**3GPP TSG RAN WG1 Meeting #112 R1-230XXXX**

**Athens, Greece, February 27th – March 3rd, 2023**

**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***
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In this contribution, we summarize the related issues and proposals based on the contributions submitted in RAN1#112 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: Support of simultaneously monitoring DCI format 0\_X/1\_X and legacy DCI formats for cross-carrier scheduling, and support of simultaneously monitoring DCI format 0\_X/1\_X and legacy DCI formats for self-carrier scheduling should be reported separately.***Spreadtrum:***Proposal 3: The DCI format 0\_X/1\_X and DCI format 0\_0/1\_0, 0\_1/1\_1 and/or 0\_2/1\_2 for a multi-scheduled cell can only be from a same scheduling cell.* **Nokia:***Proposal 2.3: 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.,* $M\_{PDCCH}^{max,slot,μ}, C\_{PDCCH}^{max,slot,μ}, M\_{PDCCH}^{total,slot,μ}$ *and* $C\_{PDCCH}^{total,slot,μ}$*) 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 1: 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.***CMCC:***Proposal 1. Monitoring DCI format 0\_X/1\_X and legacy DCI formats simultaneously from different scheduling cells for a scheduled cell should be deprioritized in Rel-18.* |

### 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: Nokia*
	+ *No: Spreadtrum, vivo, xiaomi, CMCC*

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 this is the last meeting to complete the WI and possible standardization effort, moderator suggests not discussing this issue.

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

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| **Huawei, HiSilicon***Proposal 2: Accept the proposal 2-8rev2 in R1-2212924 that 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 3: DCI size alignment rules similar as specified for legacy DCI formats are applicable for multi-cell scheduling PDCCH to maintain the “3+1” DCI size budget.**Proposal 4: Multiple sets of cells scheduled from a same scheduling cell are supported in Rel-18, of which each can be scheduled by a single PDCCH, and different n\_CI values can be configured for different sets of cells when multiple sets of cells are configured for scheduling.***Spreadtrum:***Proposal 1: For DCI format 0\_X/1\_X and legacy DCI formats:* * *Alt 1: The search space configured with DCI format 0\_X/1\_X cannot be configured with legacy DCI formats.*
* *Alt 2: A new UE capability is introduced to report the supportive of monitoring both DCI format 0\_X/1\_X and legacy DCI formats in the same search space*

*Proposal 2: Same reference cell for a set of cells is used, no matter of BWP switching.* *Proposal 4: It needs to clarify the number of search space set with DCI format 0\_X/1\_X, one or multiple.**Proposal 5: The following step for DCI size alignment can be applied.*

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| *Step 0 – Step 3 are same, add Step 2B for DCI format 0\_X/1\_X**Step 4:** + *Step 4A: (unchanged) DCI format 0\_0/1\_0 in USS is aligned to the size in CSS (1)*
	+ *Step 4D: DCI format 0\_X and 1\_X are aligned (2)*
	+ *Step 4B: (unchanged) DCI format 0\_2 and 1\_2 are aligned (3)*
	+ *Step 4C: (unchanged) DCI format 0\_1 and 1\_1 are aligned (4)*
	+ *Step 4E: DCI format 0\_X/1\_X is aligned with DCI format 0\_1/1\_1(3)*
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*Proposal 6: 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 the set of cells.** *The payload size and the bitwidths of all the fields of DCI format 0\_X is the same for any 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 co-scheduled cell combinations of the set of cells*

*Proposal 7: For a cell in a set of multi-cell scheduling cells, DCI format 0\_1 and 1\_1 of the active BWP are the reference legacy DCI format to get legacy configurations of DCI fields for DCI 0\_X and 1\_X, if not mentioned additionally.* **OPPO:***Proposal 1: For multi-cell PDSCH/PUSCH scheduling,** *Multiple cell sets are allowed for a UE.*
* *For multi-cell scheduling in a cell set, 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 identify the scheduled cell set:** *Alt-1: One scheduling cell can schedule multiple cell sets, and cell set identification is included in DCI format 0\_X/1\_X.*
* *Alt-2: One scheduling cell can be configured to schedule only one cell set, and UE can have multiple scheduling cells.*
	+ *A restriction that one scheduling cell of DCI 0\_X/1\_X is not scheduled by another scheduling cell applies.*

*Proposal 7: A scaling factor is introduced to explicitly define the capabilities for single-cell scheduling and multi-cell scheduling.* *Proposal 8: Set a restriction for DCI format configuration, such as DCI format 0\_2/1\_2 and DCI format 0\_X/1\_X cannot be configured simultaneously.***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: In case the reference cell is one cell of the set of cells which search space of DCI format 0\_X/1\_X is configured on and associated with the search space of the scheduling cell with the same search space ID if search space of the DCI format 0\_X/1\_X is configured on the cell in addition to the scheduling cell, the candidates of USS of DCI format 0\_X/1\_X are the summation of candidates of the same aggregation level in the USS with same ID in one scheduled cell and the scheduling cell.**Proposal 10: 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 11: 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 clarified.***Nokia:***Proposal 2.1: The UE can be configured with up to 4 sets of cells within a PUCCH group 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.*
* *The DCI content (DCI field(s), type(s) and/& sizes) can be separately configured for each set of cells.*

*Proposal 2.4: The DCI size for DCI format 0\_X (or 1\_X) for a set of cells is RRC configured.* *Proposal 2.5: Support CRC scrambling for DCI format 0\_X / 1\_X with CRC scrambled by C-RNTI and MCS-C-RNTI** *CRC scrambling for DCI format 0\_X / 1\_X by CS-RNTI is not supported or at least SPS & Type 2 CG activation / release using 0\_X / 1\_X is not supported*
* *CRC scrambling for DCI format 0\_X by SP-CSI-RNTI is not supported*

**Vivo:***Proposal 5. For a set of cells that is configured for multi-cell scheduling, the payload size of DCI format 0\_X/1\_X is derived by UE based on RRC configurations of co-scheduled cell combinations within the set of cells.** *The payload size of DCI format 0\_X is the same for active BWP combination(s) for all the co-scheduled cell combinations of the set of cells.*
* *The payload size of DCI format 1\_X is the same for active BWP combination(s) for all the co-scheduled cell combinations of the set of cells.*
* *The size is determined as the maximum size assumed for mc-DCI scheduling active BWP combination for all the co-scheduled cell combinations*

*Proposal 6. For a field in a mc-DCI, the field size is determined based on the current active BWP combination, and the corresponding information bits are determined based on the configurations of the indicated BWP combination. If the total number of information bits for all fields required for a mc-DCI scheduling a cell combination is smaller than the total number of information bits for a mc-DCI scheduling another cell combination, 0 are padded to the end of the total information bits to align to the mc-DCI size of the other cell combination.**Proposal 7. Field positions of the cell indicator and BWP indicator in a mc-DCI are fixed.**Proposal 8. If a mc-DCI triggers BWP switching, its size is the same as the mc-DCI scheduling the current active BWP combination(s).**Proposal 9. For interpreting a field in mc-DCI triggering BWP switching, the field size is the same as that of the mc-DCI scheduling the active BWP combination(s), furthermore, the information bits in the field are determined based on the configurations of the indicated BWP combination.**Proposal 10. From the perspective of the reference cell, mc-DCI and sc-DCI formats (if configured) should be assigned with the same n\_CI value, and they should be configured in different SSs.**Proposal 11. From the perspective of the reference cell of a cell set, a mc-DCI scheduling the cell set is treated as a unicast DCI for the reference cell.**Proposal 21. If multiple sets of cells which are configured for multi-cell scheduling are supported, the cell sets should be orthogonal, and each cell set has its own unique reference cell.***Xiaomi:***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.**Proposal 3: The UE can be configured with multiple sets of cells for multi-cell scheduling, without overlapped cells among different sets of cells.**Proposal 4: The scheduling cell for different set of cells is separately configured.***CATT:***Proposal 1: More than one set of cells can be configured for a UE.**Proposal 2: If more than one set of cells is configured to be monitored on a same scheduling cell, gNB configures different DCI size for DCI format 0\_X/1\_X corresponding to different cell sets of the same scheduling cell.***China Telecom:***Proposal 1: A UE can be configured one or multiple sets of cells with each set configured for multi-cell scheduling using DCI format 0\_X/1\_X, and multiple sets of cells scheduled from a same scheduling cell is supported in Rel-18.*Proposal 7: *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 cells within 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 derived by UE based on RRC configuration and 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 derived by UE based on RRC configuration and same for all the co-scheduled cell combinations within the set of cells.***NEC:***Proposal 1: Align size of format 0\_X/1\_X after alignment of DCI format 0\_1/1\_1 on the reference cell.***Intel:***Proposal 7** *The multiple cells that can be scheduled by a scheduling cell can be divided into two or more 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 sets of cells*
	+ *For a set of cells, the DCI size can be determined based on the configured sizes of all the DCI fields*

*Proposal 8** *The reference cell for DCI size and BD/CCE counting can be separately determined for the two or more sets of cells that can be scheduled by the same scheduling cell.*
* *The* $n\_{CI}$ *value can be separately determined for the two or more sets of cells that can be scheduled by the same scheduling cell*

*Proposal 9* * *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.*

**CMCC:***Proposal 2. One or multiple sets of cells can be configured for multi-cell scheduling. When multiple sets of cells are configured for multi-cell scheduling,** *Each set of cells consists of completely different cells.*
* *Separate n\_CI values are configured for different sets of cells.*
* *Reference cell for counting DCI size and BD/CCE of DCI format 0\_X/1\_X is independently determined for each set of cells.*
* *Search space configuration of DCI format 0\_X/1\_X is independently configured for each set of cells.*
* *DCI size of DCI format 0\_X is independently determined for each set of cells.*
* *DCI size of DCI format 1\_X is independently determined for each set of cells.*
* *Multiple sets of cells scheduled from a same scheduling cell is supported in Rel-18, and which set of cells the DCI format 1\_X/0\_X is associated with is differentiated by network configuration for the multiple sets of cells.*

*Proposal 3. For a set of cells configured for multi-cell scheduling, 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 is the same for all the co-scheduled cell combinations within the set of cells.*
* *The payload size of DCI format 1\_X is the same for all the co-scheduled cell combinations within the set of cells.*

