully disabled functionalities (e.g., CBG or multi-TRP operation) are reserved.*   *Proposal 12: For a Type-3 field, RAN1 needs to conclude on the following:*   * *UE behavior when indicated as cell-common or Type-1A field (e.g., for FDRA), or* * *Single or multiple values in DCI format 0\_X/1\_X, similar to a Type-1B or Type-2 field, when indicated as cell-specific.*   *Proposal 13: Do not support sub-groups for Type-3 fields in a DCI format 0\_X/1\_X.*  *Proposal 14: Support the following fields in MC-DCI as Type-1 fields:*   * *Type-1A fields, such as: frequency hopping (FH), TCI state, TDRA;*   + *Also, Type-3 fields that are configured as cell-common (Type-1A), such as: FDRA, antenna port (APs), SRI, TMPI.* * *Type-1B fields, such as: TDRA, Indicator of co-scheduled cells, Rate matching indicator, aperiodic ZP CSI-RS, SRS request, TCI state;*   + *Also, any Type-3 fields that are configured as cell-specific and determined to be Type-1B.* * *Type-1C fields, such as: CSI request, UL-SCH, and beta offset, and priority indicator.* * *Note: RAN1 to decide whether TDRA and TCI state fields are Type-1A or Type-1B.*   *Proposal 15: For values provided for Type-1C fields {CSI request, UL-SCH, beta offset, Priority indicator} in a DCI format 0\_X, the UE determines an applicable PUSCH from co-scheduled PUSCHs, if any, based on Rel-17 rules.*  *Proposal 16: For the TDRA table for multi-cell scheduling, down-select one of:*   * *Alt-1: a single, cell-common, TDRA table for multi-cell scheduling is configured by RRC;*   + *TDRA field in DCI format 0\_X/1\_X is determined as a Type-1A field that indicates a same row index from corresponding new multi-cell TDRA tables;* * *Alt-2: a single joint multi-cell TDRA table is configured by RRC and provides separate TDRA information for each cell from a set of co-scheduled cells.*   + *TDRA field in DCI format 0\_X/1\_X is determined as a Type-1B field that indicates a row index from a joint multi-cell TDRA table.*   *Proposal 17: Support PDSCH/PUSCH repetitions for DCI formats 0\_X/1\_X scheduling, down-select from the following two Options.*   * *Option 1: {SLIV, mapping type, scheduling offset K0 (or K2), number of PDSCH (or PUSCH) repetitions} is indicated separately or jointly for the co-scheduled PDSCHs/PUSCHs.* * *Option 2: The number of repetitions of co-scheduled PDSCHs/PUSCHs is determined by pdsch-aggregationFactor/pusch-aggregationFactor.*   *Proposal 18: For the FDRA field in DCI format 0\_X/1\_X:*   * *When configured as a cell-common (Type-1) field, and the co-scheduled cells have active DL/UL BWPs with different size, the UE determines the FDRA for each cell from LSBs of the FDRA field*   + *The UE also expects a same resource allocation type for the co-scheduled cells.* * *When configured as a cell-specific field, separate values are provided in DCI format 0\_X/1\_X*    + *The UE can have different resource allocation types among the co-scheduled cells.*   + *FDRA bits for non-scheduled cells are used to increase the granularity of FDRA values for scheduled cells.*   *Proposal 19: For TCI state field in DCI format 1\_X:*   * *When TCI state field is present in DCI format 1\_X, a value provides new indicated DL/UL/joint TCI states on the co-scheduled cells and corresponding lists of cells indicated by simultaneousTCI-UpdateList1/2/3/4* * *When TCI state field is not present in DCI format 1\_X, the UE follows the DL/joint TCI state indicated by SC-DCI formats.*   *Proposal 20: HPN and MCS are Type-2 fields in DCI format 0\_X/1\_X.*   * *Also Type-3 fields that are configured as cell-specific and determined to be Type-2, such as, FDRA, SRI, TPMI;* * *A size for RV, HPN, and Type-3 fields that are determined as Type-2 fields, is configurable;* * *MCS for co-scheduled cells is differential to the MCS of one cell from the co-scheduled cells;* * *A same MCS value applies to a PDSCH with 2 TBs / codewords.*   *Proposal 21: DCI format 0\_X/1\_X does not support indication for BWP-ID, UL/SUL, TCI state, DM-RS sequence initialization, and VRB-to-PRB mapping.*  **Qualcomm:**  *Proposal 6:*   * *TDRA, BWP indicator, VRB-to-PRB, PRB bundling size, RM-indicator, ZP-CSI-RS indicator, TCI-state, DMRS sequence initialization, FH flag, beta-offset indicator, SRS request, priority indicator: joint indication: Type-1B*   + *Similar to TDRA for Rel-16/Rel-17 multi-slot PDSCH/PUSCH scheduling* * *MCS: Type-3*   + *Configured ‘mcs-Table’ is the same for all the cells in the group*   + *‘cqi-Table’ for the cells in the group is expected to be the same for appropriate link adaptation*   + *Consider up to 2 groups per DCI* * *Antenna port(s), Precoder information and number of layer(s), SRS resource indicator, TPC for PUSCH: Type-3*   + *RRC parameters are configured so that the same look-up table is referred for a group of cells*   + *Allow 1 or 2 groups per DCI format 0\_X/1\_X* * *FDRA: Type-1B or Type-2*   + *Opt.1: Type-1B, where:*     - *Continuous RB indexing over the RBs of the multiple co-scheduled cells for FDRA purpose*   + *Opt.2: Type-2, where:*     - *For Type-0, larger RBG size is supported*     - *For Type-1, RBG-based RIV is used* * *HARQ process indicator: Type-1A (or Type-2, if critical issue is identified with Type-1A)* * *SCell dormancy indicator, PDCCH monitoring adaptation, CSI request, UL-SCH indicator, PDCCH monitoring adaptation: Type-1A* * *ChannelAcces-CPext, minimum K0/K2 offset: Type-1A* * *UL/SUL indicator: Not included*   **Ericsson:**  *Proposal 11: For mc-DCI, at least the following fields should be applicable for each subgroup of cells scheduled by mc-DCI*   * *TDRA* * *VRB-to-PRB mapping* * *PRB bundling size indicator* * *Rate matching indicator* * *ZP CSI-RS trigger* * *Antenna port(s)* * *Transmission configuration indication* * *DM-RS sequence initialization* * *BWP*   *Proposal 12: For each cell, support separate configuration of RBG size(s) used for PUSCH/PDSCH scheduling using mc-DCI.*  *Proposal 13: For frequency domain resource allocation (FDRA) using mc-DCI, support joint coding of individual RIVs of each cell to reduce overhead for FDRA type 1.*  *Proposal 14: For mc-DCI, RV field size is explicitly configurable per cell (0/1/2 bits).*  *Proposal 15: For mc-DCI, support joint coding of MCS indication for co-scheduled cells in a subgroup*   * *MCS index for a first cell is five bits (Index 1), and for each of remaining cells in the subgroup, differential MCS index is indicated relative to the Index 1.* * *For each of the remaining cells, up to 3 bits for differential MCS index, and the differential MCS offsets are configured by higher layers.*   *Proposal 22: UL/SUL scheduling combined with multi-cell PUSCH scheduling and presence of UL/SUL indicator in DCI format 0\_X should reuse the existing procedures.*  **LG:**  *Proposal #5: Clarify and update the classification of DCI field types and details of each field type as the followings.*   * *Type-1C: A single field indicates an information to only one of co-scheduled cells, and a (predefined or preconfigured) default value is applied to other co-scheduled cells.* * *Type-2 (& 3): The size of separate field per cell (or sub-group) is reduced compared to the case of single-cell scheduling to avoid increase of for multi-cell DCI payload size.* * *Type-3: The cell sub-grouping is done per field (or field group) for scheduling (DCI) efficiency/ flexibility, based on all the configured cells (not per co-scheduled cell combination).* * *Type-4 (new): This field is omitted in multi-cell scheduling case (in this case, a default value is applied to the scheduled cells), but it is present in single-cell scheduling case.*   *Proposal #6: Support the following originally proposed in RAN1#110bis-e.*   * *For DCI format 1\_X/0\_X, Type-1C fields at least include the following:*   + *beta offset indicator*   + *CSI request*   + *UL-SCH indicator*   *Proposal #7: Support the TDRA indication for co-scheduled cells based on the followings.*   * *Refer to multiple legacy single-cell TDRA tables* * *Apply a same K0/K2 value for co-scheduled cells*   *Proposal #8: Classify each DCI field (in current DL/UL DCI format) as in Tables 1 and 2, based on the Type-1/2/3/4 field with clarifications/updates in Proposal #5.*   * *Need to consider and address the FFS points listed in “Note” column for some DCI fields in the Tables 1 and 2.* * *Consider how to do the ordering of multiple fields corresponding to different cells or sub-groups in the multi-cell DCI.*   *Table 1: Classification of each field in DL DCI format for multi-cell scheduling DCI.*   |  |  |  | | --- | --- | --- | | Field | Type | Note | | DCI format flag | 1 |  | | CIF | 1 |  | | BWP indicator | 1C (or 4) |  | | FDRA | 3 (or 1A) | FFS on different number of RBs/RBGs between cells | | TDRA | 1B |  | | VRB-to-PRB | 1C |  | | PRB bundling size | 1C |  | | Rate matching | 1C | FFS on different number of RM patterns between cells | | ZP CSI-RS | 1C | FFS on different number of A-ZP CSI-RS sets between cells | | MCS (TB1+TB2) | 3 (or 1A) | FFS on different max number of TBs per PDSCH between cells  FFS on whether MCS is separate or common for 2 TBs in a PDSCH  FFS on different configuration of MCS-C-RNTI (presence) between cells | | NDI (TB1+TB2) | 2 |  | | RV (TB1+TB2) | 2 |  | | HARQ ID | 1A (or 3) | FFS on different max number of HARQ processes between cells | | DAI | 1 |  | | TPC | 1 |  | | PRI | 1 |  | | K1 | 1 |  | | Type-3 CB trigger | 1 |  | | Antenna port(s) | 2 (or 3) | FFS on different DMRS structure between cells | | TCI | 1B (or 2) | FFS on different TCI mode / field presence between cells | | SRS request | 1C | FFS on different number of UL carriers between cells | | DMRS seq-init | 1C (or 4) |  | | Priority indicator | 1A | FFS on different configuration of Priority indicator (presence) between cells | | LBT/CPE | 1A |  | | Min sched-offset | 1C (or 4) |  | | SCell dormancy | 4 |  |   *Table 2: Classification of each field in UL DCI format for multi-cell scheduling DCI.*   |  |  |  | | --- | --- | --- | | Field | Type | Note | | DCI format flag | 1 |  | | CIF | 1 |  | | UL/SUL indicator | 4 |  | | BWP indicator | 1C (or 4) |  | | FDRA | 3 (or 1A) | FFS on different number of RBs/RBGs between cells | | TDRA | 1B |  | | FH flag | 1C (or 4) |  | | MCS | 3 (or 1A) | FFS on different configuration of MCS-C-RNTI (presence) between cells | | NDI | 2 |  | | RV | 2 |  | | HARQ ID | 1A (or 3) | FFS on different max number of HARQ processes between cells | | 1st DAI | 1 |  | | 2nd DAI | 1 |  | | TPC | 1C |  | | SRI | 1B (or 2) | FFS on different (non-)CB type / number of SRI table entries between cells | | TPMI | 2 (or 3) | FFS on different number of TPMI table entries between cells | | AP | 2 (or 3) | FFS on different DMRS structure / maximum rank between cells | | SRS request | 1C | FFS on different number of UL carriers between cells | | CSI request | 1C |  | | PTRS-DMRS | 1C (or 2) | FFS on different number of PTRS ports between cells | | Beta offset | 1C |  | | DMRS seq-init | 1C (or 4) |  | | UL-SCH indicator | 4 |  | | LBT/CPE/CAPC | 1A (or 3) | FFS on different number of LBT table entries between cells | | OLPC param set | 1C | FFS on different number of OLPC parameter sets between cells | | Priority indicator | 1A | FFS on different configuration of Priority indicator (presence) between cells | | Invalid symbol | 1C |  | | Min sched-offset | 1C (or 4) |  | | SCell dormancy | 4 |  |   **ZTE:**  *Proposal 2: Except for the fields that must be separately indicated (e.g., NDI, RV), 2 sub-groups can be designed for a configurable field, where each sub-group corresponds to one separate indication of this field.*  *Proposal 3: The fields are categorized as below.*   * *Type-1 field:*    + *Type-1A:HPN, priority indicator*   + *Type-1B:Indicator of co-scheduled cells*   + *Type-1C:CSI request, UL-SCH indicator, beta offset indicator* * *Type-2 field: RV with 1 bit* * *Type-3 field: PRB bundling size indicator, Rate matching indicator, ZP CSI-RS trigger, Antenna port(s), SRS request, DMRS sequence initialization, TPC for scheduled PUSCHs, Modulation and coding scheme, Bandwidth part indicator, Time domain resource assignment, Frequency domain resource assignment, VRB-to-PRB mapping, SRI*   *Proposal 4: CSI request field should be applied to the scheduled PUSCH with the smallest serving cell index, i.e., if A-CSI request is triggered by DCI 0\_X, CSI is carried by the scheduled PUSCH with the smallest serving cell index.*  *Proposal 6: For the TDRA table design, the network should configure a new TDRA table, with each row including separate configurations for multiple scheduled cells.*  *Proposal 7: The FDRA field for the co-scheduled cells should belongs to Type-3. In case shared FDRA indication is applied, a reference cell is used for FDRA size determination.* |

### Moderator summary and proposals based on contributions

Regarding DCI field type classification, RAN1#110bis-e reached below agreement:

|  |
| --- |
| **Agreement**  At least the following fields are excluded from DCI format 1\_X/0\_X:   * CBGTI * CBGFI * PDSCH group index * New feedback indicator * Number of requested PDSCH group(s) * Sidelink assignment index * Second TPC command for scheduled PUSCH * Second SRS resource indicator * Second Precoding information * Second PTRS-DMRS association * Second TPC command for scheduled PUCCH   **Agreement**  For DCI format 1\_X/0\_X, Type-1 fields at least include the following:   * Priority indicator * Indicator of co-scheduled cells * beta offset indicator * CSI request * UL-SCH indicator * FFS: ChannelAccess-CPext |

In RAN1#111 meeting, regarding the DCI field types, companies’ views are summarized in below Table 1 and Table 2.

Table 1: DCI field types for DCI format 1\_X (“√” means the field has been agreed in previous meeting)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| DCI FIELDS | Type 1A | Type 1B | Type 1C | Type 2 | Type 3 | Omitted |
| Identifier for DCI formats | √ |  |  |  |  |  |
| Indicator of co-scheduled cells | CMCC, LG, Samsung, | ZTE, SPRD, Samsung, Nokia |  |  |  |  |
| Bandwidth part indicator | Nokia | QC, | LG, | OPPO, Lenovo, | ZTE, CMCC, Ericsson, | SPRD, xiaomi, FGI, LG, Samsung, |
| Frequency domain resource assignment | OPPO, | Lenovo, CMCC, QC, Ericsson, |  | xiaomi, FGI, QC | Nokia/CATT, ZTE, xiaomi, SPRD, vivo, Intel, LG, Samsung, |  |
| Time domain resource assignment | Samsung, | Nokia, SPRD, OPPO, Lenovo, FGI, Samsung, LG, QC, |  |  | ZTE, CMCC, Ericsson, |  |
| VRB-to-PRB mapping | Intel, OPPO, FGI, | QC, | LG, |  | Nokia, ZTE, SPRD, vivo, CATT, Lenovo, CMCC, Ericsson, | Samsung, |
| PRB bundling size indicator | OPPO, | QC, | LG, |  | Nokia, ZTE, SPRD, vivo, CATT, Lenovo, CMCC, FGI, Ericsson, | Samsung, |
| Rate matching indicator | Intel, OPPO, | Samsung, QC, | LG, |  | Nokia, ZTE, SPRD, vivo, CATT, Lenovo, CMCC, FGI, Ericsson, |  |
| ZP CSI-RS trigger | Intel, OPPO, | Samsung, QC, | LG, | Nokia | ZTE, SPRD, Lenovo, CMCC, FGI, Ericsson, |  |
| TB1: Modulation and coding scheme | LG, |  |  | HW, vivo, OPPO, xiaomi, Lenovo, CMCC, Samsung, | ZTE, SPRD, FGI, Intel, LG, Nokia, QC, Ericsson, |  |
| TB1: New data indicator |  |  |  | √ |  |  |
| TB1: Redundancy version |  |  |  | √ |  |  |
| TB2: Modulation and coding scheme |  |  |  | Samsung, OPPO, | Nokia, SPRD, FGI, |  |
| TB2: New data indicator |  |  |  | √ |  |  |
| TB2: Redundancy version |  |  |  | √ |  |  |
| HARQ process number | OPPO, Intel, LG, QC, ZTE, |  |  | HW, xiaomi, Lenovo, CMCC, Samsung, QC, Nokia | SPRD, FGI, LG, |  |
| Downlink assignment index | √ |  |  |  |  |  |
| TPC command for scheduled PUCCH | √ |  |  |  |  |  |
| PUCCH resource indicator | √ |  |  |  |  |  |
| PDSCH-to-HARQ timing indicator | √ |  |  |  |  |  |
| One shot HARQ ACK request | √ |  |  |  |  |  |
| Enhanced Type 3 codebook indicator | HW, SPRD, FGI, Nokia |  |  |  |  | Samsung, |
| HARQ-ACK retransmission indicator | Nokia |  |  |  |  | SPRD, FGI, Samsung |
| Antenna port(s) | OPPO, |  |  | LG, | ZTE, SPRD, CATT, Lenovo, CMCC, FGI, LG, Samsung, Ericsson, QC, Nokia |  |
| Transmission configuration indication | Samsung, OPPO, | LG, Samsung, QC, |  | LG, | SPRD, CATT, Lenovo, CMCC, FGI, Ericsson, Nokia |  |
| SRS request | Intel, OPPO, | Samsung, | FGI, LG, |  | ZTE, SPRD, vivo, Lenovo, CMCC, Nokia |  |
| DMRS sequence initialization | Intel, | QC, | LG, | Nokia | ZTE, SPRD, vivo, Lenovo, CMCC, FGI, Ericsson, | LG, Samsung, |
| Priority indicator | SPRD, OPPO, CMCC, Lenovo, LG, ZTE, Nokia |  |  |  |  |  |
| PDCCH monitoring adaptation indication | QC, |  | HW, SPRD, FGI, Nokia |  |  | Lenovo, Samsung, |
| PUCCH Cell indicator | HW, FGI, Nokia |  |  |  |  | Lenovo, |
| Minimum applicable scheduling offset indicator | OPPO, |  | LG, |  |  | SPRD, Lenovo, FGI, LG, Samsung, |
| SCell dormancy indication | HW, QC, |  |  |  |  | SPRD, Lenovo, FGI, LG, Samsung, |
| ChannelAccess-Cpext | CATT, Lenovo, DCM, LG, Samsung, QC, |  |  | xiaomi |  | FGI, |

Table 2: DCI field types for DCI format 0\_X(“√” means the field has been agreed in previous meeting)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **DCI FIELDS OF FORMAT 0\_X** | Type 1A | Type 1B | Type 1C | Type 2 | Type 3 | Omitted |
| Identifier for DCI formats | √ |  |  |  |  |  |
| Indicator of co-scheduled cells | LG, Samsung, | ZTE, SPRD, Samsung, Nokia |  |  |  |  |
| DFI flag |  |  |  |  |  | SPRD, FGI, |
| BWP indicator |  | QC, | LG, | OPPO, Lenovo, | ZTE, CMCC, Ericsson, | SPRD, xiaomi, FGI, LG, Samsung, |
| Frequency domain resource assignment | OPPO, LG, | Lenovo, CMCC, QC, Ericsson, |  | xiaomi, FGI, QC, | xiaomi, ZTE, SPRD, vivo, CATT, Intel, LG, Samsung, Nokia |  |
| Time domain resource assignment | Samsung, | SPRD, Lenovo, Nokia, OPPO, FGI, Samsung, QC, LG, |  |  | CMCC, ZTE, Ericsson, |  |
| Frequency hopping flag | OPPO, Samsung, | QC, | LG, |  | SPRD, CATT, FGI, Nokia | LG, |
| Modulation and coding scheme | LG, |  |  | HW, vivo, OPPO, xiaomi, Lenovo, CMCC, Samsung, | SPRD, Intel, FGI, LG, QC, Nokia, Ericsson, ZTE, |  |
| New data indicator |  |  |  | √ |  |  |
| Redundancy version |  |  |  | √ |  |  |
| HARQ process number | Intel, ZTE, OPPO, LG, QC, |  |  | HW, xiaomi, Lenovo, CMCC, Samsung, QC, Nokia | SPRD, FGI, LG, |  |
| Downlink assignment index | √ |  |  |  |  |  |
| TPC command for scheduled PUSCH |  |  | Nokia | SPRD, OPPO, | ZTE, FGI, Samsung, QC, |  |
| Precoding information and number of layers | OPPO, |  |  | LG, | SPRD, CATT, FGI, QC, Nokia |  |
| Antenna ports | OPPO, |  |  | LG, | ZTE, SPRD, CATT, Lenovo, CMCC, FGI, Samsung, Ericsson, QC, Nokia |  |
| SRS request | Intel, OPPO, | Samsung, QC, | LG, Nokia |  | ZTE, SPRD, vivo, CATT, Lenovo, FGI, |  |
| SRS resource indicator | OPPO, |  | Nokia |  | Lenovo, FGI, Samsung, QC, |  |
| SRS offset indicator |  |  | Nokia |  | SPRD, |  |
| SRS resource set indicator |  |  |  |  |  | SPRD, Samsung, |
| CSI request | OPPO, QC, |  | SPRD, ZTE, LG, Samsung, Nokia |  | SPRD, |  |
| PTRS-DMRS association | OPPO, |  | LG, | LG, | SPRD, CATT, FGI, Nokia | Samsung, |
| beta\_offset indicator | OPPO, Nokia | QC, SPRD | LG, Samsung, ZTE |  | SPRD, |  |
| DMRS sequence initialization | Nokia, Intel, OPPO, | QC, | LG, |  | SPRD, vivo, Lenovo, CMCC, FGI, Ericsson, ZTE, | LG, Samsung, |
| Open-loop power control parameter set indication | Nokia |  | LG, |  | FGI, OPPO, | SPRD, |
| Priority indicator | OPPO, SPRD, CMCC, Lenovo, LG, Nokia, ZTE | QC, |  |  |  |  |
| Invalid symbol pattern indicator | HW, OPPO, FGI, Samsung, |  | LG, |  |  | SPRD, |
| PDCCH monitoring adaptation indication | QC, |  | HW, FGI, Nokia |  |  | Lenovo, Samsung, |
| UL-SCH indicator | QC, |  | Samsung,  Nokia, ZTE |  |  | LG |
| Minimum applicable scheduling offset indicator | OPPO, |  | LG, |  |  | SPRD, Lenovo, FGI, LG, Samsung, |
| Scell dormancy indication | HW, QC, |  |  |  |  | SPRD, Lenovo, FGI, LG, Samsung, |
| UL/SUL indicator |  |  | SPRD, |  |  | FGI, Samsung, QC, |
| ChannelAccess-Cpext | CATT, Lenovo, DCM, LG, Samsung, QC, |  |  | Xiaomi, |  | FGI, |

In general, according to the categorization of DCI fields in DCI format 0\_X/1\_X, there is a single field for each Type-1 field and separate field for each Type-2 field. Any other fields, if not agreed to be excluded from DCI format 0\_X/1\_X, can be left as Type-3 fields to reduce standardization effort.

Based on above summary, for both Type-1 and Type-2 fields, majority companies’ views are listed below:

Type-1A field:

* ChannelAccess-Cpext

Type-1B field:

* TDRA

Type-2 fields:

* HARQ process number

Since different companies have different preferences, moderator suggests reaching consensus on Type-1 and Type-2 fields firstly and leave remaining fields as Type-3. So, Proposal 3-1 is provided for 1st round of discussions.