*Proposal 4. For the DCI size alignment procedure in Rel-18 multi-cell scheduling, the following steps can be considered.** *The DCI size alignment procedure for legacy DCI formats in current specification is performed firstly.*
* *If the total number of different DCI sizes still exceed the restriction of DCI size budget, align the DCI sizes between DCI format 0\_X and DCI format 1\_X by zero padding.*

**CAICT:***Proposal 1: Multiple sets of cells for multi-cell scheduling with a single DCI is supported with the following assumptions:** *a cell in one set of cells can’t be included in another set of cells.*
* *n\_CI value is independently configured for each set of cells.*
* *reference cell for counting DCI size and BD/CCE of DCI format 0\_X/1\_X is independently determined for each set of cells.*
* *search space configuration of DCI format 0\_X/1\_X is independently configured for each set of cells.*
* *DCI size of DCI format 0\_X is independently determined for each set of cells.*
* *DCI size of DCI format 1\_X is independently determined for each set of cells.*

*Proposal 2: Multiple sets of cells scheduled from a same scheduling cell is supported. The set of cells the DCI format 1\_X/0\_X is associated with is differentiated by network configuration.***LG:***Proposal #15: Support the following Proposal 2-8rev2 in the 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 #16: Clarify how to specifically determine the number of PDCCH candidates for multi-cell DCI based on the agreement made in RAN1#111.**Proposal #17: Clarify whether the reference 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 #18: 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 #19: 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.** *Ordering of alignment between DCI format 0\_X/1\_X and legacy DCI format (e.g. , DCI 0\_X/1\_X 🡪 0\_2/1\_2 🡪 0\_1/1\_1, or DCI 0\_2/1\_2 🡪 0\_X/1\_X 🡪 0\_1/1\_1)*
* *Handling of up to 4 different DCI formats including the DCI 0\_X/1\_X*

*Proposal #20: On multiple sets of cells configured for multi-cell scheduling, Alt 1 or Alt 2 is preferred to avoid increase of the multi-cell DCI payload size.** *Alt 1: Multiple sets of cells scheduled from a same scheduling cell is not supported in Rel-18.*
* *Alt 2: Multiple sets of cells scheduled from a same scheduling cell is supported in Rel-18, where which set of cells the DCI format 1\_X/0\_X is associated with is differentiated by network configuration for the multiple sets of cells.*

**Samsung:***Proposal 1: Support only one set of cells configured for multi-cell scheduling from a same scheduling cell in Rl-18.** *Accordingly, conclude the FFS on “the maximum number of configurable cells for co-scheduling” as 4 cells.*

*Proposal 3: 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 4: 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.** *The size of DL MC-DCI format 1\_X can be different from the size of UL MC\_DCI format 0\_X.*

*Proposal 5: For a “reference” cell configured with both SC-DCI formats and MC-DCI formats, DCI size alignment procedures of [TS 38.212] can be extended to incorporate the DCI formats 0\_X/1\_X:** *If the “3+1” rule is not satisfied after performing the Rel-17 DCI size alignment procedures for the SC-DCI formats, the UE applies zero padding to whichever of DCI formats 0\_X or 1\_X that has a smaller size, so that they have equal size.*
* *The UE does not expect to be configured a “reference” cell for which, after Rel-17 DCI size alignment procedures for the SC-DCI formats and after DCI size matching between DCI formats 0\_X and 1\_X, the “3+1” rule is not yet satisfied.*

*Proposal 6:* *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 7: For a UE with search space sharing capability, clarify that “serving cell* $n\_{CI,2}$*” can be replaced by the “set of cells configured for multi-cell scheduling” along with the corresponding RRC configured* $n\_{CI}$ *value (per the agreement from RAN1#111).***Langbo:***Proposal 1: 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 is configured on one or all of the cells in the set.**Proposal 2: Only a single set of cells for multi-cell scheduling per scheduling cell is supported.***ITRI:***Proposal 1:** *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.*
	+ *A cell with largest cell-ID indicated by the DCI format 0\_X/1\_X should be ignored from the scheduling, 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.*

*Proposal 2:** *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 by RRC signaling.*
* *When multiple sets of cells are configured for multi-cell scheduling, separate n\_CI values are configured for different sets of cells*

**Apple:***Proposal 1: For multiple sets of cells configured to UE for multi-cells scheduling, same cell should not be supported to be configured as a scheduling cell for more than one set of cells.**Proposal 2: For BD/CCE counting, splitting factor could be supported to divide the budget between DCI format 0\_X/1\_X and legacy DCI formats:** *BD/CCE budget limit per factor as well as a total for a cell should be followed*
* *It can be considered as an optional UE capability*

*Proposal 3: 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.*

*Proposal 4: If both legacy cross-carrier scheduling and single DCI-based multi-cell scheduling is configured to a UE for a cell, then multi-cell scheduling is used for this cell only in combination with at least one more cell from the set (except for the case of self-scheduling), otherwise, if only this cell needs to be scheduled, then legacy cross-carrier scheduling is used***Qualcomm:***Proposal 1: A 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.*

*Proposal 3: Support DCI format 0\_X/1\_X payload/fields adjustment based on SCell activation/deactivation and dormant/non-dormant BWP-switch** *When all the cells in the set of cells is active and non-dormant, the UE monitors DCI format 0\_X/1\_X identified for all the cells in the set of cells. The DCI format 0\_X/1\_X includes all the necessary fields for all the set of cells in the set of cells.*
* *When one or some of the SCell(s) in the set of cells is deactivated or dormancy, the DCI format 0\_X/1\_X payload/fields are adjusted based on active and non-dormant cells in the set of cells.*
* *When only one cell in the set of cells for a DCI format 0\_X/1\_X is active and non-dormant, monitoring the DCI format 0\_X/1\_X can be stopped.*
* *DCI format 0\_X/1\_X payload/fields is adjusted during the time period for SCell activation/deactivation or SCell dormant/non-dormant BWP-switch*
* *During the period, the UE is not required to monitor the DCI format 0\_X/1\_X.*

*Proposal 5: Update the DCI size alignment procedure in TS 38.212 7.3.1.0 to accommodate DCI format 0\_X/1\_X as follows:** *Steps 0, 1, 2, and 2A: same as legacy*
* *Step 2B (after Step 2A): UE determines the sizes of the DCI formats 0\_X and 1\_X*
* *Step 3: same as legacy*
* *Step 4A-0 (before Step 4A):*
	+ *If the number of information bits in the DCI format 0\_X prior to padding is less than the payload size of the DCI format 1\_X counted on the same reference cell, a number of zero padding bits are generated for the DCI format 0\_X until the payload size equals that of the DCI format 1\_X.*
	+ *If the number of information bits in the DCI format 1\_X prior to padding is less than the payload size of the DCI format 0\_X counted on the same reference cell, a number of zero padding bits are generated for the DCI format 1\_X until the payload size equals that of the DCI format 0\_X.*
* *Steps 4A, 4B, 4C: same as legacy*
* *Step 4D (after Step 4C):*
	+ *If the number of information bits in the DCI format 0\_X/1\_X after Step 4A-0 is less than the payload size of the DCI format 1\_1/0\_1 after Step 4C counted on the reference cell, a number of zero padding bits are generated for the DCI format 0\_X/1\_X until the payload size equals that of the DCI format 1\_1/0\_1.*
	+ *If the number of information bits in the DCI format 0\_1/1\_1 after Step 4C counted on the reference cell is less than the payload size of the DCI format 1\_X/0\_X after Step 4A-0 counted on the reference cell, a number of zero padding bits are generated for the DCI format 0\_1/1\_1 until the payload size equals that of the DCI format 1\_X/0\_X.*

**NTT DOCOMO:***Proposal 1: The configuration of multiple sets of cells for a UE should be allowed.** *A cell belongs to at most one set of cells and cannot be included in multiple sets of cells.*

*Proposal 2: If multiple sets of cells are configured for a UE, the scheduling cell for each set of cells can be the same cell or different cell.**Proposal 3: If multiple sets of cells are configured for a UE,** *the corresponding set of cells for the DCI format 0\_X/1\_X is indicated via co-scheduled cell indicator in the DCI format 0\_X/1\_X and the indicated value should be n\_CI value in the search space equation.*
* *the actual co-scheduled cells and corresponding TDRA configurations are indicated via TDRA field in the DCI format 0\_X/1\_X.*

*Proposal 11: 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 12: 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.*
* *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.*

**Ericsson:***Proposal 1: For multi-cell scheduling, maximum number of sets of cell(s) is four.**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: 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.***Google:***Proposal 1: Introduce a new RNTI for DCI format 0\_X/1\_X.**Proposal 2: For DCI size alignment procedure, down select from the following alternatives** *Alt-1: Use legacy Rel. 17 DCI size alignment procedure for DCI format 0\_X/1\_X. It is based on base station implementation to make sure the number of monitored DCI size is under the DCI size budget.*
* *Alt-2: If the number of monitored DCI size exceeds the DCI size budget, the UE aligns the size of DCI format 0\_1/1\_1 to the DCI format 0\_X/1\_X.*

*Proposal 3: Down select a UE behaviour from following alternatives when the reference cell is deactivated.** *Alt-1: The UE does not expect the reference cell to be deactivated (i.e., based on gNB implementation).*
* *Alt-2: The UE counts the DCI size and BD/CCE budget of DCI format 0\_X/1\_X on the reference cell, regardless the reference cell is activated or deactivated.*
* *Alt-3: The UE counts the DCI size and BD/CCE budget of DCI format 0\_X/1\_X on another cell (e.g., scheduling cell or another cell in the set of cell for multi-cell scheduling) when the reference cell is deactivated by the gNB.*

*Proposal 4: If a UE simultaneously monitors DCI format 0\_X/1\_X and legacy DCI format 0\_1/1\_1 on a scheduling cell, the UE suspends monitoring DCI format 0\_X/1\_X when the scheduling cell is the only one active cell in the set of cells for multi-cell scheduling.***MediaTek:***Proposal 1: To maintain the benefit of UE power saving, the same rule for PDCCH monitoring of non-scheduling cells in legacy is applied to R18 multi-cell scheduling:** *A UE does not expect to monitor PDCCH candidates on an active DL BWP of a secondary cell if the UE is configured to monitor PDCCH candidates of PDSCH/PUSCH scheduling for that secondary cell on another serving cell.*

*Proposal 2: 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 4: Use the CCE index formula in 38.213 10.1 to stagger the DCI with different set of scheduled cells. When multiple sets of cells are configured for multi-cell scheduling, separate n\_CI values are configured for different sets of cells. One example is shown below:*

|  |  |
| --- | --- |
| A set of cells which is configured for multi-cell scheduling | nCI (set index) |
| Cell 1, Cell 2, Cell 3, Cell 4 | 0 |
| Cell 2, Cell 3 | 1 |
| Cell 2, Cell 3, Cell 4 | 2 |
| Cell 1, Cell 3 | 3 |

*Proposal 5: When multiple sets of cells are configured for multi-cell scheduling, a scheduled cells combination in one set of cells can’t be included in another set of cells. One example is shown below:*

|  |  |  |
| --- | --- | --- |
| A set of cells which is configured for multi-cell scheduling | nCI (set index) | Scheduled cells combinations in this set |
| Cell 1, Cell 2, Cell 3, Cell 4 | 0 | [1, 2, 3, 4], [1, 2, 3] |
| Cell 2, Cell 3 | 1 | [2, 3], [2], [3]  |
| Cell 2, Cell 3, Cell 4 | 2 | [2, 3, 4], [3, 4], [4] |
| Cell 1, Cell 3 | 3 | [1, 3], [1] |

 |

### Moderator summary and proposals based on contributions

* 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.

|  |
| --- |
| Proposal 2-2 rev1:* 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.
 |

For RAN1#112 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 2 companies: Nokia, Ericsson,*
* DCI 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.
* *Supported by 13 companies: Huawei, Spreadtrum, ZTE, vivo, xiaomi, China Telecom, Lenovo, CMCC, LGE, Samsung, ITRI, NTT DOCOMO, MediaTek,*

From the moderator’s point of view, Proposal 2-8rev2 in RAN1#110bis-e and same Proposal 2-2rev1 in RAN1#111 meeting reflect majority vast 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 2-1 for triggering the discussion with addition that the payload size of DCI format 0\_X/1\_X is equal to the largest payload size among all the co-scheduled cell combinations.

* On DCI size alignment

According to the agreement in RAN1#111, 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, so a UE can monitor up to three different sizes of DCIs scrambled by C-RNTI and one DCI scrambled by RNTI other than C-RNTI. Furthermore, according to the agreements in RAN1#110bis-e meeting, RAN1 specification supports monitoring the DCI format 0\_X/1\_X and legacy single cell scheduling DCI format(s) 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, and 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. Hence, when DCI format 0\_0/1\_0, 0\_1/1\_1, 0\_2/1\_2 and DCI format 0\_X/1\_X are configured to be monitored for a UE, how to align the DCI sizes to maintain the existing DCI size budget including DCI format 0\_X/1\_X needs to be specified.

For RAN1#112 meeting, on DCI size alignment procedure, 11 companies [Huawei, Spreadtrum, ZTE, NEC, Intel, CMCC, LGE, Samsung, Qualcomm, NTT DOCOMO, Google] express their views on how to maintain the existing DCI size budget on the reference cell for a set of cells configured for multi-cell scheduling. As mentioned by some companies, typically, the UE can be configured to count a size of DCI format 0\_X/1\_X on a reference cell which is configured with few DCI sizes (e.g., only 1 or 2 DCI sizes). If existing DCI size budget on the reference cell can’t be maintained, it does make sense to align the size of DCI formats 0\_X and 1\_X by zero padding. Further performing size alignment procedure between DCI format 0\_X/1\_X and DCI format 0\_1/1\_1 is not expected since it requires large padding bits to DCI format 0\_1/1\_1, an extra indicator for indicating single-cell or multi-cell scheduling and against the motivation of introducing multi-cell scheduling. From that perspective, it is straightforward to add the restriction that UE expects “3+1” budget is maintained on the reference cell after size alignment of DCI formats 0\_X and 1\_X by zero padding. Hence, Proposal 2-2 is provided for further collecting companies’ views.

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

In RAN1#111 meeting, RAN1 has agreed that up to 4 cells are supported within a set of cells which is configured for multi-cell scheduling,

|  |
| --- |
| **Agreement**For a set of cells which is configured for multi-cell scheduling, up to 4 cells within the set of cells are supported.* A DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the same set of cells.
 |

For multi-cell scheduling, if a UE can be configured with at most one set of cells for multi-cell scheduling, i.e., up to 4 cells can be co-scheduled by one DCI format 0\_X/1\_X, 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. Hence, multiple sets of cells need to be configured for respective multi-cell scheduling for more flexibility in Rel-18 CA framework.

During RAN1#111 meeting, below proposal is made and fully discussed in online and offline sessions.

|  |
| --- |
| Proposal 2-3 rev4:* 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 by RRC signaling.
* A UE can be configured one or multiple sets of cells with each set configured for multi-cell scheduling using DCI format 0\_X/1\_X.
	+ When multiple sets of cells are configured,
		- a cell in one set of cells can’t be included in another set of cells.
		- n\_CI value is independently configured for each set of cells.
		- reference cell for counting DCI size and BD/CCE of DCI format 0\_X/1\_X is independently determined for each set of cells.
		- search space configuration of DCI format 0\_X/1\_X is independently configured for each set of cells.
		- DCI size of DCI format 0\_X is independently determined for each set of cells.
		- DCI size of DCI format 1\_X is independently determined for each set of cells.
		- Alt 1: Multiple sets of cells scheduled from a same scheduling cell is not supported in Rel-18;
		- Alt 2: Multiple sets of cells scheduled from a same scheduling cell is supported in Rel-18, where which set of cells the DCI format 1\_X/0\_X is associated with is differentiated by network configuration for the multiple sets of cells.
		- Alt 3: Multiple sets of cells scheduled from a same scheduling cell is supported in Rel-18, where the DCI format 1\_X/0\_X has an indication field that indicates which set of cells the DCI format 1\_X/0\_X is associated with.
 |

One open issue is whether to support a same scheduling cell for multiple sets of cells and if supported how to differentiate the set of cells a DCI format 1\_X/0\_X is associated with, e.g., differentiated by network configuration for the multiple sets of cells or by explicit set indication in the DCI format.

For RAN1#112 meeting, 19 companies [Huawei, OPPO, Nokia, vivo, xiaomi, CATT, China Telecom, Intel, CMCC, CAICT, LGE, Samsung, Langbo, ITRI, Apple, Qualcomm, NTT DOCOMO, Ericsson, MediaTek] support multiple sets of cells can be configured for UE for multi-cell scheduling. The detailed views and preferred solutions are summarized as below:

* + - *Alt 1: Multiple sets of cells scheduled from a same scheduling cell is not supported in Rel-18.*
	+ *Supported by 5 companies: OPPO, LG, Samsung, Langbo, Apple,*
		- *Alt 2: Multiple sets of cells scheduled from a same scheduling cell is supported in Rel-18, where which set of cells the DCI format 1\_X/0\_X is associated with is differentiated by network configuration for the multiple sets of cells.*
	+ *Supported by 7 companies: Huawei, xiaomi, CATT, Intel, CMCC, CAICT, LG,*
		- *Alt 3: Multiple sets of cells scheduled from a same scheduling cell is supported in Rel-18, where the DCI format 1\_X/0\_X has an indication field that indicates which set of cells the DCI format 1\_X/0\_X is associated with.*
	+ *Supported by 6 companies: OPPO, Nokia, China Telecom, Qualcomm, NTT DOCOMO, Ericsson,*

Based on above summary, there is no clear majority on the preferred alternatives. For Alt 3, the proponent companies have different preferences on the detailed indicator for set differentiation, e.g., two companies prefer cell set indication in the DCI, two companies prefer using CIF indicating the associated n\_CI for the scheduled set of cells, one company prefer using indicator of co-scheduled cells for cell set indication and TDRA for indicating the scheduled cells within the scheduled cell set, and one company prefer using indicator of co-scheduled cells for cell set indication and FDRA for implicitly indicating the scheduled cells within the scheduled cell set. From moderator’s point of view, one feasible way is to agree multiple sets of cells can be scheduled from different scheduling cells or a same scheduling cell firstly and differentiated by network configuration (e.g., different DCI size, different n\_CI value) when multiple sets of cells are scheduled from a same scheduling cell. It is noted that the reference cell is different for the multiple sets of cells in case of same scheduling cell because “a cell in one set of cells can’t be included in another set of cells”.

Hence, Proposal 2-3 is provided for further collecting companies’ views.

### 1st round of discussions

#### Proposal 2-1:

* 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 and equal to the largest payload size among all the co-scheduled cell combinations.
* The payload size of DCI format 1\_X is the same for all the co-scheduled cell combinations and equal to the largest payload size among all the co-scheduled cell combinations.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | We think a direct RRC configuration of the DCI payload size for DCI format 0\_X / 1\_X per set of cells to be the simpler alternative (for the gNB and UE to handle) and providing more robustness in case of e.g. BWP switching etc. |
| Qualcomm | We are not so sure why we have to agree the main bullet. Once we agree bitwidths of all the field in a DCI format 0\_X/1\_X for a set of cells, the total payload size of DCI format 0\_X/1\_X can be determined. The question related to the subbullets of Proposal 2-1 (and probably also related to Nokia’s point) is, whether the DCI payload size must be kept unchanged even when BWP switching is carried out on one or some or all the cells in the set. It is not clear whether the proposal 2-1 intends to say the payload has to be unchanged regardless of BWP switching. From our point of view, changing DCI payload size according to BWP switch is the existing legacy behavior for legacy DCI formats and hence should naturally be applied to DCI format 0\_X/1\_X. For example, FDRA bits for a cell should be adjusted depending on the bandwidth of the active BWP of the cell.Moreover, we think such DCI payload size adjustment can be extended for SCell deactivation/dormancy. For a deactivated/dormant SCell, there is no data scheduling. Therefore, if a SCell in the set of cells for multi-cell scheduling is deactivated/dormant, the bits in the DCI format 0\_X/1\_X are unnecessary. During the time period for processing SCell deactivation/dormancy, it is possible for the UE to adjust the payload size of the DCI format 0\_X/1\_X. |
| Apple | In principle, we agree that for a given set, the size is fixed regardless of the number of co-scheduled cells. However, we also agree that once the length of each field is agreed, we don’t need explicit configuration of the overall DCI size.From this point of view, we can probably remove the main bullet. |
| Spreadtrum | According to payload size, we also prefer the bitwidths of all the fields are also same, which is per-field basis same, not total payload size basis same. Because for all types of fields in DCI 0\_X/1\_X, the bitwidths of each field are same and equal to the largest payload size among all the co-scheduled cell combinations:* Type-1A/1B fields are applied to each co-scheduled cell, their bitwidths are same, which are independent of co-scheduled cell combination.
* Type-1C field is applied to one cell, it is same
* The only field type is Type-2 field, which has not been discuss yet. But we think the common understanding is the size is also equal to the largest payload size