### 1st round of discussions

#### Proposal 3-1:

* For DCI format 1\_X/0\_X,
* Type-1A fields at least include below:
  + ChannelAccess-Cpext
* Type-1B fields at least include below:
  + TDRA
* Type-2 fields at least include below:
  + HARQ process number
* Note: The DCI fields in DCI format 0\_X/1\_X are Type-3 unless it is agreed as Type-1 or Type-2 field.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Spreadtrum | The proposal includes so much information for Type-3. Does it want to proposal beside the fields have already agreed and above three fields, all the others would not be treated separately? |
| Qualcomm | We consider it is important to make sure that different RBs can be assigned for different cells in the set by a DCI format 1\_X/0\_X. We prefer to make FDRA being Type-1B, but we are OK with Type-2.  Regarding the proposal on Type-3 (note in the last sub-bullet), it is necessary to clarify what Type-3 for the other fields means.   * For example, if FDRA is defined as Type-3, does it mean that RA-type and all the necessary RRC parameters for FDRA have to be the same across cells in the same sub-group, and the field indicates exactly same RBs for the cells in the same sub-group? If this is the intention, we do not think it makes sense. It is unclear how gNB can handle multi-user scheduling with such very restrictive RB allocation. * Another example; if RM-indicator is defined as Type-3, does it means that network has to configure the same RM pattern list and the field codebpoint has to indicate the exactly same RM patterns for the cells in the same sub-group? |
|  |  |
|  |  |
|  |  |
|  |  |

## Max number of cells within each set and indication of scheduled cells

|  |  |
| --- | --- |
| **Huawei:**  *Proposal 5: The indicator in DCI format 0\_X/1\_X should indicate both the set index of a set of cells to be co-scheduled and the combination index for cells within a same set of cells.*  **Nokia:**  *Proposal 3.1.1: The maximum number of configurable cells for co-scheduling using DCI formats 0\_X / 1\_X is 8.*  *Proposal 3.1.3: If only 4 cells within a set of cells are supported, RAN1 to support that the UE can be configured one or multiple sets of cells. Therefore, the following two RAN1#110bis-e moderator proposals should be agreed together with the following proposed modifications in red:*   |  | | --- | | Proposal 3-5rev7: ·         For a set of cells which is configured for multi-cell scheduling, RAN1 specification supports up to 4 cells within the set of cells.  o    A DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the set of cells.  ·         For multi-cell scheduling, the co-scheduled cells are indicated by an indicator in DCI format 0\_X/1\_X which points to one row of a table defining combinations of co-scheduled cells for the set of cells.   * The table is configured by RRC signaling for a set of cells.  Proposal 2-6rev1:  * For monitoring PDCCH candidates for a set of cells which is configured for multi-cell scheduling, the n\_CI in the search space equation is determined by a value configured for the set of cells. * The UE can be configured one or multiple sets of cells which are configured for multi-cell scheduling. * When multiple sets of cells are configured for multi-cell scheduling,   + separate n\_CI values are configured for different sets of cells   + separate tables for co-scheduled cell indication are configured for different sets of cells   + separate search spaces are configured for different sets of cells (as the cell configured with the search space cannot be part of more than one configuration of set of cells)   + the DCI size of 0\_X (or 1\_X) is the same for all co-scheduled cell combinations for a set of cells, but can be different between different sets of cells * When multiple sets of cells are configured for multi-cell scheduling, a cell in one set of cells can’t be included in another set of cells. |   **Vivo：**  *Proposal 2. The maximum number of configurable cells for co-scheduling is to UE capability.*  *Proposal 3. For the indication of the co-scheduled cell, the co-scheduled cells are indicated by an indicator in DCI format 0\_X/1\_X which points to one row of a RRC table defining combinations of co-scheduled cells.*  *Proposal 4. The corresponding BWP combination(s) for multi-cell scheduling for each combination of co-scheduled cells should be configured by RRC as well, and the BWP combination(s) can be jointly configured with combinations of co-scheduled cells in the same RRC table, or in separate RRC tables; DCI format 0\_X/1\_X also indicates a BWP combination corresponding to the combination of co-scheduled cells scheduled by the DCI format 0\_X/1\_X.*  *Proposal 5. If a cell included in a cell combination in the RRC table defining combinations of co-scheduled cells is deactivated, gNB is still allowed to indicate the cell combination including the deactivated cell in DCI format 0\_X/1\_X.*  **Fujitsu:**  *Proposal 2: For multi-cell scheduling, the co-scheduled cells are indicated by an indicator in DCI format 0\_X/1\_X which points to one row of a table defining combinations of scheduled cells.*   * *The indicator is CIF.* * *The table is configured by RRC signaling.*   **CATT:**  *Proposal 1: The maximum number of configured cells within a set of cells can be 4.*  *Proposal 2: Multiple sets of cells can be configured for multi-cell scheduling, but one cell can be only configured in one set of cells.*  *Proposal 3: For multi-cell scheduling, one cell can be configured as scheduling cell for only a set of cells.*  *Proposal 4：The actual co-scheduled cells can be indicated by an indicator in DCI format 0\_X/1\_X, and each value corresponds to a combination of co-scheduled cells that is configured by RRC signalling.*  **Spreadtrum:**  *Proposal 1: Support Proposal 3-5rev7 in RAN1#110b-e with update*   * *For a set of cells which is configured for multi-cell scheduling, RAN1 specification supports up to 4 cells within the set of cells.*   + *A DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the set of cells.* * *For multi-cell scheduling, the co-scheduled cells are indicated by an indicator in DCI format 0\_X/1\_X which points to one row of a table defining combinations of co-scheduled cells.*   + *The table is configured by RRC signalling.*   + *Separate tables can be configured for multi-cell PDSCH scheduling and multi-cell PUSCH scheduling*   **Xiaomi:**  *Proposal 1: The use cases only with the same SCS configuration or carrier type among the co-scheduled cells are supported in Rel-18.*  *Proposal 2: The number of the scheduled cells by a single DCI can be semi-statically configured with a value less than or equal to the maximum number of co-scheduled cells*  *Proposal 3: The maximum number of configurable cells for co-scheduling is 4.*  *Proposal 13: The associations between a CIF value and a combination of co-scheduled cells can be configured following legacy configuration framework to support the MC-scheduling with a single DCI.*  **Intel:**  *Proposal 3: For multi-cell scheduling,*   * *Maximum number of configurable cells for multi-cell scheduling is 4.* * *Carrier indication field is included in the DCI to determine a set of carriers from a configured table.*   **OPPO:**  *Proposal 1: Updated the proposal 3-5rev7 (from RAN1 #110b) as following.*   * *For a set of cells which is configured for multi-cell scheduling, RAN1 specification supports up to 4 cells within the set of cells.*   + *A DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the set of cells.* * *Multiple cell sets are allowed.* * *For multi-cell scheduling, the co-scheduled cells are indicated by an indicator in DCI format 0\_X/1\_X which points to one row of a table defining combinations of co-scheduled cells.*   + *The table is configured by RRC signaling.*   + *The table is configured per cell set*   *Proposal 2: When multiple cell sets are configured, one or more of the following should be taken into account to distinguish the scheduled cell sets:*   * *There is no scheduled cell being configured into more than one cell set.* * *Different DCI size of DCI format 0\_X/1\_X for different cell sets.* * *Including cell set indication in DCI format 0\_X/1\_X.*   **China Telecom:**  Proposal 3: For the indication of actual co-scheduled cells among the set of up to 4 cells, maximum 4 bits bitmap is used as the indicator of co-scheduled cells.  **Lenovo:**  *Proposal 1: For a set of cells which is configured for multi-cell scheduling, RAN1 specification supports up to 8 cells within the set of cells in Rel-18.*  *Proposal 2: For a set of cells which is configured for multi-cell scheduling, a DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the set of cells.*  *Proposal 3: For a set of cells which is configured for multi-cell scheduling, the co-scheduled cells are indicated by an indicator in DCI format 0\_X/1\_X which points to one row of a RRC configured table defining combinations of co-scheduled cells.*  **CMCC:**  *Proposal 1. The maximum number of configurable cells for multi-cell scheduling can be more than 4.*  *Proposal 2. For a set of cells which is configured for multi-cell scheduling, RAN1 specification supports up to 4 cells within the set of cells.*   * *A DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the set of cells.*   *Proposal 3. Considering the indication of co-scheduled cells within a set of cells, possible combinations of scheduled cells can be pre-configured by RRC signaling, and the co-scheduled cells are indicated by an indicator in the DCI format 0\_X/1\_X.*  **Apple:**  *Proposal 1: For a set of cells which is configured for multi-cell scheduling, RAN1 specification supports up to 4 cells within the set of cells.*   * *The maximum number of cells within the set of cells is reported as a UE capability.* * *A DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the set of cells.*   **FGI:**  *Proposal 9: Option 3 (first preference) or Option 1 (second preference) is adopted for indicating co-scheduled cells.*  **CAICT:**  *Proposal 3: A table defining combinations of the length of bit fields for each cell scheduling is preconfigured. One indicator in DCI format 0\_X/1\_X indicates one row of the table which implicitly indicates the scheduled cells.*  **NTT DOCOMO:**  *Proposal 1:*   * *For a set of cells which is configured for multi-cell scheduling, RAN1 specification supports up to 4 cells within the set of cells.*   + *Multiple sets of cells can be configured for a UE.*   + *When multiple sets of cells are configured for multi-cell scheduling, a cell in one set of cells can’t be included in another set of cells.*   *Proposal 2:*   * *For multi-cell scheduling, the co-scheduled cells are indicated by an indicator in DCI format 0\_X/1\_X which points to one row of a table defining combinations of co-scheduled cells.*   + *The table is configured by RRC signaling for each set of cells via multiple RRC tables, e.g., one set of cells can be co-scheduled by one DCI format 0\_X/1\_X while another set of cells can be co-scheduled by another DCI format 0\_X/1\_X.*   + *The size of co-scheduled cell indicator in the DCI format 0\_X/1\_X is determined based on the size of the table.*   **Samsung:**  *Proposal 1: RAN1 specifications should support up to 8 cells for the FFS on “the maximum number of configurable cells for co-scheduling”. Additional restrictions, if needed, can be left for UE capability discussions.*  *Proposal 2: RAN1 specifications should support one or multiple “sets of cells configured for multi-cell scheduling” that include up to 8 cells with each “set of cells” corresponding to one n\_CI value.*   * *Additional restrictions, if needed, on a maximum number of “sets of cells”, and a maximum number of cells in each “set of cells” can be left for UE capability discussions.*   *Proposal 3: RRC configures cell-set-indicator field (CSIF) values that correspond to configured combinations/subsets of co-scheduled cells (Option 1).*   * *A CSIF value is unique among different “sets of cells configured for multi-cell scheduling”;* * *Explicit configuration of a table defining combinations/subsets of co-scheduled cells is preferred.* * *Separate tables can be configured for multi-cell PDSCH scheduling and multi-cell PUSCH scheduling.*   **Ericsson:**  *Proposal 1: For a set of cells which is configured for multi-cell scheduling, maximum number of cells with the set is four.*   * *Maximum number of sets can be up to four.*   *Proposal 10: Use a bitmap for indication of co-scheduled cells by DCI format 0\_X/1\_X.*  **Langbo:**  *Proposal 8: Option 1, i.e., an indicator in the DCI points to one row of a table defining combinations of scheduled cells is supported for multi-cell scheduling.*  *Proposal 9: Separate tables are configured respectively for multi-cell PDSCH scheduling and multi-cell PUSCH scheduling.*  **LGE:**  *Proposal #1: Support the following Proposal 3-5rev7 in FL summary at RAN1#110bis-e.*   * *For a set of cells which is configured for multi-cell scheduling, RAN1 specification supports up to 4 cells within the set of cells.*   + *A DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the set of cells.* * *For multi-cell scheduling, the co-scheduled cells are indicated by an indicator in DCI format 0\_X/1\_X which points to one row of a table defining combinations of co-scheduled cells.*   + *The table is configured by RRC signaling.*   *Proposal #2: Reuse CIF field and the corresponding RRC structure for indication of co-scheduled cells by DCI format 0\_X/1\_X.*   * *Configure common CIF table between multi-cell PDSCH scheduling and multi-cell PUSCH scheduling by following current cell-level CIF without DL/UL differentiation.*   *Proposal #3: Consider the case where an invalid cell (e.g. in deactivated state or with dormant BWP or with UL/DL collision or with invalid FDRA/TDRA) is included within co-scheduled cells.*   * *Drop the PDSCH/PUSCH scheduled for the invalid cell and the corresponding HARQ-ACK feedback is omitted or mapped as NACK.*   **ITRI:**  *Proposal 3:*   * *For multi-cell scheduling, the co-scheduled cells are indicated by the CIF field in DCI format 0\_X/1\_X which points to one row of a table defining combinations of co-scheduled cells, and the table is configured by RRC signaling.*   **NEC:**  *Proposal 1: The co-scheduled cells are indicated by an indicator (e.g. 4 bits CIF field) in DCI format 0\_X/1\_X which points to one row of a table defining combinations of co-scheduled cells. RAN1 further discuss whether DCI size should be changed when the indicator changes, i.e. whether DCI size is changed like BWP indicator in legacy DCI.*  **ZTE:**  *Proposal 1: The maximum number of configurable cells for co-scheduling should be equal to the maximum number of co-scheduled cells by a single MC-DCI.*  *Proposal 5: A codepoint of CIF field indicates a row of a table comprising the co-scheduled cells.*   * *The table is configured by RRC.* * *The PDSCH and PUSCH can be configured with different table.* |

### Moderator summary and proposals based on contributions

Maximum number of cells within each set of cells for multi-cell scheduling and indicator of co-scheduled cells have been extensively discussed inn RAN1#110bis-e meeting and formulated in below proposal for further discussion:

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| --- |
| Proposal 3-5rev7:          For a set of cells which is configured for multi-cell scheduling, RAN1 specification supports up to 4 cells within the set of cells.  o    ~~FFS: The maximum number of cells within the set of cells is reported as a UE capability.~~  o    A DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the set of cells.           For multi-cell scheduling, the co-scheduled cells are indicated by an indicator in DCI format 0\_X/1\_X which points to one row of a table defining combinations of co-scheduled cells.   * The table is configured by RRC signaling. |

Regarding maximum number of cells within each set of cells for multi-cell scheduling, companies’ preferences are listed below:

*Maximum 8 cells within a set of cells configured for multi-cell scheduling*:

* *Supported by 3 companies [Nokia, Lenovo, Samsung]*

*Maximum 4 cells within a set of cells configured for multi-cell scheduling*:

* *Supported by 11 companies [CATT, Spreadtrum, Intel, OPPO, CMCC, China Telecom, Apple, NTT DOCOMO, Ericsson, LGE, ZTE]*

Regarding the detailed design of indicator of co-scheduled cells, companies’ preferences are listed below:

Option 1:

* Supported by 20 companies [Huawei, Nokia, vivo, Fujitsu, CATT, Spreadtrum, xiaomi, Intel, OPPO, Lenovo, CMCC, FGI, CAICT, Samsung, NTT DOCOMO, Langbo, LG, ITRI, NEC, ZTE]

Option 2:

* Supported by 2 companies [China Telecom, Ericsson]

Option 3:

* Supported by 1 company [FGI]

Based on above, vast majority companies prefer up to 4 cells within a set of cells and Option 1: predefining a table with each row defining a combination of scheduled cells and using DCI to indicate one row of the table. So the DCI overhead can be reduced and the scheduling flexibility is guaranteed. Regarding Option 2, as mentioned by majority companies, the bit overhead for indicating the co-scheduled cells is a main concern even when the UE is configured with up to 4 cells. Option 3 may need more clarification on detailed design. Since usually more DL serving cells are aggregated in DL CA compared to UL CA, separate configuration of tables for DCI format 0\_X and 1\_X are needed.

Hence, moderator suggests going with similar proposal as Proposal 3-5rev7 in previous meeting to conclude this issue.

### 1st round of discussions

#### Proposal 3-2:

* For a set of cells which is configured for multi-cell scheduling, RAN1 specification supports up to 4 cells within the set of cells.
* A DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the set of cells.
* For a set of cells which is configured for multi-cell scheduling, the co-scheduled cells are indicated by an indicator in DCI format 0\_X/1\_X which points to one row of a table defining combinations of co-scheduled cells for the set of cells.
* The table is configured by RRC signaling for the set of cells.
* The size of the indicator is determined based on the number of rows in the table.
* Separate tables can be configured for multi-cell PDSCH scheduling and multi-cell PUSCH scheduling for the set of cells.

Companies are encouraged to provide comments in the table below.

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| --- | --- |
| **Company** | **Comment** |
| Qualcomm | We are OK with the first bullet.  We are NOT OK with the 2nd bullet. The 2nd bullet relates to our previous comment to Proposal 2-2: *we also consider that the bitwidths of any fields of the DCI 0\_X/1\_X (and also interpretation of any fields) for a set of cells has to be fixed by RRC configuration and does not change regardless of which cells in the set area actually scheduled. We understand there are some proposals on “dynamic interpretation of DCI fields depending on actually co-scheduled cells”. However, such solution has never been discussed/investigated until today, and we do not see the complete solution for such design.* We are not OK with the 2nd bullet until we make sure that the payload size, bitwidths of any fields, and interpretation of any fields, do not change regardless of which cells are actually co-scheduled by the DCI within the set of cells. This must be agreed first. |
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# HARQ enhancements

Based on contributions submitted by companies, below issues are prioritized for discussion in this meeting. Within each sub-section, the summary from moderator’s perspective is listed and followed by draft proposals for further discussion round by round.

## Background and submitted proposals

Regarding this issue, companies’ views are summarized as below:

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| **Huawei, HiSilicon**  *Proposal 11: Accept proposal 4-1rev2 in R1-2210662 that reference PDSCH can be the PDSCH ending last as indicated in the DCI format 1\_X among the set of co-scheduled PDSCHs.*  *Proposal 12: The PDSCH which ends last as indicated in the DCI format is used to determine the last DCI format among the multiple DCI formats which are within the same MO. If ending time of last PDSCH in multiple DCI formats is the same, the PDSCH with the smallest serving cell index can be further adopted to determine the last DCI format.*  **Nokia:**  *Proposal 5.1.1: dl-DataToUL-ACK is used for operation of DCI format 1\_X.*  *Proposal 5.1.2: The reference PDSCH is the PDSCH of the first cell in the table row of the indicated co-scheduled cells.*  *Proposal 5.1.3: The PDSCH of the first cell in the table row of the indicated co-scheduled cells and/or its associated cell is used for the last DCI format determination (for PRI) and DAI counting.*  *Proposal 5.2.1: The Type 1 HARQ-ACK codebook construction is not enhanced / changed for the purpose of multi-cell PDSCH scheduling:*   * *FFS: required additional restrictions*   *Proposal 5.2.2: If the UE is configured with Type 1 HARQ-ACK codebook, the UE is not expecting HARQ-ACK information of a PDSCH scheduled through multi-cell scheduled using DCI format 1\_X that cannot be mapped to the Type 1 HARQ-ACK CB of a PUCCH.*  **Vivo:**  *Proposal 17. For multi-PDSCH scheduled by DCI format 1-X, the reference PDSCH to determine the PUCCH slot is the PDSCH with the latest ending time among the co-scheduled PDSCHs.*  *Proposal 18: For DCI format 1-X, the reference cell index to derive the DCI format order for determining PUCCH resource is the cell index of PDSCH with the smallest serving cell index among the co-scheduled PDSCHs.*  *Proposal 19. For type 2 HARQ-ACK codebook, the reference PDSCH to determine the DAI counter is the PDSCH with smallest serving cell index among the set of co-scheduled cells.*  *Proposal 20. For type-1 HARQ-ACK codebook, K1 extension similar to the multi-PDSCH scheduling should be supported, by extending the design of joint coded SLIVs to the multiple co-scheduled cells, while the R15 SLIV pruning procedure can still be reused.*  *Proposal 21. The TDRA table for mc-DCI scheduling is derived by legacy TDRA table, e.g., pdsch-TimeDomainAllocationList provided in PDSCH-Config, or configured by new RRC parameter.*  *Proposal 22. For detailed TDRA table design, the following two options can be considered:*   * *option 1. each entry in the TDRA table for mc-scheduling always points to all configurable cells, which cells are actually scheduled by a DCI format 1\_X/0\_X are determined based on the cell indicator.* * *option 2. each entry in the TDRA table for mc-scheduling points to a number of co-scheduled cells corresponding to a combination, thus each row of the TDRA table can have different numbers of the entries, there is no need of separate cell indicator field.*   **CATT:**  *Proposal 17: For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_X, the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_X among the set of co-scheduled PDSCHs.*  *Proposal 18: The UE should ignore the NDI value corresponding to the PDSCH/PUSCH in the cell:*   * *If a UE is scheduled by a DCI format 1\_X to receive PDSCH over multiple cells, and if tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated, indicates that, for a cell from the multiple cells, at least one symbol from a set of symbols where the UE is scheduled PDSCH reception in the cell is an uplink symbol.* * *If a UE is scheduled by a DCI format 0\_X to transmit PUSCH over multiple cells, and if tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated, indicates that, for a cell from the multiple cells, at least one symbol from a set of symbols where the UE is scheduled PUSCH transmission in the cell is a downlink symbol*   *Proposal 19: For Type-2 HARQ-ACK codebook, for a set of cells which is co-scheduled by a DCI format 1\_X, the reference PDSCH to determine DAI counting is the PDSCH with smallest serving cell index among the set of co-scheduled cells.*  *Proposal 21: For a set of cells which is co-scheduled by a DCI format 1\_X, the PDSCH with the smallest serving cell index among the set of co-scheduled cells is used to determine last DCI format for PUCCH determination among DCI formats within a same PDCCH MO.*  *Proposal 22: For the case when both DCI format 1\_X and other DCI format are received in a same PDCCH MO for scheduling PDSCHs on the same [reference] scheduled cells, the gNB should indicate the same PRI for the DCI formats in a same PDCCH MO.*  *Proposal 23: When Type-1 HARQ-ACK is configured for multi-cell scheduling, the K1 set extension procedure should be performed for each cell based on the K1 set and TDRA table configured for multi-cell scheduling.*  *Proposal 24: When a cell can be scheduled by both DCI format 1\_X and legacy DCI format, the actual K1 set for Type-1 CB generation is provided by the union of K1 set configured for legacy single-cell scheduling and the extended K1\* set for multi-cell scheduling.*  **Spreadtrum:**  *Proposal 11: If Type-1B is used for Time domain resource allocation field of DCI 1\_X, SLIV pruning and K1 set extension should be applied for Type-1 HARQ-ACK codebook*  **Xiaomi:**  *Proposal 14: For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_X, the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_X among the set of co-scheduled PDSCHs.*  **Intel:**  *Proposal 12*   * *For PUCCH slot/sub-slot determination, the reference PDSCH is the last PDSCH, i.e., with the last ending symbol in co-scheduled cells.*   *Proposal 13*   * *For Type-1 HARQ-ACK codebook for multi-cell scheduling,*    + *For candidate DL slots, with restriction of same SCS for carriers, the candidate DL slots can be determined by minor modification of Rel-17 multi-PDSCH scheduling extended K1 based on K1 for reference PDSCH, and slot offset between reference PDSCH and PDSCHs in different CCs, or simplify based on configured K1 values as in Rel-15 with the restriction that the effective K1 for each CC is always a subset of the configured K1.*   + *For candidate PDSCH within a DL slot, SLIV pruning is based on SLIVs for the corresponding CC, i.e., only adding the single SLIV for the corresponding CC rather than all SLIVs of the row into a set for SLIV pruning for that CC.*   *Proposal 14*   * *For Type-2 HARQ-ACK codebook, for the sub-codebook for multi-cell PDSCH scheduling,*    + *DAI ordering is based on the serving cell index of a reference PDSCH per PDCCH, which is determined by the PDSCH with smallest serving cell index.*   + *For PUCCH transmission power when UCI bits is not greater than 11 bits, the number of HARQ-ACK bits is determined based on the number of HARQ-ACK bits for both single-cell and multi-cell scheduling .*   *Proposal 15*   * *For last DCI determination, either using smallest serving cell index of co-scheduled PDSCHs and starting PDSCH symbol as reference PDSCH for a PDCCH to uniquely determine a last DCI, or do not introduce any enhancement for last DCI determination.*   **OPPO:**  *Proposal 15: For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_X, the reference PDSCH is the scheduled PDSCH ending last as indicated in the DCI format 1\_X among the set of co-scheduled PDSCHs.*  *Proposal 16: For Type-2 HARQ-ACK codebook, for a set of cells which is co-scheduled by a DCI format 1\_X, the reference PDSCH to determine DAI counting is the PDSCH with smallest serving cell index among the set of co-scheduled cells.*  *Proposal 17: For a set of cells which is co-scheduled by a DCI format 1\_X, the PDSCH with the smallest serving cell index among the set of co-scheduled cells is used to determine last DCI format for PUCCH determination among DCI formats within a same PDCCH MO. If there are more than one DCIs scheduling PDSCHs with the same smallest serving cell index, the following alternatives can be further studied:*   * *Alt 1: rely on gNB scheduling, e.g. to indicate same PRI when PDCCHs in the same MO scheduled PDSCHs with the same smallest serving cell.* * *Alt 2: define additional rule on top of smallest serving cell index to identify a unique last DCI format, e.g. using the starting symbol of PDSCH, which is same as the rule for DAI counting.*   *Proposal 18: For Type-1 HARQ-ACK codebook construction, the following alternatives can be considered:*   * *Alt 1: the candidate PDSCH slots are still determined by the configured K1 set while restrict that the slot offset(s) between the co-scheduled PDSCH(s) and the HARQ-ACK is always within the configured K1 set.* * *Alt 2: the K1 set is extended per-cell based on the slot offset between the reference PDSCH and the co-scheduled PDSCH of the target cell and the candidate PDSCH slots are determined by the per-cell extended K1 set.*   *Proposal 19: For determination of possible PDSCH locations within a slot:*   * *If new TDRA table(s) are defined, then modification is needed for SLIV pruning, e.g. the SLIV set for one cell needs to include all the SLIVs corresponding to that cell in the newly defined TDRA tables(s).* * *If legacy TDRA table(s) are reused, then no modification is needed for SLIV pruning.*   *Proposal 20: DCI format 1\_X should not be used to trigger HARQ-ACK retransmission.*  *Proposal 21: To trigger a Type-3 HARQ-ACK codebook, One-shot HARQ-ACK request field in DCI format 1\_X is set to “1”.*  *Proposal 22: To trigger an eType-3 HARQ-ACK codebook, One-shot HARQ-ACK request field in DCI format 1\_X is set to “1”,*   * *If Enhanced Type 3 codebook indicator field is configured as one Type-1A field, it indicates a set index of configured CCs/HARQ processes;* * *If Enhanced Type 3 codebook indicator field is not configured,*   + *If every MCS field in DCI 1\_X is used to carry valid MCS information for a TB, the first set of configured CCs/HARQ processes is triggered; otherwise, the first MCS field not carrying valid MCS information for a TB is used to indicate a set index of configured CCs/HARQ processes.*   **Lenovo:**  *Proposal 14: The PDSCH ending last among a set of co-scheduled PDSCHs by a DCI format 1\_X is used for determining the timing of a PUCCH carrying HARQ-ACK information corresponding to the set of co-scheduled PDSCHs.*  *Proposal 15: For Type-2 HARQ-ACK codebook, for a set of cells which is co-scheduled by a DCI format 1\_X, DAI is associated with the cell with smallest serving cell index among the set of co-scheduled cells.*  *Proposal 16: For a set of cells which is co-scheduled by a DCI format 1\_X, the PDSCH with the smallest serving cell index among the set of co-scheduled cells is used to determine last DCI format for PUCCH determination among DCI formats within a same PDCCH monitoring occasion.*  *Proposal 17: It is up to gNB implementation to resolve the issue when multiple DCI formats are transmitted in same PDCCH monitoring occasion on same scheduling cell for scheduling PDSCHs on same cell.*  *Proposal 18: For Type-1 HARQ-ACK codebook, all the PDSCHs co-scheduled by a DCI format 1\_X should be included in the candidate PDSCH reception occasions of respective cell.*  **FGI:**  *Proposal 10: The reference PDSCH is the PDSCH received in the lastet DL slot (), and if there are more than one PDSCHs received in the latest DL slot (), the PDSCH received in the cell with the lowest serving cell index is determined as the reference PDSCH.*  *Proposal 11: The reference PDSCH is used for DAI counting.*  *Proposal 12: The PUSCH scheduled by the legacy DCI format should be considered as having higher priority than the PUSCH scheduled by the DCI format 0\_X when determining the PUSCH for UCI multiplexing.*  **CAICT:**  *Proposal 4: The PDSCH ending last as indicated in the DCI format 1\_X among the set of co-scheduled PDSCHs is the reference PDSCH for HARQ-ACK timing determination.*  *Proposal 5: For Type-2 HARQ-ACK codebook, for a set of cells which is co-scheduled by a DCI format 1\_X, the reference PDSCH to determine DAI counting is the PDSCH with smallest serving cell index among the set of co-scheduled cells.*  *Proposal 6: For a set of cells which is co-scheduled by a DCI format 1\_X, the PDSCH with the smallest serving cell index among the set of co-scheduled cells is used to determine last DCI format for PUCCH determination among DCI formats within a same PDCCH MO.*  *Proposal 7: If both DCI format 1\_X and other DCI format 1\_0/1\_1/2\_1/1\_X are received in a same PDCCH monitoring occasion, the same PRI could be indicated by gNB in these DCIs.*  **NTT DOCOMO:**  *Proposal 9: For PDSCH-to-HARQ feedback timing indicator, the reference PDSCH should be the PDSCH which ends at last in time domain among the co-scheduled PDSCHs.*  *Proposal 10:*   * *For Type-2 HARQ-ACK codebook, for a set of cells which is co-scheduled by a DCI format 1\_X, the reference PDSCH to determine DAI counting is the PDSCH with smallest serving cell index among the set of co-scheduled cells.* * *For a set of cells which is co-scheduled by a DCI format 1\_X, the PDSCH with the smallest serving cell index among the set of co-scheduled cells is used to determine last DCI format for PUCCH determination among DCI formats within a same PDCCH MO.*   **Samsung:**  *Proposal 22: For determination of PUCCH resource/slot with HARQ-ACK for multiple PDSCHs on multiple cells scheduled by a DCI format 1\_X, the reference PDSCH is the PDSCH on the cell with the smallest index.*   * *The PDSCH corresponding to the cell with the smallest cell index is used to determine the order of DCI formats (and therefore, the “last DCI”) for PUCCH resource determination.*   *Proposal 23: The set of K1 values for DCI format 1\_X is:*   * *Option 1: separately provided from the sets of K1 values for SC-DCI formats,*   + *For Option 1, conclude whether the configured K1 values for DCI format 1\_X can include a value that is not configured for any SC-DCI format;* * *Option 2: included in the union of the sets of K1 values for SC-DCI formats.*   *Proposal 24: For the Type-1 HARQ-ACK codebook, down-select one of:*   * *Option 1: the UE expects to receive co-scheduled PDSCHs in a same slot (i.e., same K0 value);* * *Option 2: the UE can receive co-scheduled PDSCHs in different slots (i.e., different K0 value).*   *Proposal 25: For the TDRA table for multi-cell scheduling, conclude whether the TDRA table for multi-cell scheduling can include rows/entries that are not configured in any single-cell TDRA table.*  *Proposal 26: For Type-1 HARQ-ACK codebook generation:*   * *When K1 values and TDRA rows for multi-cell scheduling are also provided for single-cell scheduling on a cell, and all co-scheduled PDSCHs have a same K0 value, Type-1 CB is same as in Rel-17;* * *Otherwise, candidate PDSCH receptions are generated based on the union of single-cell and multi-cell TDRA tables and K1 values.*   *Proposal 27: For the two Type-2 HARQ-ACK sub-CBs in presence of multi-cell scheduling, clarify that HARQ-ACK corresponding to DCI formats that do not schedule a PDSCH is included in the first sub-CB.*  *Proposal 28: For the second Type-2 HARQ-ACK sub-codebook corresponding to multi-cell scheduling, RAN1 to conclude on the placement of “NACK” values along/within HARQ-ACK information bits for co-scheduled PDSCHs when fewer than a maximum number of cells are co-scheduled.*  *Proposal 29: For a Type-2 HARQ-ACK codebook and for an MC-DCI format 1\_X that schedules multiple PDSCHs on a set of co-scheduled cells:*   * *“serving cell” in the definition of counter DAI in DCI format 1\_X is defined based on a smallest cell index from co-scheduled cells.*   *Proposal 30: If a PUCCH overlaps with PUSCHs scheduled by SC-DCI formats and PUSCHs scheduled by an DCI format 0\_X, the UE multiplexes the UCI in a PUSCH scheduled by an SC-DCI format as in Rel-17.*  *Proposal 31: For multi-PUSCHs scheduled by DCI format 0\_X, when the corresponding UL grant indicates UL DAI but a PUCCH with HARQ-ACK is absent throughout the multi-PUSCHs, the UE does not multiplex HARQ-ACK on any of the PUSCHs.*  **Qualcomm:**  *Proposal 7:*   * *Agree Proposal 4-1rev2, i.e.,*   + *For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_X, the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_X among the set of co-scheduled PDSCHs.* * *Agree Proposal 4-4rev3 with removing the FFS sub-bullet, i.e.,*   + *For a set of cells which is co-scheduled by a DCI format 1\_X, the PDSCH with the smallest serving cell index among the set of co-scheduled cells is used to determine last DCI format for PUCCH determination among DCI formats within a same PDCCH MO.*   **Ericsson:**  *Observation 3: The choice of reference PDSCH for timing of PUCCH should be aligned with related cases used in legacy procedures such as PDSCH repetition or multi-slot PDCHs scheduling.*  *Observation 4: The choice of reference PDSCH for timing of PUCCH does not need to be aligned with the choice of reference PDSCH for DAI counting. The determination of the former impacts what K1 value is signaled, while the latter impacts the arrangements of the HARQ-ACK bits in a codebook.*  *Proposal 16: For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_X, the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_X among the set of co-scheduled PDSCHs (Proposal 4-1rev2 in RAN1#110b-e).*  *Proposal 17: Type-1 HARQ-ACK codebook is supported when a DCI 1\_X schedules PDSCHs across cells.*  *Proposal 18: For Type-1 HARQ-ACK codebook generation corresponding to a set of co-scheduled PDSCHs scheduled by a DCI 1\_X across cells, the timing occasion corresponding to (e.g., ) in is used for a co-scheduled PDSCH on cell c that ends earlier than UL slots from the corresponding PUCCH slot. In case of presence of other HARQ-ACK information corresponding to occasion , bundling of HARQ-ACK information is performed.*  *Proposal 19: For Type-2 HARQ-ACK codebook, for a set of cells which is co-scheduled by a DCI format 1\_X, the reference PDSCH to determine DAI counting is the PDSCH with smallest serving cell index among the set of co-scheduled cells (i.e., Specify 1st bullet in Proposal 4-4-rev3 in RAN1#110b-e).*  *Observation 5: No additional specification is needed or justified for determining the last DCI format for the purpose of PUCCH resource determination when a DCI format 1\_X is involved. Any ambiguity related issue exists in legacy procedures with legacy DCI and is not specific to the introduction of DCI 1\_X.*  *Proposal 20: Existing procedures for determining the last DCI format for the purpose of PUCCH resource determination when a DCI format 1\_X is involved, should be reused (i.e., Do not specify/discuss 2nd bullet in Proposal 4-4rev3 in RAN1#110b-e not needed).*  *Proposal 21: The value of the DAI field in a DCI format 0\_X is applicable for HARQ-ACK multiplexing in any of the PUSCHs when that PUSCH for HARQ-ACK multiplexing is determined following the existing procedures.*  **MediaTek:**  *Proposal 10: Reference PDSCH of a PUCCH carrying HARQ-ACK should be the last PDSCH of co-scheduled PDSCHs by multi-cell scheduling DCI as the majority supported Proposal 4-1rev2 in the moderator summary during RAN1 #110-bis-e [2].*  **LGE：**  *Proposal #17: Consider the following Proposal 4-1rev2 in FL summary at RAN1#110bis-e after deciding whether to apply a same K0 value for co-scheduled cells considering Type-1 HARQ-ACK codebook construction.*   * *For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_X, the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_X among the set of co-scheduled PDSCHs.*   *Proposal #18: Consider how to construct Type-1 HARQ-ACK codebook in case with multi-cell PDSCH scheduling, in terms of following two aspects.*   * *SLIV pruning procedure for the cell schedulable by the multi-cell DCI (e.g. extension of SLIV set as for Rel-17 multi-PDSCH scheduling)* * *Determination of K1 set for the cell schedulable by the multi-cell DCI (e.g. extension of K1 set as for Rel-17 multi-PDSCH scheduling)*   *Proposal #19: Clarify the following aspects for the construction of Type-2 HARQ-ACK codebook in case with multi-cell PDSCH scheduling.*   * *The ordering of HARQ-ACK bits for a DCI format 1\_X in case when one of the cells co-scheduled by the DCI has collision with semi-static UL symbol* * *HARQ-ACK payload size of the second sub-codebook in case when only one DCI 1\_X (scheduling multiple cells) is received by the UE*   *Proposal #20: Support the following Proposal 4-4rev3 in FL summary at RAN1#110bis-e, with update on the last sub-bullet (in red) as below.*   * *For Type-2 HARQ-ACK codebook, for a set of cells which is co-scheduled by a DCI format 1\_X, the reference PDSCH to determine DAI counting is the PDSCH with smallest serving cell index among the set of co-scheduled cells.* * *For a set of cells which is co-scheduled by a DCI format 1\_X, the PDSCH with the smallest serving cell index among the set of co-scheduled cells is used to determine last DCI format for PUCCH determination among DCI formats within a same PDCCH MO.*   + *The last ending (or starting) PDSCH is used to determine the last DCI format in case when both DCI format 1\_X and other DCI format 1\_0/1\_1/1\_2/1\_X are received in a same PDCCH MO on a same scheduling cell for scheduling PDSCH on same smallest scheduled cell index.*   *Proposal #21: Clarify the following aspects for the triggering of Rel-17 Type-3 HARQ-ACK codebook in case with multi-cell PDSCH scheduling.*   * *Whether all the cells co-scheduled by DCI 1\_X trigging a Type-3 CB index are to be included in the HARQ-ACK payload of the (triggered) Type-3 CB index* * *How to determine the MCS field used for indication of Type-3 CB index (in DCI 1\_X) in case of Type-3 CB triggering without PDSCH scheduling*   **NEC:**  *Proposal 3: For HARQ-ACK codebook Type-1 and for joint TDRA indication among cells, a reference cell among multiple cells is used to generate type-1 codebook. Each PDSCH on non-reference cell has the same HARQ-ACK bit position with the corresponding PDSCH indicated by TDRA on the reference cell.*  **ZTE:**  *Proposal 15: The PDSCH with the latest ending symbol and the corresponding k1 offset should be used to determine the PUCCH slot.*  *Proposal 16: No additional specification efforts is needed for supporting the Type-1 codebook for multi-cell scheduling.*  *Proposal 17: The UE should ignore the PDSCH or PUSCH scheduled on the deactivated SCell if the deactivated SCell is scheduled by the DCI format 0\_X/1\_X with a co-scheduled indicator including the deactivated SCell.*  *Proposal 18: For Type-2 codebook, a DCI format 1\_X scheduling more than one cell is associated with the second sub-codebook when only one scheduled cell is activated cell.*  *Proposal 19: For Type-2 codebook, the PDSCH with the smallest cell index should be used to determine the counter DAI order.*  *Proposal 20: For Type-2 codebook, the mechanism of counter DAI order should be used to determine the last DCI when both the DCI format 1\_X and other DCI format 1\_0/1\_1/1\_2/1\_X are received in the same PDCCH monitoring occasion, i.e., the DCI scheduling the PDSCH with the larger serving cell index, or later PDSCH starting time should be the last DCI.* |

## Moderator summary and proposals based on contributions

* On reference PDSCH for HARQ-ACK feedback timing determination

Regarding HARQ-ACK feedback timing determination for co-scheduled cells, as agreed in RAN1#110, a single PDSCH-to-HARQ\_feedback timing indicator is included in the DCI format 1\_X for indicating a slot-level timing offset between a slot where a reference PDSCH is received and the PUCCH slot. Thus, the PUCCH slot is determined based on the reference PDSCH and the indicated K1 value.