In a summary, not only the payload size but also the bitwidths of all the fields can be included in the proposal:* For a set of cells which is configured for multi-cell scheduling, the payload size of DCI format 0\_X/1\_X and the bitwidths of all the fields are 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 and the bitwidths of all the fields are the same for all the co-scheduled cell combinations and equal to the largest payload size among all the co-scheduled cell combinations.
* The payload size of DCI format 1\_X and the bitwidths of all the fields are the same for all the co-scheduled cell combinations and equal to the largest payload size among all the co-scheduled cell combinations.
 |
| Xiaomi | We are fine with the principle that the payload of the MC DCI is derived based on the RRC configuration of the co-scheduled cell combination within the set. However, we do see the benefit to change the payload size with the BWP switch. In this sense, the two sub-bullet can be updated, e.g, “The payload size of DCI format 0\_X/1\_X is the same for all the co-scheduled cell combinations and equal to the largest payload size based on the configuration of the active BWP among all the co-scheduled cell combinations” |
| CATT | We are OK with the proposal and agree with spreadtrum and xiaomi. From our point of view, the intention of this proposal is determined the method of DCI payload size determination. Further, the payload size of DCI 0\_1/1\_X is determined based on the sum of DCI field size in the DCI 0\_X/1\_X. We think the main bullet can be updated as following:* 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 according to the sum payload size of all DCI fields in DCI format 0\_X/1\_X, and the payload size of each DCI field in DCI format 0\_X/1\_X is equal to the largest payload size of each field among all the co-scheduled cell combinations.
 |
| ZTE | We support this proposal. For unicast scheduling, the gNB should configure all the necessary configurations for the DCI field for format 0\_X and 1\_X. Therefore, the UE can determine the DCI size based on the configuration. In addition, the DCI size should be fixed and the maximum size should be used. |
| vivo | DisagreeThe proposal indicates that the mc-DCI size remains unchanged even when BWP switching occurs. This means the size must be determined as the largest number of bits assumed for all BWPs configured for all cell combinations in a cell set, and therefore the resulted mc-DCI size would be very large. It is questionable whether mc-DCI can achieve gain with such large DCI size compared to multiple sc-DCI. Secondly, in the legacy DCI size determination procedure, the sc-DCI size is determined based on the configuration of active BWP only. If the active BWP is switched, then the sc-DCI size is changed as well. This principle is particularly beneficial for keeping the sc-DCI size small and reducing PDCCH burden when the active BWP has only a few RBs. Thus, this principle should be considered in mc scheduling as well.Proposal 2-1:* 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 the active BWP (s) of the co-scheduled cell combinations within the set of cells.
* The payload size of DCI format 0\_X is the same for the active BWP (s) for all the co-scheduled cell combinations and equal to the largest payload size among all the co-scheduled cell combinations with active BWP(s).
* The payload size of DCI format 1\_X is the same for the active BWP (s) for all the co-scheduled cell combinations and equal to the largest payload size among all the co-scheduled cell combinations with active BWP(s).

Regarding whether such DCI payload size adjustment can be extended for SCell deactivation/dormancy, as dormancy <->non-dormancy switching is conducted based on typical DCI based BWP switching, we think no special treatment for Scell dormancy is needed. Dormant bwp of the dormant Scell still can be considered in the DCI size determination procedure. Similarly, there is no need to exclude the inactive cell in the DCI size determination, and the size can be derived based on the bwp with *firstActiveDownlinkBWP-Id* |
| Samsung | OK with the proposal. The proposal leads to simple specification/implementation, the principle is typical in NR, and avoids signalling support. We assume that the DCI will be filled with zeros when the usable size is smaller than the maximum size. It should be clear that DCI size determination is based on the configuration of the respective active BWPs (and a reference BWP can be used for a deactivated cell) – as for legacy DCI formats. Impact of BWP switching on certain DCI fields (e.g., FDRA) can be handled based on existing rules in 38.212.  |
| ITRI | Support. The DCI size should not be changed due to BWP switching. |

#### Proposal 2-2:

* For a set of cells which is configured for multi-cell scheduling using DCI format 0\_X/1\_X, if DCI size budget on the reference cell can’t be maintained after performing Rel-17 DCI size alignment procedures for legacy DCI formats, UE applies zero padding to whichever of DCI formats 0\_X or 1\_X that has a smaller size to have equal size.
* The UE expects “3+1” budget is maintained on the reference cell after size alignment of DCI formats 0\_X and 1\_X.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support, but think it would be good to say in which order this is doneWe think it should be step 4D (after the alignment of 0\_1/1\_1) |
| Qualcomm | The proposal is not sufficient – it cannot achieve “3+1” DCI size budget when the UE monitors DCI formats 0\_0/1\_0/0\_1/1\_1/0\_2/1\_2 and DCI formats 0\_X/1\_X that are all counted on the same cell (RAN1 agreed to support this as highlighted below). After the procedure in Proposal 2-2, the UE still has 4 DCI sizes with C-RNTI.**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.

Although monitoring such massive number of DCI formats for the same reference cell would be non-typical, we need to commit the agreement. One simple way is to add one more step, e.g., alignment between DCI format 0\_X/1\_X and DCI format 0\_1/1\_1 that are counted on the same reference cell. Note that we are not OK to agree “4 DCI sizes with C-RNTI”. This violates the RAN1#111 agreement “Existing DCI size budget is maintained on each cell of the set of cells”. |
| Apple | We are generally fine with FL’s proposal and also agree with Nokia’s suggestion |
| Spreadtrum | We support the intention of the proposal to only do DCI 0\_X/1\_X alignment, but the alignment order of DCI format 0\_X/1\_X and legacy DCI format can be studied further. The proposal suggest to do legacy DCI format alignment first, and then DCI 0\_X/1\_X. However, we think DCI 0\_X/1\_X alignment can be done before at least 0\_1/1\_1, to allow DCI 0\_1 and 1\_1 to have its own DCI sizeWe also agree with QC’s comments, so a NOTE is necessary just to emphasis Such as:* + *Step 4A: (unchanged) DCI format 0\_0/1\_0 in USS is aligned to the size in CSS*
	+ *Step 4D: DCI format 0\_X and 1\_X are aligned*
	+ *Step 4B: (unchanged) DCI format 0\_2 and 1\_2 are aligned*
	+ *Step 4C: (unchanged) DCI format 0\_1 and 1\_1 are aligned*

Note: the UE is not expected to handle a configuration that, after applying the above steps, results in the total number of different DCI sizes with C-RNTI configured to monitor is more than 3 for the cell;  |
| Xiaomi | We are fine with the proposal. Meanwhile, we don’t think additional size alignment procedure beside the size alignment of DCI 0\_X and 1\_X is needed. It can be up ot the gNB’s configuration to avoid exceeding the 3+1 limits. |
| CATT | Support. It can up to gNB configuration to ensure the “3+1” budget on reference cell after the size alignment of DCI format 0\_X and DCI format 1\_X. |
| ZTE | We think the ‘3+1’ budget maintenance may be possible for a scheduled cell. However, it may be impossible for a scheduling cell, especially when all the legacy DCI formats (x\_0, x\_1, and x\_2) are configured, based on the agreement of “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.”. The sub-bullet means that the scheduling cell cannot be configured as the reference cell since the self-scheduling is always support for the scheduling cell if the DCI format 0\_0/1\_0/0\_1/1\_1/0\_2/1\_2 configured. While based on previous agreement, the scheduling cell is the reference cell if the scheduling cell is included in the set of cells and search space of the DCI format 0\_X/1\_X is configured only on the scheduling cell.To resolve this, we think all the 4 DCI size budget can be used for C-RNTI as a simplest change, which is also not exceeded the maximum number of DCI size for UE handling. Note, the drawback of alignment between DCI format 0\_X/1\_X and DCI format 0\_1/1\_1 or DCI format 0\_2/1\_2 comprise (1) lead to large padding bits; (2) new flag to indicate different formats, which can also be resolved.  |
| vivo | Support. NW should pick a cell with sufficient DCI budget as the reference cell to avoid alignment between sc-DCI and mc-DCI. |
| Samsung | Support.DCI size matching between DCI 0\_X and DCI 1\_X can be considered if needed, but further size matching between DCI 0\_X/1\_X and single-cell DCI e.g. 0\_1/1\_1 is not reasonable as it would be against the reason for having an MC-DCI, would unnecessarily complicate the DCI size alignment procedure, and would require changes to single-cell scheduling, such as a “single-cell / multi-cell indicator” field in all SC-DCI formats.Also, the order is clear from “*after performing Rel-17 DCI size alignment procedures for legacy DCI formats*”, but OK to add “(after step 4C)” for better clarity. |
| ITRI | Support Nokia’s suggestion |

#### Proposal 2-3:

* A UE can be configured one or multiple sets of cells with each set configured for multi-cell scheduling using DCI format 0\_X/1\_X.
* When multiple sets of cells are configured,
	+ a cell in one set of cells can’t be included in another set of cells.
	+ n\_CI value is independently configured for each set of cells.
	+ reference cell for counting DCI size and BD/CCE of DCI format 0\_X/1\_X is independently determined for each set of cells.
	+ search space configuration of DCI format 0\_X/1\_X is independently configured for each set of cells.
	+ DCI size of DCI format 0\_X is independently determined for each set of cells.
	+ DCI size of DCI format 1\_X is independently determined for each set of cells.
	+ The multiple sets of cells can be scheduled by DCI format 0\_X/1\_X from different scheduling cells.
	+ The multiple sets of cells can be scheduled by DCI format 0\_X/1\_X from a same scheduling cell.
		- Which set of cells the DCI format 0\_X/1\_X is associated with is differentiated by network configuration for the multiple sets of cells.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | SupportWould be good to know the maximum number of sets that can be supported. We think up to 4 sets per PUCCH group could be supported.  |
| Qualcomm | Support in principle.First of all, starting with “a UE can be configured with..” looks like the proposal is mandatory for multi-cell scheduling. Suggest to add “Following is supported: …”.Suggest to rephrase the 2nd sub-sub-bullet as “unique n\_CI value is configured for each set of cells”. It is unclear what “independently” means.Suggest to delete “independently” from 3rd, 4th, 5th, and 6th sub-sub bullets due to the same reason. Unclear what “independently” means.For the last sub-sub-bullet “Which set of cells the DCI format 0\_X/1\_X is associated with is differentiated by network configuration for the multiple set of cells”, it is unclear how to achieve this. For the legacy cross-carrier scheduling, two aspects enable this; (1) different n\_CI values for different scheduled cells from the same scheduling cell, and (2) different CIF field values for different scheduled cells from the same scheduling cell when the DCI payloads for different scheduled cells are the same. We consider the same approach should be taken; i.e., having a DCI field in the DCI format 0\_X/1\_X that indicates the target set of cells. We think both (1) and (2) should be enabled. Otherwise, multi-cell scheduling will create an error case that was not in legacy cross-carrier scheduling.With the above, we suggest to update Proposal 2-3 as follows:* Following is supported in Rel-18 multi-cell scheduling:
* A UE can be configured one or multiple sets of cells with each set configured for multi-cell scheduling using DCI format 0\_X/1\_X.
* When multiple sets of cells are configured,
	+ a cell in one set of cells can’t be included in another set of cells.
	+ Unique n\_CI value is ~~independently~~ configured for each set of cells.
	+ reference cell for counting DCI size and BD/CCE of DCI format 0\_X/1\_X is ~~independently~~ determined for each set of cells.
	+ search space configuration of DCI format 0\_X/1\_X is ~~independently~~ configured for each set of cells.
	+ DCI size of DCI format 0\_X is ~~independently~~ determined for each set of cells.
	+ DCI size of DCI format 1\_X is ~~independently~~ determined for each set of cells.
	+ The multiple sets of cells can be scheduled by DCI format 0\_X/1\_X from different scheduling cells.
	+ The multiple sets of cells can be scheduled by DCI format 0\_X/1\_X from a same scheduling cell.
		- Support a DCI field in DCI format 0\_X/1\_X that indicates the value of n\_CI for the set of cells ~~Which set of cells the DCI format 0\_X/1\_X is associated with is differentiated by network configuration for the multiple sets of cells~~.
 |
| Apple | We agree with the updates from QC on deleting “independently” from the bullets and adding “unique” to n\_CI.We don’t agree and cannot accept the last bullet where multiple sets of cells can be scheduled from the same scheduling cell. First, we have not yet agreed on the number of sets of cells that be configured/supported. Assuming, if we agree on 4, then essentially, based on this bullet, we will have the same cell that be configured to support scheduling of 16 cells for both legacy DCI formats as well as DCI format 0\_X/1\_X. The cell can become extremely overloaded and considering that we maintina legacy BD/CCE as well as DCI size budget, this is highly undesirable. For this reason, we think that the multiple sets of cells should be scheduled by different scheduling cells. |
| Spreadtrum | We support the intention of the proposal for the supportive of multiple sets of cells. And also agree with Apple that the multiple sets of cells should be scheduled by different scheduling cells. In this case,* + The DCI do not need to carry n\_CI.
	+ And “search space configuration of DCI format 0\_X/1\_X is independently configured for each set of cells” does not need, because when multiple sets of cells are from different scheduling cells, the search space configuration of DCI format 0\_X/1\_X is of course independently configured for each set of cells on different scheduling cells.
 |
| Xiaomi | We basically share Apple’s view that different scheduling cell should be used to different set of cells. The overload is an issue if we allow same scheduling cell for different set. Meanwhile, additional standard work is needed possibly to distinguish the scheduling grants for different cell set. |
| CATT | We are OK with the proposal in principle. Regarding the last bullet, there are two methods can be achieved by gNB configuration to differentiate multiple set of cells. i) gNB can configure different DCI sizes for the multiple set of cells. ii) gNB can configure different monitor occasions for the DCI format 0\_X/1\_X associated with different set of cells. If multiple sets of cells scheduled from the same scheduling cell is supported, i.e. up to 2 set of cells, the above methods can be adopt and will not have any impact on the current spec. |
| ZTE | Support the intention of this proposal. In general, the configuration for different sets should be independent. It can be predicted that at most 4 sets can be configured since there are at most 16 cells in CA operation. In this case, the network can differentiate the DCI formats for different sets via implementation. For the last bullet, if the size of DCI formats 0\_X/1\_X for different sets are same, an indicator of different sets may be introduced; if the size of DCI formats 0\_X/1\_X for different sets are different and the scheduling cell is the reference cell for more than one set, DCI size budget is more challenged. |
| vivo | Agree with QC that the n\_CI should be unique for different cell sets.The last sub-bullet, not ok* + - Which set of cells the DCI format 0\_X/1\_X is associated with is differentiated by network configuration for the multiple sets of cells.

It is unclear how would NW ensure this, NW may allocate different CORESET/SS/BWP/CCE for different sets. As UE vender, we prefer a clear guidance for implementation. Once different n\_CI values are configured for different sets, NW can ensure that the configured n\_CI values can distinguish which set of cells the DCI format 0\_X/1\_X is associated with through two aspects:1. Ensure that PDCCH candidates/CCEs for different n\_CI are different; 2. If PDCCH candidates/CCE for two n\_CI are fully overlapped, ensure that the mc-DCI sizes corresponding to the two n\_CI values are different. In this case, UE can distinguish the associated cell set for a received mc-DCI in the BD procedure, mc-DCI does not need to carry a field indicating the n\_CI value.* + The multiple sets of cells can be scheduled by DCI format 0\_X/1\_X from a same scheduling cell.
		- NW should ensure that the configured n\_CI values can distinguish which set of cells the DCI format 0\_X/1\_X is associated with
 |
| Samsung | Partially support.We would first like to note that supporting multiple sets of cells from different scheduling cells may have no spec impact (may not need an agreement). That can be a simple solution to accommodate multi-cell scheduling for more than 4 cells.Supporting multiple sets of cells from a same scheduling cell would involve additional DCI size handling and require additional specification support (per the long list above, and more items may be identified later e.g., in RRC configuration aspects) unless certain restrictions are also agreed. We prefer to take the simple approach at this stage and not support multiple sets of cells from a same scheduling cell but also open to simple solutions/restrictions that avoid/minimize specification impact. |
| ITRI | Support |

# 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

|  |
| --- |
| **Huawei:***Proposal 8: The BWP indicator can be applied for all co-scheduled cells within the cell set when BWP switching happens.**Proposal 9: UL/SUL indicator should be included in DCI format 0\_X (as agreed) and it can be configurable between Type-1A and Type-2 upon gNB configuration.**Proposal 10: Remaining fields in multi-cell scheduling DCI 1\_X are advised to classify as follows:** *Type-1A: Enhanced Type 3 codebook indicator, Priority indicator, ChannelAccess-Cpext, Minimum applicable scheduling offset indicator, SCell dormancy indication, PUCCH Cell indicator.*
* *Type-1C: PDCCH monitoring adaptation indication.*
* *Omitted: HARQ-ACK retransmission indicator.*

*Proposal 11: Remaining fields in multi-cell scheduling DCI 0\_X are advised to classify as follows:** *Type-1A: UL-SCH Indicator, Priority indicator, Invalid symbol pattern indicator, Minimum applicable scheduling offset indicator, SCell dormancy indication.*
* *Type-1B: Beta\_offset indicator.*
* *Type-1C: CSI request, PDCCH monitoring adaptation indication.*

**Spreadtrum:***Proposal 8: The size of Type 1A is based on maximum size of this field in legacy format across all cells in the set configured for the DCI format.** *The field is interpreted as same as this field in the legacy DCI format.*
* *When this field is with less bits in legacy DCI format for a cell, a corresponding number of LSB is interpreted for this cell based on the legacy index*
* *If a cell does not have this field in legacy DCI format, it is ignored for this cell*

*Proposal 9: Type-1B field size is dependent on number of rows in the configured table.* * *Each row in the configured table contains indications for each cell in the set which has this field, which has this field in legacy DCI format*
* *The indications for each cell are interpreted as a part of its legacy DCI format.*

*Proposal 10: If Type-1C field is applied, the smallest serving cell index in the co-scheduled cell combination or the cell with the earliest PDSCH/PUSCH in the time domain can be the cell utilise the field, and the other cells ignore it.* *Proposal 11: Type-2 field sizes can be determined by the maximum number of co-schedulable cells among all possible combinations of co-scheduled cells among the same set of cells indicated by “Indication of scheduled cells”** *Field size of the Type-2 fields is* $max(\sum\_{i}^{co-scheduled cell number}field lenghth \left(cell i\right))$
* *Location of indicated bits for each cell is according to the order of the co-scheduled cells*
* *Size of indicated bits for each cell is fixed, according to legacy formats for each cell*
* *Paddings are at the end of the filed to align the size for all combinations*

*Proposal 12: The undecided fields in DCI format 1\_X are with the below type classification:** *Indicator of co-scheduled cells: Type 1B*
* *Time domain resource assignment: Type 1B*
* *Priority indicator: Type 1A*
* *ChannelAccess-Cpext: Type 1A*
* *Enhanced Type 3 codebook indicator: Type 1A*
* *HARQ-ACK retransmission indicator: omitted*
* *PDCCH monitoring adaptation indication: omitted*
* *PUCCH Cell indicator: omitted*
* *Minimum applicable scheduling offset indicator: omitted*

*Proposal 13: The undecided fields in DCI format 0\_X are with the below type classification:** *Indicator of co-scheduled cells: Type 1B*
* *UL/SUL indicator: Configurable between Type 1A and Type 2*
* *Time domain resource assignment: Type 1B*
* *CSI request: Type 1C*
* *beta offset indicator: Type 1B*
* *UL-SCH indicator: Type 1C or NA*
* *ChannelAccess-CPext-CAPC: Type 1A*
* *Priority indicator: Type 1A*
* *Minimum applicable scheduling offset indicator: omitted*
* *PDCCH monitoring adaptation indication: omitted*