Since HARQ-ACK feedback for co-scheduled PDSCHs is to be transmitted in same PUCCH, the reference PDSCH should be the last PDSCH among the co-scheduled PDSCHs so that UE can have sufficient processing time to decode all the co-scheduled PDSCHs and prepare one PUCCH.

Using the PDSCH ending last among the set of co-scheduled PDSCHs as the reference PDSCH for HARQ timing determination has been proposed in RAN1#110bis-e meeting and polished as below Proposal 4-1rev2.

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| Proposal 4-1rev2:  * For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_X, the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_X among the set of co-scheduled PDSCHs. |

For RAN1#111 meeting, regarding reference PDSCH for HARQ-ACK feedback timing determination, 16 companies express their preferences on the reference PDSCH. The summary is listed below.

* *Last PDSCH (supported by 14 companies):* 
  + *Huawei, vivo, CATT, xiaomi, Intel, OPPO, Lenovo, FGI, CAICT, NTT DOCOMO, Qualcomm, Ericsson, MTK, ZTE*
* *1st PDSCH (supported by 1 companies):* 
  + *Nokia,*
* *The smallest cell index (supported by 1 company):* 
  + *Samsung,*

Since using the last PDSCH as the reference PDSCH to determine HARQ-ACK feedback timing can give UE more processing time, moderator suggests going with last PDSCH among co-scheduled cells as the reference. Proposal 4-1 is provided for the first round of discussion, which is same to Proposal 4-1rev2 in final FL summary of RAN1#110bis-e meeting.

* On last DCI format for PUCCH resource determination

For PUCCH resource, it is determined by the last DCI format among DCI formats pointing to a same slot for PUCCH transmission. In legacy operation, the DCI formats are first indexed in an ascending order across serving cell indexes for a same PDCCH monitoring occasion and are then indexed in an ascending order across PDCCH monitoring occasion indexes.

In Rel-18, for a set of cells which is co-scheduled by a DCI format 1\_X, it is straightforward to use the PDSCH with the smallest serving cell index among the set of co-scheduled PDSCHs to determine last DCI format for PUCCH resource determination among DCI formats within a same PDCCH MO.

During RAN1#110bis-e meeting, one legacy issue firstly discussed in Rel-16 MR-DC is raised, i.e., how to determine the last DCI format when multiple DCI formats are transmitted in same PDCCH monitoring occasion on a same scheduling cell for scheduling PDSCHs on a same scheduled cell. The relevant proposal is extensively discussed in previous RAN1 meeting and finally formulated as below.

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| Proposal 4-4rev3:  * For Type-2 HARQ-ACK codebook, for a set of cells which is co-scheduled by a DCI format 1\_X, the reference PDSCH to determine DAI counting is the PDSCH with smallest serving cell index among the set of co-scheduled cells. * For a set of cells which is co-scheduled by a DCI format 1\_X, the PDSCH with the smallest serving cell index among the set of co-scheduled cells is used to determine last DCI format for PUCCH determination among DCI formats within a same PDCCH MO.   + FFS: which PDSCH is used to determine the last DCI format in case when both DCI format 1\_X and other DCI format 1\_0/1\_1/2\_1/1\_X are received in a same PDCCH monitoring occasion on a same scheduling cell for scheduling PDSCHs on same scheduled cell |

For RAN1#111 meeting, regarding last DCI format for PUCCH resource determination, companies’ preferences on the last DCI format determination are summarized as below:

* *Using the PDSCH with smallest cell index among co-scheduled PDSCHs for determining last DCI among multiple DCIs in same MO (supported by 9 companies):*
  + *Vivo, CATT, OPPO, Lenovo, CAICT, NTT DOCOMO, Samsung, Qualcomm, LG,*
* *Using last PDSCH among co-scheduled PDSCHs for determining last DCI among multiple DCIs in same MO (supported by 1 company):* 
  + *Huawei,*
* *Using 1st scheduled PDSCH among co-scheduled PDSCHs for determining last DCI among multiple DCIs in same MO (supported by 1 company):* 
  + *Nokia,*

When multiple DCI formats are transmitted in same PDCCH MO on same scheduling cell for scheduling PDSCHs on same cell, companies’ preferences are summarized as below:

* *Alt 1: it is up to gNB implementation to resolve the issue of last DCI format.*
  + *CATT, Intel, OPPO, Lenovo, CAICT, Ericsson*
* *Alt 2: define additional rules to resolve the issue of last DCI format.*
  + *Intel, OPPO, LG, ZTE*

From moderator’s point of view, for a set of cells co-scheduled by a DCI format 1\_X, one of the set of cells needs to be associated with the DCI format 1\_X. Using the PDSCH with smallest cell index among co-scheduled PDSCHs for determining last DCI among multiple DCIs in same MO, as captured in Proposal 4-4rev3 in RAN1#110bis-e meeting, can be agreeable to all companies. Regarding the issue when both DCI format 1\_X and other DCI formats are received in a same PDCCH MO on a same scheduling cell for scheduling PDSCH on same cell, majority companies prefer up to gNB scheduling to resolve the issues of last DCI format determination, e.g., gNB indicates same PRI for such DCI formats.

Since RAN1#111 is the last meeting for Rel-18 MCE and same issue has been discussed in Rel-16 MR-DC, moderator suggests following same conclusion as Rel-16 MR-DC and leaving it up to gNB to resolve this issue.

Hence, Proposal 4-2 is provided for discussion.

* On Type-2 HARQ-ACK codebook

For Type-2 HARQ-ACK codebook, there is one open issue on DAI counting for DCI format 1\_X. In legacy single cell scheduling operation, DAI is associated with the scheduled cell. For multi-cell scheduling, one DCI schedules multiple serving cells. One of co-scheduled cells should be selected for determining DAI order.

Using the PDSCH with the smallest serving cell index among the set of co-scheduled cells for determining DAI order has been proposed in RAN1#110bis-e meeting and polished as below Proposal 4-4rev3.

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| Proposal 4-4rev3:  * For Type-2 HARQ-ACK codebook, for a set of cells which is co-scheduled by a DCI format 1\_X, the reference PDSCH to determine DAI counting is the PDSCH with smallest serving cell index among the set of co-scheduled cells. * For a set of cells which is co-scheduled by a DCI format 1\_X, the PDSCH with the smallest serving cell index among the set of co-scheduled cells is used to determine last DCI format for PUCCH determination among DCI formats within a same PDCCH MO. * FFS: which PDSCH is used to determine the last DCI format in case when both DCI format 1\_X and other DCI format 1\_0/1\_1/2\_1/1\_X are received in a same PDCCH monitoring occasion on a same scheduling cell for scheduling PDSCHs on same scheduled cell |

For RAN1#111 meeting, companies’ views on determining DAI counting among the set of co-scheduled cells are summarized as below:

* *Using the PDSCH with smallest serving cell index among the set of co-scheduled cells for DAI counting.*
  + *Supported by vivo, CATT, Intel, OPPO, Lenovo, FGI, CAICT, NTT DOCOMO, Samsung, Ericsson, LGE, ZTE*
* *Using the PDSCH of the first cell in the table row of the indicated co-scheduled cells and/or its associated cell is used for DAI counting.*
  + *Supported by Nokia,*

From moderator’s point of view, the simplest way is to define the reference PDSCH for determining DAI counting as the PDSCH with smallest serving cell index among the co-scheduled cells.

Hence, Proposal 4-3 is provided for discussion which is same to Proposal 4-4rev3 in RAN1#110bis-e meeting.

* On Type-1 HARQ-ACK codebook

In RAN1#110bis meeting, below agreement on TDRA indication is made and listed below:

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| **Agreement**  For a set of cells co-scheduled by a DCI format 0\_X/1\_X, time domain resource allocations for the set of cells are indicated by a single TDRA field in the DCI format 0\_X/1\_X.   * Separate {SLIV, mapping type, scheduling offset K0 (or K2)} is indicated for each of co-scheduled PDSCHs/PUSCHs. * FFS details of the TDRA table design |

According to above agreement on TDRA indication, when a DCI format 1\_X is transmitted for co-scheduling multiple PDSCHs on multiple cells, a single TDRA field in the DCI format 1\_X points to one row of a TDRA table where each row of the TDRA table is configured with separate SLIV, mapping type, and scheduling offset (K0) for each of co-scheduled PDSCHs.

Hence, for a DCI format 1\_X scheduling a set of cells, if the PDSCH ending last as indicated in the DCI format 1\_X among the co-scheduled PDSCHs is used as the reference PDSCH for determining the PUCCH timing, then the k1 value indicated by the PDSCH-to-HARQ\_feedback timing indicator field in the DCI format 1\_X is associated with the reference PDSCH among the co-scheduled PDSCHs. According to the indicated k1 value and the determined reference PDSCH, the PUCCH slot can be derived. Furthermore, according to the K1 set and the derived PUCCH slot, the candidate PDSCH reception occasions on each cell can be further derived. The problem is some non-reference PDSCHs of the set of co-scheduled PDSCHs may be located out of the candidate PDSCH reception occasions on the respective cells when the TDRA field in the DCI format 1\_X indicates different K0 values for co-scheduled PDSCHs. Thus, the corresponding HARQ-ACK information for those PDSCHs out of candidate PDSCH reception occasions cannot be reported in a Type-1 HARQ-ACK codebook.

As agreed in RAN#97 meeting, below agreement is made to support Type-1 HARQ-ACK codebook with restriction of same SCS/carrier type/duplex mode among co-scheduled cells. Whether there are additional restrictions can be discussed in RAN1.

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| Conclusion:   * Deprioritize any optimization for unlicensed spectrum operation for designing the multi-cell PUSCH/PDSCH scheduling in Rel-18. * Enhanced Type-2 HARQ-ACK codebook is not supported for the multi-cell PUSCH/PDSCH scheduling in Rel-18. * Type-1 HARQ-ACK codebook is supported only for the case where co-scheduled cells by a DCI format 1\_X have same SCS/carrier type/duplex mode in Rel-18. * Additional restriction(s) can be discussed in RAN1 * Configuring more than one scheduling cell for DCI format 0\_X/1\_X for each scheduled cell is not supported for the multi-cell PUSCH/PDSCH scheduling in Rel-18. |

For RAN1#111 meeting, companies’ views on Type-1 HARQ-ACK codebook for multi-cell scheduling are summarized. Two companies [Nokia, ZTE] prefer Type-1 HARQ-ACK codebook construction is not enhanced / changed for the purpose of multi-cell PDSCH scheduling. Four companies [Nokia, OPPO, Lenovo, Intel] prefer additional restrictions for Type-1 HARQ-ACK codebook, e.g., all the PDSCHs co-scheduled by a DCI format 1\_X should be included in the candidate PDSCH reception occasions of respective cell, the slot offset(s) between the co-scheduled PDSCH(s) and the HARQ-ACK is always within the configured K1 set, effective K1 for each CC is always a subset of the configured K1, or UE is not expecting HARQ-ACK information of a PDSCH scheduled through multi-cell scheduled using DCI format 1\_X that cannot be mapped to the Type-1 HARQ-ACK CB of a PUCCH. Six companies [Vivo, CATT, Spreadtrum, Intel, OPPO, LG] support K1 set extension as Rel-17 multi-PDSCH scheduling. One company [Samsung] propose down-selection between additional restriction of same K0 value and different K0 value. Two companies [NEC, Ericsson] propose additional rules for Type-1 HARQ-ACK codebook generation.