**OPPO:***Proposal 5: RAN1 considers the following alternatives to determine the bit width of Type 2 DCI field:** *Alt 1: The bit width of Type 2 DCI field is determined by the maximum required bit size for the field among all the candidate scheduled cell combinations allowed by the CIF configuration;*
* *Alt 2: The bit width of Type 2 DCI field is determined by N\*M, where N is the maximum number of cells which can be co-scheduled by DCI format 0\_X/1\_X, M is the maximum required bit size for the field among all the cells in the set of cells;*
* *Alt 3: The bit width of Type 2 DCI field is determined by the largest N values among {Mi}, where Mi is the required bit size for the field for cell i in the set of cells.*

**ZTE:***Proposal 1: The agreed Type-1 fields are further categorized as below.** *Type-1 field:*
	+ *Type-1A: Priority indicator*
	+ *Type-1C: CSI request, UL-SCH indicator, beta offset indicator*

*Proposal 2: 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 3: The indicator of co-scheduled cells should belong to Type-1B field and jointly indicate the co-scheduled cells.**Proposal 6: Some pending fields are further categorized as below.** *Type-1A field: enhanced Type 3 codebook indicator, HARQ-ACK retransmission indicator, PUCCH Cell indicator*
* *Type-2 field: HARQ-ACK bitmap*

*Proposal 7: The following fields can be reused in DCI format 0\_X/1\_X without classifying the field type.** *SCell dormancy indication, PDCCH monitoring adaptation indication*

**Nokia:***Proposal 2.2.1: The CIF field is included in DCI format 0\_X/1\_X to indicate only the n\_CI associated with the set of cells.** *Note: The CIF field can therefore not be used to indicate the co-scheduled cell combination.*

*Proposal 2.2.3: For (a search space of) a set of cells which is configured for multi-cell scheduling, the UE can be configured to monitor for DCI format 0\_X or 1\_X or 0\_X & 1\_X.* *Proposal 3.1.1.1: 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 3.1.1.2: On the applicable RRC parameters for DCI formats 0\_X / 1X:** *The RRC parameters applicable for DCI format 0\_1 also apply to DCI format 0\_X, if not agreed otherwise or if not having a DCI format 0\_X specific configuration.*
* *The RRC parameters applicable for DCI format 1\_1 also apply to DCI format 1\_X, if not agreed otherwise or if not having a DCI format 1\_X specific configuration.*

*Proposal 3.1.2.2: The RRC configuration and operation for Type 1B fields in DCI formats 0\_X/1\_X is a as follows:** *A table of size {1...2max\_num\_bits\_DCI\_field, set\_of\_cell\_size} is configured for each Type 1B field in DCI format 0\_X and 1\_X*
	+ *Note: 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*
	+ *Note: e.g. for the SRS request field agreed as Type 1B with up to 4 bits, a table with up 16 rows and up to 4 columns (as up to 4 cells within the set of cells) is configured.*
* *The value range of each of the table entries corresponds to the value range of the DCI field for DCI format 0\_1 / 1\_1*
	+ *Note: e.g. for the SRS request field, the value range within the table will be {00, 01, 10, 11}*
* *The applicable value for a scheduled cell is determined based on the indicated DCI field value in DCI format 0\_X/1\_X determining the table row and the scheduled cell determining the table column.*
* *The applicable value of the scheduled cells is then applied for the scheduling operation in the same way as the DCI field value in DCI format 0\_1 / 1\_1*
	+ *Note: e.g. for the SRS request, the indicated value from the set of 4 possible values {00,01,10,11} is used to determine the SRS request on the scheduled cell of interest based on Table 7.3.1.1.2-24 of 38.212*

*Proposal 3.1.3.1: The Priority Indicator in DCI format 0\_X and 1\_X is 1bit and of Type 1A.* * *The DCI field presence in DCI format 1\_X is RRC configured per set of cells using priorityIndicatorDCI-1-X*
* *The DCI field presence in DCI format 1\_X is RRC configured per set of cells using priorityIndicatorDCI-0-X*

*Proposal 3.1.3.2: The ChannelAccess-CPext field in DCI format 0\_X / 1\_X is of Type 1A. The field size is determined by the largest field size for each of the cells within the set of cells.* *Proposal 3.2.1: Support restricting the number of codewords to 1 for DCI format 1\_X by configuring CodeWordRestriction-DCI-1\_X per set of cells.* * *Note: If CodeWordRestriction-DCI-1\_X is configured, the maximum number of codewords schedulable on a cell for DCI format 1\_X is set to 1. Otherwise, the cell & DL BWP specific configuration of maxNrofCodeWord applies also to scheduling for DCI format 1\_X.*

*Proposal 3.2.2: In addition to the already agreed HARQ & PUCCH related DCI fields in DCI format 1\_X, support the following DCI fields as Type 1A in DCI format 1\_X:* * *Enhanced Type 3 codebook indicator*
	+ *Note: separate configuration for the DCI field presence could be considered per set of cells pdsch-HARQ-ACK-EnhType3DCI-FieldDCI1-X*
* *HARQ-ACK retransmission indicator*
	+ *Note: separate configuration for the DCI field presence could be considered per set of cells using pdsch-HARQ-ACK-RetxDCI-1-X*
* *PUCCH Cell indicator*

*Proposal 3.3.1: The CSI request field in DCI format 0\_X is of Type 1C and CSI request operation is applied to the first cell in the list of scheduled cells.**Proposal 3.3.2: The beta\_offset indicator in DCI format 0\_X is 2bit and of Type 1A.* * *The beta\_offset indicator is present in DCI format 0\_X, if at least one of the cells within the set of cells is configured with betaOffsets as ‘dynamic’*

*Proposal 3.3.3: The UL-SCH indicator field in DCI format 0\_X is 1bit and of Type 1C and applies to the first cell in the list of scheduled cells only. For the remaining cells, UL-SCH presence is assumed (i.e. ‘1’).* *Proposal 3.3.5: The UL / SUL indicator field is of Type 1 C (0~1 bit).* *Proposal 3.3.6: The SRS resource set indicator is included in DCI format 0\_X as a Type 1A field of 1 bit allowing to select a single applicable SRS resource set (from the two SRS resource sets of ‘codebook/non-codebook’).* * *Note: If the field is not to be included in the DCI, clarifications on the feature combination will be needed (feature combination supported and/or which SRS resource set is applicable).*

**Vivo：***Proposal 2. For a cell set, BWP indicator field size is determined based on the maximum size of this field in legacy formats across cells in the cell set configured for the mc-DCI, indication is applied to all co-scheduled cell(s) having 1 or 2 bits for this field in legacy formats; and the corresponding 1 or 2 LSB of the indicator is interpreted independently for each cell based on the BWP ID for the corresponding cell.**Proposal 3. For a cell combination scheduled by a mc-DCI, when the current active BWP of at least one co-scheduled cell in the cell combination is different from the BWP indicated by THE mc-DCI, BWP switching is triggered for that co-scheduled cell(s).**Proposal 4. An extra bit or a codepoint of the BWP indicator indicates that the mc-DCI still schedules the current active BWPs of the scheduled cell combination.**Proposal 13. If a co-scheduled cell becomes inactive or dormant, gNB is still allowed to indicate a cell combination including that cell in DCI format 0\_X/1\_X, UE simply ignores the scheduling information for the inactive/dormant cell.* *Proposal 14. If a co-scheduled cell becomes inactive, the active BWP is assumed to be the first active BWP for that cell when determining the mc-DCI size and field size.* *Proposal 15. The size of the SUL/UL indicator in mc-DCI can be configured according to the deployment.* *Proposal 16. Mc-DCI format includes 1-bit DCI format indicator to indicate whether it is DCI format 0\_X or DCI format 1\_X.* **Xiaomi:***Proposal 7: The UL/SUL indicator is a type 2 field. The field size is sum of {0, 1} bits for each serving cell within the set of co-scheduled cells**Proposal 8: A predefined rule, e.g., in the order of the cell ID is needed to distinguish the target information for each co-scheduled cell for a type 2 DCI field.**Proposal 9: The total bit-length required for a type 2 DCI field is derived based on the configured cell combinations for co-scheduling rather than based on the configured cell number in the set.**Proposal 10: A predefined rule, e.g., from the LSB/MSB of the DCI field is needed to acquire the target information for a co-scheduled cell for a type 1A DCI field.***CATT:***Proposal 4: For Type 1A field, when the indication has no corresponding higher layer parameter for one cell, the UE can interpret the indication by using a default value for the cell.**Proposal 5: For Type 1B field, network configures a table for each BWP and the indicated bit is interpreted as pointing row in the configured table of active BWP of each cell.**Proposal 7: The UL/SUL indicator in a DCI format 0\_X for multi-cell PUSCH scheduling can be the sum of {0, 1} bits for each cell in the set configured for the DCI format 0\_X.**Proposal 8: The TDRA, CSI request and UL-SCH indicator can be defined as Type 1B field in DCI format 0\_X/1\_X.**Proposal 9: The ChannelAcess-CPext, Priority indicator and Beta offset indicator can be designed as Type 1A field in DCI format 0\_X/1\_X.**Proposal 10: The enhanced Type 3 codebook indicator, the HARQ-ACK retransmission indicator and PUCCH Cell indicator can be included in DCI format 1\_X as Type 1A field.**Proposal 11:The minimum applicable scheduling offset indicator, SCell dormancy indication and PDCCH monitoring adaptation indication should be omitted in DCI format 1\_X.**Proposal 12: The enhanced Type 3 codebook indicator and ChannelAccess-Cpext-CACP should be included in DCI format 0\_X and can be defined as Type 1A field.**Proposal 13: The open-loop power control parameter set indication, Invalid symbol pattern indicator, Minimum applicable scheduling offset indicator and SCell dormancy indication can be omitted in DCI format 0\_X.***China Telecom:***Proposal 2: UL/SUL indicator in a DCI format 0\_X for multi-cell PUSCH scheduling is sum of {0, 1} bits for each cell in the set configured for the DCI format 0\_X (i.e., Type 2)** *The number of bit (i.e., 0 or 1) for a cell in the set is determined according to the existing mechanism defined in TS 38.212 for UL/SUL indicator field.*

*Proposal 4:* *A type 1B field in DCI format 0\_X/1\_X indicates one row of a configured table, which contains N elements corresponding respectively to each cell in the associate set and on the cell the single cell scheduling DCI also has the same field.** *N is the number of cells on which the legacy single cell scheduling DCI has the same field in the cell set associated with the format 0\_X/1\_X DCI.*
* *An element is interpreted in the same way as the same field in legacy DCI.*

*Proposal 5: The indicator of co-scheduled cells is a Type-1A field to indicate the set of cells associated with the DCI format 1\_X/0\_X.***Lenovo:***Proposal 5: ChannelAccess-CPext in DCI format 1\_X belongs to Type-1C field.* *Proposal 6: ChannelAccess-CPext in DCI format 0\_X belongs to Type-1B field.* *Proposal 7: TDRA field in DCI format 0\_X/1\_X belongs to Type-1B field.**Proposal 8: Priority indicator in DCI format 0\_X/1\_X belongs to Type-1A field.**Proposal 9: Indicator of co-scheduled cells in DCI format 0\_X/1\_X belongs to Type-1B field.**Proposal 10: Beta offset indicator, UL-SCH indicator and CSI request in DCI format 0\_X belongs to Type-1C field.**Proposal 11: DFI flag, PDCCH monitoring adaptation indication, HARQ-ACK retransmission indicator, Enhanced Type 3 codebook indicator, PUCCH Cell indicator, Minimum applicable scheduling offset indicator, and SCell dormancy indication are excluded from 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 scheduled 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.*

**NEC:***Proposal 2: UE ignores the BWP indicator field in DCI for a cell if BWP indicator value in DCI is not within configured BWP indicator value for the cell.**Proposal 3: It has benefit to study “borrowing” bits from other cell for type-2 field when the bitwidth of the field for a cell of the indicated BWP is larger than the bitwidth of the field for the cell of the active BWP.**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.*

**Intel:***Proposal 2** *For Type 1A field, field size is determined as maximum field size for each cell from configured carrier indication table for multi-cell scheduling.*
	+ *If the field size for a co-scheduled cell is 0, the field in the DCI format 0\_X and/or 1\_X is not applied.*
	+ *If the field size for a co-scheduled cell is less than the determined field size in the DCI format 0\_X and/or 1\_X, LSB of the field is applied.*

*Proposal 3** *For Type 1B field, each row of a configured table for joint indication includes N sub-fields, 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 sub-field based on the indicated carrier index within the N configured cells.*
	+ *The sub-field is pointed to the configuration based on single-cell scheduling.*

*Proposal 4** *For Type 2 field, field size for DCI format 0\_X or 1\_X is determined as maximum size among sum of sub-field size for each cell among all rows of carrier indication table.*

*Proposal 6** *Priority indicator is considered as Type 1B field.*
* *Beta offset indicator is considered as Type 1A field.*
* *UL/SUL indicator is considered as Type 1C field.*
* *CSI request and UL-SCH indicator are considered as Type 1C field.*
	+ *PUSCH in a cell with smallest cell index can be used to carry CSI report.*
	+ *UL-SCH is only applied to the cell carrying CSI report.*
	+ *UE does not expect both UL-SCH and CSI request bit field equal to 0 (i.e., DCI 0\_X does not support A-SRS transmission without PUSCH)*

**CMCC:***Proposal 7. For DCI format 0\_X, UL/SUL indicator should be included, and it can be configured as Type 2 field with separate indicator for each co-scheduled cell within the set of cells.***CAICT:***Proposal 3: Further enhancements are considered to overcome the scheduling restriction if unique RNTI is used in the CRC bit filed.**Proposal 4: 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.***LG:***Proposal #1: Decide the followings as Type 1A field in the multi-cell DCI.** *TDRA*
* *ChannelAccess-CPext-CAPC*
* *Priority indicator*
* *Enhanced Type 3 codebook indicator*
* *HARQ-ACK retransmission indicator*
* *PUCCH Cell indicator*
* *SCell dormancy indication*

*Proposal #2: Decide how to determine the Type 1A field size in multi-cell DCI, by considering different number of configured states/indexes/rows across cells.** *The Type 1A field size is determined Alt A) based on the maximum or Alt B) based on the minimum, among the number of configured states/indexes/rows across cells.*
	+ *With Alt A, some (high) state/index/row indicated via the Type 1A field would be invalid in certain cell X when the cell X is configured with smaller number of states/indexes/rows than the maximum number among cells. For this case, following alternatives can be considered.*
		- *Alt 1: Interpret only MSB or LSB part within Type 1A field for the cell X*
		- *Alt 2: Fill (high) states/indexes/rows with valid values for the cell X*
		- *Alt 3: Apply default value if invalid state/index/row for the cell X is indicated*
		- *Alt 4: Assume no change from latest indication if invalid state for the cell X is indicated*
		- *Alt 5: Assume no scheduling on cell X if invalid state/index/row for the cell X is indicated*

*Proposal #3: Consider how to handle different Priority indicator (“PI”) configuration (i.e., presence or absence) across co-scheduled cells, with following alternatives.** *Alt 1: Assume LP for the cell(s) not configured with PI (note: this might be only applicable to PUSCH scheduling case)*
* *Alt 2: Apply the indicated priority via PI field in multi-cell DCI if all co-scheduled cells are configured with PI, while assuming LP for all cells if at least one of co-scheduled cells is not configured with PI*
* *Alt 3: Assume no scheduling for the cell(s) not configured with PI if HP is indicated via PI field in the multi-cell DCI*

*Proposal #4: consider interaction (or handling) between Type 1B based TCI field in the multi-cell DCI (its associated multi-cell TCI table) and the TCI update by MAC CE.** *For example, updating the multi-cell TCI table based on legacy TCI update (e.g. with restriction (updated to same or smaller number of TCI states) and/or based on rule) or updating the multi-cell TCI table directly by MAC CE (e.g. together or separate with legacy TCI update), can be considered.*

*Proposal #5: The cell to which the beta offset value indicated via multi-cell DCI is applied, is determined as the cell selected for UCI multiplexing on PUSCH (among co-scheduled cells).* *Proposal #6: The cell to which the CSI request indicated via multi-cell DCI is applied, is determined as the cell with lowest cell index or with earliest PUSCH starting symbol (among co-scheduled cells).* * *The cell to which the “no UL-SCH” indication is applied, is determined as same cell.*

*Proposal #7: Decide how to determine the Type 2 field size in multi-cell DCI, by considering different field size (configured for single-cell scheduling) across cells.** *The Type 2 field size as the maximum among the sum of per-cell field sizes (configured for single-cell scheduling) for each co-scheduled cell combination.*

*Proposal #8: Consider reduction of per-cell field size in the multi-cell DCI to reduce total size of Type 2 field in the multi-cell DCI.** *For example, configuring reduced number of HARQ processes (or AP/SRI table rows) for the multi-cell DCI compared to single-cell DCI or applying 1-bit RV (or TPC) for the case of multi-cell DCI based scheduling, can be considered.*

*Proposal #9: Consider how to support/handle different MCS-C-RNTI (associated MCS table) configuration (i.e., presence or absence) across co-scheduled cells, with following alternatives.** *Alt 1: Not allow MCS-C-RNTI based scheduling for the co-scheduled cell combination having at least one cell without MCS-C-RNTI configuration*
* *Alt 2: Apply MCS table associated with C-RNTI in the cell without MCS-C-RNTI configuration even if the multi-cell DCI is scheduled based on MCS-C-RNTI*
* *Alt 3: Assume no scheduling on the cell without MCS-C-RNTI configuration if the multi-cell DCI is scheduled based on MCS-C-RNTI*

*Proposal #11: Consider following aspects for composition of DCI fields in the multi-cell DCI.** *Single-cell DCI format referred for DCI field (e.g. Type 1A/2 based field) composition in the multi-cell DCI*
* *Ordering of multiple fields (associated with a same DCI field based on Type 2) corresponding to different cells in the multi-cell DCI*
* *Omitting the fields corresponding to the invalid (e.g. deactivated or dormant) cell in the multi-cell DCI*
* *Fallback to the field sizes in legacy single-cell DCI in case when only one cell is scheduled by the multi-cell DCI*

*Proposal #13: 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 #14: 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.*

**Samsung:***Proposal 8: Conclude on the following DCI fields as Type-1A:** *ChannelAccess-Cpext, Priority indicator, Invalid symbols pattern;*
* *UL/SUL indicator with 1 bit (as for the BWP indicator) with the same value applicable to scheduled cell(s) with both NUL and SUL carriers.*

*Proposal 9: The size of a Type-1A field (or a field configured as Type-1A) is based on the maximum size of the field across different cells in the set of cells configured for multi-cell scheduling.** *The UE reads, based on the corresponding configuration in each of the cells, a number of LSBs from the field value, and ignores the remaining MSBs, if any.*

*Proposal 10: For the BWP indicator field in a DCI format 0\_X/1\_X, the UE applies BWP switching, if applicable, only for the scheduled cell combination indicated by the DCI format 0\_X/1\_X.** *BWP switching is not applied to non-scheduled cells from the set of cells configured for multi-cell scheduling.*

*Proposal 12: 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 13: For Type-1B fields (possibly expect for the TCI state field) in a DCI format 0\_X/1\_X, when the indicator of co-scheduled cells in the DCI format indicates a cell combination from the set of cells configured for multi-cell scheduling, and when the DCI format indicates a value of a Type-1B field that points to a row from a corresponding joint multi-cell table, the UE:** *Option 1: expects that that a number of entries in the row is always same as the number of cells in the cell combination;*
* *Option 2: reads a first number of entries from the row equal to the number of cells in the cell combination and discards the rest of entries in the row, if any;*
* *Option 3: expects that the row includes a same number of entries as the number of cells in the set of cells, and the UE reads entries with locations/indexes corresponding to the cells in the cell combination.*

*Proposal 14: For TCI state field in DCI format 1\_X:** *A value of the TCI state field in DCI format 1\_X provides new indicated DL/UL/joint TCI states for the co-scheduled cells and for cells in corresponding lists of cells indicated by simultaneousTCI-UpdateList.*

*Proposal 15: Conclude on the following fields as Type-1C:** *CSI request, UL-SCH, and beta offset.*
* *For these fields, the UE determines an applicable PUSCH from co-scheduled PUSCHs, if any, based on Rel-17 rules.*

*Proposal 16: For compression of Type-2 fields in DCI 0\_X/1\_X:** *Support a configurable bit-width for RV and HPN, and also for SRI and TPMI when configured as Type-2 fields;*
* *Support indication of a same MCS value to apply to a PDSCH with 2 TBs/codewords in DCI 1\_X.*