From moderator’s point of view, considering this is the last meeting to complete Rel-18 MCE and the principle of RAN#97 on simplifying Type-1 HARQ-ACK codebook as well as quite diverse views among companies, the most feasible way is to support Type-1 HARQ-ACK codebook with additional restrictions, e.g., UE is not expecting HARQ-ACK information of a PDSCH scheduled through multi-cell scheduled using DCI format 1\_X that cannot be mapped to the Type-1 HARQ-ACK CB of a PUCCH.

Hence, Proposal 4-4 is provided for 1st round of discussion.

## 1st round of discussions

#### Proposal 4-1:

* For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_X, the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_X among the set of co-scheduled PDSCHs.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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#### Proposal 4-2:

* For a set of cells which is co-scheduled by a DCI format 1\_X, the PDSCH with the smallest serving cell index among the set of co-scheduled cells is used to determine last DCI format for PUCCH determination among DCI formats within a same PDCCH MO.
* It is up to gNB implementation to resolve the last DCI format issue when both DCI format 1\_X and other DCI format 1\_0/1\_1/2\_1/1\_X are received in a same PDCCH monitoring occasion on a same scheduling cell for scheduling PDSCHs on same scheduled cell.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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#### Proposal 4-3:

* For Type-2 HARQ-ACK codebook, for a set of cells which is co-scheduled by a DCI format 1\_X, the reference PDSCH to determine DAI counting is the PDSCH with smallest serving cell index among the set of co-scheduled cells.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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#### Proposal 4-4:

* Type-1 HARQ-ACK codebook is supported for multi-cell scheduling with restriction that HARQ-ACK information for all PDSCHs scheduled by DCI format 1\_X is mapped in the Type-1 HARQ-ACK codebook.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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# Others

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| **Huawei:**  *Proposal 13: Multi-cell PDSCH/PUSCH scheduling and Rel-17 MBS are not expected to be configured simultaneously.*  *Proposal 14: Different priorities should not be by default supported for a UE operating multi-cell PDSCH/PUSCH scheduling.*  **Apple:**  *Proposal 10: RAN1 should discuss the application of default beams for multiple scheduled cells in case when scheduling offset may not be long enough for all of the scheduled cells to apply the indicated TCI in the multi-cell scheduling DCI*  **Samsung:**  *Proposal 32: Support scrambling the CRC of DCI formats 1\_X/0\_X wit CS-RNTI. The SPS PDSCH/CG PUSCH activation/release/retransmission can be determined separately for each of the co-scheduled cells.*  **LGE:**  *Proposal #22: Consider other aspects related to the multi-cell PDSCH/PUSCH scheduling, including the followings.*   * *How to perform CG/SPS activation/release* * *How to indicate TB disabling for PDSCH* * *How to handle the out-of-order HARQ issue*   *Proposal #23: Clarify how to handle the case when the active BWP of a cell among co-scheduled cells is switched to other BWP configured with different SCS from other co-scheduled cells.*  **ITRI:**  *Proposal 4:*   * *A DCI format 0\_X can activate/release a type 2 CG PUSCH transmission on a co-scheduled cell.* * *A DCI format 1\_X can activate/release a SPS PDSCH reception on a co-scheduled cell.*   **NEC:**  *Proposal 4: Two options could be down-select on whether DCI 0\_X/1\_X can be applied for CG/SPS transmission.*   * *Option 1: DCI format 1\_X/0\_X is not used for CG/SPS transmission, i.e. not scrambled with a CS-RNTI.* * *Option 2: DCI format 1\_X/0\_X is used for CG/SPS transmission only one cell is indicated to schedule.* |

# Proposals for online/offline discussion

# References

1. R1-2210856 Discussion on multi-cell scheduling with a single DCI Huawei, HiSilicon
2. R1-2210924 On multi-cell PUSCH/PDSCH scheduling with a single DCI Nokia, Nokia Shanghai Bell
3. R1-2211022 Discussion on multi-cell scheduling vivo
4. R1-2211045Discussion on Multi-cell PUSCH/PDSCH scheduling with a single DCI ZTE
5. R1-2211063 Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI Google Inc.
6. R1-2211082 Consideration on multi-cell PUSCH/PDSCH scheduling with a single DCI Fujitsu
7. R1-2211213 Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI CATT
8. R1-2211244 Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI Spreadtrum Communications
9. R1-2211376 Discussion on the remaining issues for the multi-cell scheduling with a single DCI xiaomi
10. R1-2211414 Discussions on multi-cell scheduling with a single DCI Intel Corporation
11. [R1-2211488](file:///C:\Users\younsun\Documents\3GPP%20documents\RAN1%20tdocs\TSGR1_111\Docs\R1-2211488.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI OPPO
12. [R1-2211534](file:///C:\Users\younsun\Documents\3GPP%20documents\RAN1%20tdocs\TSGR1_111\Docs\R1-2211534.ZIP) Discussion on multi-cell scheduling with a single DCI China Telecom
13. R1-2211585 On multi-cell scheduling via a single DCI Lenovo
14. R1-2211695 Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI CMCC
15. [R1-2211824](file:///C:\Users\younsun\Documents\3GPP%20documents\RAN1%20tdocs\TSGR1_111\Docs\R1-2211824.zip) On multi-cell PUSCH/PDSCH scheduling with a single DCI Apple
16. R1-2211878 Discussion on Multicarrier scheduling with a single DCI FGI
17. R1-2211919 Discussions on multi-cell PUSCH/PDSCH scheduling with a single DCI CAICT
18. R1-2211998 Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI NTT DOCOMO, INC.
19. R1-2212060 On multi-cell PUSCH/PDSCH scheduling with a single DCI Samsung
20. [R1-2212132](file:///C:\Users\younsun\Documents\3GPP%20documents\RAN1%20tdocs\TSGR1_111\Docs\R1-2212132.zip) Multi-cell PUSCH/PDSCH scheduling with a single DCI Qualcomm Incorporated
21. R1-2212156 Multi-cell PUSCH/PDSCH scheduling with a single DCI Ericsson
22. R1-2212190 Discussions on multi-cell PUSCH/PDSCH scheduling with a single DCI Langbo
23. R1-2212252 On multi-cell PUSCH/PDSCH scheduling with a single DCI MediaTek Inc.
24. R1-2212303 Discussion on Multi-cell PUSCH/PDSCH scheduling with a single DCI LG Electronics
25. R1-2212336 Discussion on multi-cell scheduling with a single DCI ITRI
26. R1-2212362 Discussion on Multi-cell PXSCH scheduling with a single DCI NEC

# List of agreements:

## Agreements made in RAN1#109-e

**Agreement**

Agree the following terminologies ONLY for convenience of discussion:

* DCI format 0\_X is used for scheduling multiple PUSCHs on multiple cells with one PUSCH per cell
* DCI format 1\_X is used for scheduling multiple PDSCHs on multiple cells with one PDSCH per cell.

The above does not imply introducing new DCI format(s) at this point.

**Agreement**

* Different TBs are scheduled on different cells by DCI format 0\_X.
* Different TBs are scheduled on different cells by DCI format 1\_X.

**Agreement**

Fallback DCI (i.e., DCI formats 0\_0 and 1\_0) does not support multi-cell scheduling.

**Agreement**

The DCI for multi-cell scheduling is monitored only in USS set.

**Agreement**

* PDSCH cannot be scheduled by DCI format 0\_X.
* PUSCH cannot be scheduled by DCI format 1\_X.

**Agreement**

* All the co-scheduled cells by a DCI format 1\_X and the scheduling cell are included in the same PUCCH group.
* FFS: All the co-scheduled cells by a DCI format 0\_X and the scheduling cell are included in the same [cell or PUCCH group].

**Agreement**

* DCI format 0-X/1-X on a scheduling cell can be used to schedule PUSCHs/PDSCHs on multiple cells including the scheduling cell.
* DCI format 0-X/1-X on a scheduling cell can be used to schedule PUSCHs/PDSCHs on multiple cells not including the scheduling cell.

**Agreement**

* For a UE, the maximum number of cells scheduled by a DCI format 0\_X can be same or different to the maximum number of cells scheduled by a DCI format 1\_X.

**Working Assumption**

* All HARQ-ACK codebook types (Type-1/2/3) are applicable when multi-carrier PDSCH scheduling is configured.

**Agreement**

* One value for the maximum number of co-scheduled cells by a DCI format 0\_X in Rel-18 is selected from {3, 4, 8}.
* For a UE, the maximum number of co-scheduled cells by a DCI format 0\_X can be smaller than or equal to the maximum number supported in Rel-18.

**Agreement**

* One value for the maximum number of co-scheduled cells by a DCI format 1\_X in Rel-18 is selected from {3, 4, 8}.
* For a UE, the maximum number of co-scheduled cells by a DCI format 1\_X can be smaller than or equal to the maximum number supported in Rel-18.

**Agreement**

* **(Working assumption)** DCI format 0\_X/1\_X is a new DCI format for multi-cell scheduling
* DCI format 0\_X can be used for single cell PUSCH scheduling.
* DCI format 1\_X can be used for single cell PDSCH scheduling.
* FFS: UE monitors one of or both multi-cell scheduling DCI and legacy single cell scheduling DCI for a scheduled cell.

**Agreement**

* DCI format 0-X/1-X can be transmitted on PCell.
* DCI format 0-X/1-X can be transmitted on a SCell at least when the DCI format 0-X/1-X does not schedule PUSCH/PDSCH on PCell.
* FFS whether a DCI format 0-X/1-X can be transmitted on an SCell if the DCI format 0-X/1-X schedules PUSCH/PDSCH on PCell.

**Agreement**

Further study DCI size budget including below options for multi-cell scheduling DCI:

* Option 1: Existing DCI size budget is maintained per scheduled cell.
  + Alt 1-1: DCI size budget is maintained via DCI size alignment and DCI size budget of DCI format 0\_X/1\_X is counted for each of the co-scheduled cells.
  + Alt 1-2: DCI size budget is maintained via configured size for multi-cell scheduling DCI and DCI size budget of DCI format 0\_X/1\_X is counted for each of the co-scheduled cells.
  + Alt 1-3: DCI size budget is maintained via DCI size alignment and DCI size budget of multi-cell scheduling DCI is counted only in one scheduled cell.
* Option 2: Existing DCI size budget is not necessarily maintained per scheduled cell.
  + Alt 2-1: DCI size budget of multi-cell scheduling DCI is counted only in one scheduled cell.
  + Alt 2-2: DCI size budget of multi-cell scheduling DCI is not counted per serving cell and not considered in the related serving cell specific DCI size alignment procedure, e.g., for K co-scheduled cells, gNB guarantee the total budget of 3\*K DCI sizes is not exceeded.
  + Alt 2-3: voiding the “3+1” limit for multi-cell scheduling
  + Alt 2-4: the DCI size budget for DCI size alignment can be separately configured for each cell
  + Alt 2-5: DCI size budget of the scheduling cell can be increased to account for the DCI format for multi-cell scheduling. Accordingly, the DCI size budget of a scheduled cell can be reduced.
* Other options/alternatives could be considered.

**Agreement**

Further study BD/CCE counting for multi-cell scheduling DCI based on below options:

* Alt 1: counted on each co-scheduled cell
* Alt 2: counted only in one scheduled cell
* Alt 3: scaled down to each of co-scheduled cell according to the number of co-scheduled cells
* Alt 4: counted as part of the scheduling cell instead of each scheduled cell
* Alt 5: scaled down to each of scheduled cells excluding scheduling cell
* Alt 6: counted on each co-scheduled cell excluding scheduling cell
* Other alternatives could be considered.

**Agreement**

For multi-cell scheduling, the co-scheduled cells are indicated by DCI format 0\_X/1\_X. At least the following options are considered:

* Option 1: An indicator in the DCI points to one row of a table defining combinations of scheduled cells.
  + The table is configured by RRC signaling.
  + FFS: Separate tables can be configured for multi-cell PDSCH scheduling and multi-cell PUSCH scheduling.
* Option 2: An indicator in the DCI is a bitmap corresponding to a set of configured cells that can be scheduled by the DCI 0\_X/1\_X
  + FFS: Separate sets of configured cells for multi-cell PDSCH scheduling and multi-cell PUSCH scheduling.
* Option 3: using existing field (e.g., CIF, FDRA) to indicate whether one or more cells are scheduled or not
* Other options are not precluded.
* Note: It does not preclude other DCI information fields (e.g., BWP) to be jointly indicated by the indicator of the co-scheduled cells.

**Agreement**

For design of multi-cell scheduling DCI, companies are encouraged to consider following types of DCI fields:

* Type-1 field: A single field indicating common information to all the co-scheduled cells or separate information to each of co-scheduled cells via joint indication or an information to only one of co-scheduled cells
* Type-2 field: Separate field for each of the co-scheduled cells, or each sub-group comprising one or more co-scheduled cells where a single field is commonly applied to the co-scheduled cells belonging to a same sub-group
* Type-3 field: Common or separate to each of the co-scheduled cells or to each sub-group.
  + FFS: whether it is dependent on explicit configuration or implicit condition (e.g., intra or inter band CA, FR1 or FR2).
* Other types are not precluded.

## Agreements made in RAN1#110

**Agreement**

All the co-scheduled cells by a DCI format 0\_X and the scheduling cell are included in the same PUCCH group.

**Agreement**

Confirm below working assumption reached in RAN1#109e meeting.

* **(Working assumption)** DCI format 0\_X/1\_X is a new DCI format for multi-cell scheduling

**Working Assumption**

For a cell within a set of cells which can be co-scheduled by a DCI format 0\_X/1\_X, support monitoring the DCI format 0\_X/1\_X and legacy single cell scheduling DCI format(s) from a same scheduling cell.

* The DCI format 0\_X/1\_X and the legacy DCI format(s) can be monitored simultaneously.
  + FFS: whether monitoring of the DCI format 0\_X/1\_X and the legacy DCI format(s) is supported for one, a subset, or all cells within the set of cells.
* FFS: number of different DCI sizes for 0\_X/1\_X and for legacy DCI formats
* FFS: whether to support a subset or all legacy DCI format(s) to be monitored with DCI 0\_X/1\_X

**Working Assumption**

* The maximum number of co-scheduled cells by a DCI format 1\_X in Rel-18 is 4.
* The maximum number of co-scheduled cells by a DCI format 0\_X in Rel-18 is 4.
* FFS: The maximum number of configurable cells for co-scheduling

**Agreement**

For discussing field design of DCI format 0\_X/1\_X which schedules more than one cell, reformulate the types of DCI fields as below:

* Type-1 field:
  + Type-1A field: A single field indicating common information to all the co-scheduled cells
  + Type-1B field: A single field indicating separate information to each of co-scheduled cells via joint indication
  + Type-1C field: A single field indicating an information to only one of co-scheduled cells
* Type-2 field: Separate field for each of the co-scheduled cells
* Type-3 field: Common or separate to each of the co-scheduled cells, or separate to each sub-group, dependent on explicit configuration.
  + Note: One sub-group comprises a subset of co-scheduled cells where a single field is commonly applied to the co-scheduled cell(s) belonging to a same sub-group.
* Note: Handling of any parameters applicable to multi-cell scheduling where corresponding fields are not included in DCI format 0\_X/1\_X (if any) will be separately discussed.

**Agreement**

* For DCI format 1\_X/0\_X which can schedule more than one cell,
* Type-1 fields at least include below:
  + Type-1A:
    - Identifier for DCI formats
    - Downlink assignment index
    - TPC for scheduled PUCCH
    - PUCCH resource indicator
    - PDSCH-to-HARQ timing indicator
    - One-shot HARQ-ACK request
* Type-2 fields at least include below:
  + New data indicator per TB
  + Redundancy version per TB
* FFS: Other fields to be included in DCI format 1\_X/0\_X and which type of the fields belongs to.
* FFS: size for each field

**Agreement**

* When UE detects a DCI format 1\_X scheduling a set of PDSCHs, the UE provides corresponding HARQ-ACK information in a PUCCH transmission within UL slot , where is a number of slots and is indicated by the PDSCH-to-HARQ\_feedback timing indicator field in the DCI format and is the last UL slot overlapping with the DL slot for the reference PDSCH reception for slot-based PUCCH or an UL slot overlapping with the end of the reference PDSCH reception in DL slot for sub-slot based PUCCH.



* FFS details of reference PDSCH

**Agreement**

* For Type-2 HARQ-ACK codebook, two sub-codebooks are generated with a first sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling a single cell and a second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling more than one cell.
* Separate DAI counting for DCI(s) with each scheduling a single cell and DCI(s) with each scheduling more than one cell.
* FFS whether a DCI scheduling more than one cell is associated with the first sub-codebook or the second sub-codebook when the number of cells with actual PDSCH reception due to collision with semi-static TDD DL/UL configuration is one.
* Type-2 HARQ-ACK codebook is generated by concatenating the first sub-codebook and the second sub-codebook.
* If at least one cell of the set of cells which can be co-scheduled by a DCI format 1\_X is configured with maximum 2 codewords per PDSCH without spatial bundling,
  + FFS: the number of HARQ-ACK information bits for each DCI format 1\_X that schedules more than one cell;
* Otherwise, the number of HARQ-ACK information bits for each DCI format 1\_X that schedules more than one cell is equal to N, where N is the maximum number of cells which can be co-scheduled by a DCI format 1\_X in the PUCCH group for the UE.
* HARQ-ACK information bits for co-scheduled PDSCHs by a DCI format 1\_X is ordered based on serving cell indices associated with co-scheduled PDSCHs.
* HARQ-ACK bundling across co-scheduled cells is not supported for multi-cell scheduling.

**Agreement**

UE does not expect to be configured both CBG-based PDSCH/PUSCH transmission and the multi-cell PDSCH/PUSCH scheduling on the same or different cells within a same PUCCH group.

**Agreement**

* At least cases 1-1 and 1-2 on SCS are supported:
* Case 1-1: A DCI format 0-X/1-X on a scheduling cell can schedule multiple cells including the scheduling cell and same SCS is used among all the co-scheduled cells including the scheduling cell.
* Case 1-2: A DCI format 0-X/1-X on a scheduling cell can schedule multiple cells not including the scheduling cell and same SCS is used among all the co-scheduled cells which may be same or different to the SCS of the scheduling cell.
* Case 1-3: A DCI format 0-X/1-X on a scheduling cell can schedule multiple cells including the scheduling cell and different SCS is used among the co-scheduled cells including the scheduling cell.
* Case 1-4: A DCI format 0-X/1-X on a scheduling cell can schedule multiple cells not including the scheduling cell and different SCS is used among the co-scheduled cells.
* FFS: Whether Case 1-3 or 1-4 is additionally supported.

## Agreements made in RAN#97

**Conclusion:**

* Deprioritize any optimization for unlicensed spectrum operation for designing the multi-cell PUSCH/PDSCH scheduling in Rel-18.
* Enhanced Type-2 HARQ-ACK codebook is not supported for the multi-cell PUSCH/PDSCH scheduling in Rel-18.
* Type-1 HARQ-ACK codebook is supported only for the case where co-scheduled cells by a DCI format 1\_X have same SCS/carrier type/duplex mode in Rel-18.
* Additional restriction(s) can be discussed in RAN1
* Configuring more than one scheduling cell for DCI format 0\_X/1\_X for each scheduled cell is not supported for the multi-cell PUSCH/PDSCH scheduling in Rel-18.

**Conclusion:**

* Followings are excluded from multi-cell PDSCH/PUSCH scheduling in Rel-18.
* SCell schedules multiple cells including P(S)Cell
* Different SCS among co-scheduled cells
* Different carrier type (licensed or unlicensed, FR1 or FR2-1 or FR2-2) among co-scheduled cells
* Configuration of both multi-cell PDSCH/PUSCH scheduling and multi-TRP for a scheduled cell
* Support for any sidelink scheduling

**Conclusion:**

* Following is excluded from multi-cell PDSCH/PUSCH scheduling in Rel-18.
* PCell schedules multiple cells by DCI format 0\_X/1\_X when a sSCell is configured to schedule PCell

## Agreements made in RAN1#110bis

**Agreement**

Confirm the following working assumption reached in RAN1#110 meeting.

**Working Assumption**

* The maximum number of co-scheduled cells by a DCI format 1\_X in Rel-18 is 4.
* The maximum number of co-scheduled cells by a DCI format 0\_X in Rel-18 is 4.
* FFS: The maximum number of configurable cells for co-scheduling

**Agreement**

At least the following fields are excluded from DCI format 1\_X/0\_X:

* CBGTI
* CBGFI
* PDSCH group index
* New feedback indicator
* Number of requested PDSCH group(s)
* Sidelink assignment index
* Second TPC command for scheduled PUSCH
* Second SRS resource indicator
* Second Precoding information
* Second PTRS-DMRS association
* Second TPC command for scheduled PUCCH

**Agreement**

For DCI format 1\_X/0\_X, Type-1 fields at least include the following:

* Priority indicator
* Indicator of co-scheduled cells
* beta offset indicator
* CSI request
* UL-SCH indicator
* FFS: ChannelAccess-CPext

**Agreement**

Confirm below working assumption reached in RAN1#110 meeting with revision.

**Working Assumption**

* For any cell within a set of cells which can be co-scheduled by a DCI format 0\_X/1\_X, RAN1 specification supports monitoring the DCI format 0\_X/1\_X and DCI format 0\_0/1\_0, 0\_1/1\_1, and/or 0\_2/1\_2 (if supported by the UE), if configured from a same scheduling cell.
* The DCI format 0\_X/1\_X and the DCI format 0\_0/1\_0/0\_1/1\_1/0\_2/1\_2 can be monitored simultaneously.
* Note: This does not mean a UE is required to support number of BDs/CCEs beyond the Rel-17 limits (i.e., and ) for PDCCH candidates for each scheduled cell.

**Agreement**

For a set of cells co-scheduled by a DCI format 0\_X/1\_X, time domain resource allocations for the set of cells are ~~jointly~~ indicated by a single TDRA field in the DCI format 0\_X/1\_X.

* Separate {SLIV, mapping type, scheduling offset K0 (or K2)} is indicated for each of co-scheduled PDSCHs/PUSCHs.
* FFS details of the TDRA table design

**Agreement**

Confirm below working assumption:

**Working Assumption**

HARQ-ACK codebook types (Type-1, Rel-15 Type-2, Rel-16 Type-3, Rel-17 Type-3) are applicable when multi-cell PDSCH scheduling is configured.

**Working Assumption**

For a set of cells which is configured for multi-cell scheduling,

* Existing DCI size budget is maintained on each cell of the set of cells.
* DCI size of DCI format 0\_X/1\_X is counted on one cell among the set of cells.
  + FFS which cell DCI size of the DCI format 0\_X/1\_X is counted on.
* BD/CCE of DCI format 0\_X/1\_X is counted on one cell among the set of cells.
  + FFS which cell BD/CCE of the DCI format 0\_X/1\_X is counted on.
* Search space of DCI format 0\_X/1\_X is configured on one cell of the set of cells and associated with the search space of the scheduling cell with the same search space ID.
  + FFS which cell the SS of the DCI format 0\_X/1\_X is configured on.
* FFS: How to address Rel-17 BD/CCE limit for any given cell (operating the feature under Rel-17 BD/CCE limit)
* Note: This does not mean a UE is required to support number of BDs/CCEs beyond the Rel-17 limits (i.e., and ) for PDCCH candidates for each scheduled cell.

**Agreement**

* UE does not expect to be configured both multi-PDSCH scheduling and multi-cell PDSCH scheduling on the same or different cells within a same PUCCH group.

**Agreement**

* For Type-2 HARQ-ACK codebook, if at least one cell of a set of cells which can be co-scheduled by DCI format 1\_X is configured with maximum 2 codewords per PDSCH without spatial bundling, the number of HARQ-ACK information bits for each DCI format 1\_X that schedules more than one cell of the set of cells is equal to M, where M is the maximum number of TBs which can be co-scheduled by a DCI format 1\_X in the PUCCH group for the UE.

**Agreement**

* For Type-2 HARQ-ACK codebook, a DCI format 1\_X scheduling more than one cell is associated with the second sub-codebook when the number of cells with actual PDSCH reception due to collision with semi-static TDD DL/UL configuration is one.
* If a UE is scheduled by a DCI format 1\_X to receive PDSCH over multiple cells, and if tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated, indicates that, for a cell from the multiple cells, at least one symbol from a set of symbols where the UE is scheduled PDSCH reception in the cell is an uplink symbol, the UE does not receive the PDSCH in the cell.
* If a UE is scheduled by a DCI format 0\_X to transmit PUSCH over multiple cells, and if tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated, indicates that, for a cell from the multiple cells, at least one symbol from a set of symbols where the UE is scheduled PUSCH transmission in the cell is a downlink symbol, the UE does not transmit the PUSCH in the cell.