*Proposal 17: For Type-2 fields (and for fields configured as Type-2) in a DCI format 0\_X/1\_X, clarify whether multiple values corresponding to multiple co-scheduled cells have:** *Option 1: different bit-widths based on the corresponding configuration for the respective cell;*
* *Option 2: same bit-width based on the maximum bit-width across different cells in the set of cells configured for multi-cell scheduling (or based on explicit configuration of the bit-width).*

*Proposal 18: For a Type-2 field (or for a field configured as Type-2) in a DCI format 0\_X/1\_X:** *The bit-width of the field is a maximum total bit-width across different cell combinations configured for DCI 0\_X/1\_X.*
* *The UE reads, for each cell indicated by the DCI format 0\_X/1\_X, a number of bits based on the corresponding configuration on the respective cell, and discards the remaining bits, if any.*

*Proposal 19: When a cell from the set of cells configured for multi-cell scheduling is deactivated or dormant, the UE determines a bit-width of a field that is Type-1A or Type-2 or configurable between Type-1A and Type-2 in a DCI format 0\_X/1\_X, based on a reference BWP as in Rel-17 DSS.**Proposal 21: A DCI format 0\_X/1\_X that schedules a cell combination with more than one cell, does not support indication of the following fields:** *Enhanced Type 3 codebook indicator, Minimum applicable scheduling offset indicator, SCell dormancy indication, and PDCCH monitoring adaptation indication.*

*Proposal 22: 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) are omitted or reserved.*

**ITRI:***Proposal 3:** *The UL/SUL indicator in the DCI format 0\_X is a type 1C field.*

*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.*

**Apple:***Proposal 7: For DMRS antenna port indication with format 0\_X/1\_X, when the field type is 1A and when the indicated index by single bitfield is not available in all of the DMRS tables corresponding to each of the co-scheduled cells, then a default index is configured and applied for DMRS antenna port indication for those cells**Proposal 8: SUL/UL indicated field can be supported in the DCI format 0\_X**Proposal 9: If SUL/UL indicated field is agreed to be supported in the DCI format 0\_X, then the baseline should be a single bit field which allows for only one of the cell among the set to support SUL carrier and be actually scheduled** *Additionally, if justified, it can be considered that more than one cell is configured with SUL carrier, but the actual scheduling is still limited to just one SUL carrier*

**Qualcomm:***Proposal 2:* * *Co-scheduled cell indicator is not supported for DCI format 0\_X/1\_X in Rel-18.*

*Proposal 4:** *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*

*Proposal 6:** *Introduce necessary RRC parameters for the following Type-2 fields:*
	+ *For MCS:*
		- *mcs-TableDCI-0-X for PUSCH-Config of UL BWP for each cell*
		- *mcs-TableDCI-1-X for PDSCH-Config of DL BWP for each cell*
	+ *For HPN:*
		- *harq-ProcessNumberSizeDCI-0-X for PUSCH-Config of UL BWP for each cell*
		- *harq-ProcessNumberSizeDCI-1-X for PDSCH-Config of DL BWP for each cell*
	+ *For RV:*
		- *numberOfBitsForRV-DCI-0-X for PUSCH-Config of UL BWP for each cell*
		- *numberOfBitsForRV-DCI-1-X for PDSCH-Config of DL BWP for each cell*
* *For FDRA Type-0:*
	+ *Support RBG size of 32 for BWP size of equal to or larger than 145*
		- *This is for the case where rbg-Size in PUSCH-Config or PDSCH-Config is set to ‘config 2’*

*Proposal 7:** *For Type-1B fields, introduce a RRC parameter that is a list of N entries for each cell (or for each BWP of each cell) that tells the mapping b/w a codepoint of the field and the indicated value for each cell*
	+ *The n-th codepoint of the field corresponds to the n-th entry of the list parameter for the cell*
	+ *In the n-th entry, a value is provided, where the value indicates {RM pattern group(s), ZP CSI-RS resource set, SRS resource set, SRS offset, TCI-state} for the cell*
* *See detailed procedure in Section 3.2 of this contribution*

*Proposal 8:** *For BWP indicator, adopt either of the following options:*
	+ *Opt.1: Introduce list parameter for each cell, similar to the proposal 7 for Type-1B*
		- *An RRC parameter that is a list of up to 4 entries, where each entry has a value from (1, 2, 3, 4). The n-th codepoint of the BWP indicator field of DCI format 0\_X/1\_X corresponds to the n-th entry of the list.*
		- *If the BWP indicator field of a DCI format 0\_X/1\_X indicates the n-th codepoint, the UE checks the value of the n-th entry of the list in the serving cell configuration each cell and determine the BWP to switch, according to the value of the n-th entry.*
	+ *Opt.2: For DCI format 0\_X/1\_X, the association between codepoints of BWP indicator field and BWPs for each cell is always based on Table 7.3.1.1.2-1*
* *For VRB-to-PRB, introduce vrb-ToPRB-InterleaverDCI-1-X-r18 in PDSCH-Config for DL BWP of each cell*
* *For FH flag, introduce frequencyHoppingDCI-0-X-r18 in PUSCH-Config for UL BWP of each cell*
	+ *For PUSCHs scheduled by a DCI format 0\_X, PUSCH repetition Type-B should be either (1) not configured for any of the cells in the set, or (2) configured for all the cells in the set*
* *For PRB bundling size, introduce prb-BundlingTypeDCI-1-X-r18 in PDSCH-Config for DL BWP of each cell*
* *For OLPC parameter set indication, consider to revisit this as “configurable between Type-1A and Type-2” based on the configuration of “Type-1A or Type-2” for SRI field*

*Proposal 9:** *TDRA field is Type-1B*
* *For Antenna port(s) field in DCI format 1\_X, when the field is configured as Type-1A, the UE expects that RRC parameters for PDSCH receptions scheduled by the DCI format 1\_X for any cell in the set for the DCI format 1\_X are configured such that single Table from Tables 7.3.1.2.2-1, 7.3.1.2.2-2, 7.3.1.2.2-3, and 7.3.1.2.2-4 in TS38.212 is used for all the cells.*
* *For Antenna port(s) field in DCI format 0\_X, when the field is configured as Type-1A, the UE expects that RRC parameters for PUSCH transmissions scheduled by the DCI format 0\_X for any cell in the set for the DCI format 0\_X are configured such that single Table from Tables 7.3.1.1.2-6, 7.3.1.1.2-6A, 7.3.1.1.2-7, 7.3.1.1.2-7A, 7.3.1.1.2-8, 7.3.1.1.2-9, 7.3.1.1.2-10, 7.3.1.1.2-11, 7.3.1.1.2-12, 7.3.1.1.2-13, 7.3.1.1.2-14, 7.3.1.1.2-14, 7.3.1.1.2-15, 7.3.1.1.2-16, 7.3.1.1.2-17, 7.3.1.1.2-18, 7.3.1.1.2-19, 7.3.1.1.2-20, 7.3.1.1.2-21, 7.3.1.1.2-22, 7.3.1.1.2-23, 7.3.1.1.2-24, and 7.3.1.1.2-25 in TS38.212 is used for all the cells.*
* *For TPMI field in DCI format 0\_X, when the field is configured as Type-1A, the UE expects that RRC parameters for PUSCH transmissions scheduled by the DCI format 0\_X for any cell in the set for the DCI format 0\_X are configured such that single Table from Tables 7.3.1.1.2-2, 7.3.1.1.2-2A, 7.3.1.1.2-B, 7.3.1.1.2-3, 7.3.1.1.2-3A, 7.3.1.1.2-4, 7.3.1.1.2-4A, 7.3.1.1.2-5, and 7.3.1.1.2-5A in TS38.212 is used for all the cells.*
* *For SRI field in DCI format 0\_X, when the field is configured as Type-1A, the UE expects that RRC parameters for PUSCH transmissions scheduled by the DCI format 0\_X for any cell in the set for the DCI format 0\_X are configured such that single Table from Tables 7.3.1.1.2-28, 7.3.1.1.2-29, 7.3.1.1.2-30, 7.3.1.1.2-31, 7.3.1.1.2-32, 7.3.1.1.2-32A, and 7.3.1.1.2-32B in TS38.212 is used for all the cells.*
* *Support carrier indicator field having up to 3 bits in DCI format 0\_X/1\_X*
* *ChannelAcces-CPext and minimum K0/K2 offset are Type-1A field.*
* *UL/SUL indicator is either (1) 1 bit, or (2) not included in a DCI format 0\_X.*

**NTT DOCOMO:***Proposal 7: For multi-cell scheduling, when antenna port in DCI format 0\_X/1\_X is configured as Type-1A field and the field sizes across cells are different, the field size is determined based on the maximum size among the cells.**Proposal 8: For multi-cell scheduling,* * *priority indicator, beta-offset indicator CSI request and UL-SCH indicator in DCI format 0\_X should be Type-1A field.*
* *priority indicator in DCI format 1\_X should be Type-1A field.*

*Proposal 9: For multi-cell scheduling,* * *ChannelAccess-Cpext-CAPC, SCell dormancy indication, PDCCH monitoring adaptation indication, DFI flag and minimum applicable scheduling offset indicator in DCI format 0\_X should be Type-1A field.*
* *ChannelAccess-Cpext, Enhanced Type 3 codebook indicator, HARQ-ACK retransmission indicator, PUCCH Cell indicator, SCell dormancy indication, PDCCH monitoring adaptation indication and minimum applicable scheduling offset indicator in DCI format 1\_X should be Type-1A field.*

*Proposal 10: For multi-cell scheduling, invalid symbol pattern indicator in DCI format 0\_X should be Type-2 field.***Ericsson:***Proposal 9: For each field (Rate matching indicator, ZP CSI-RS trigger, SRS request, SRS offset indicator, TCI state), the joint indexing for the field across cells in a set is as follows:* * *A joint index table is configured for each set of cells with each row in the table containing index(es) for the respective cells in the set.*
* *An index for a cell points to a corresponding entry in a high-layer configured list for that cell.*

*Proposal 10: For priority indicator in DCI format 1\_X/0\_X** *The bit-field is same as in legacy DCI scheduling single PxSCH (1-bit if present).*
* *The indicated priority is applied to all scheduled PxSCH by DCI 0/1\_X*

*Proposal 11: For beta offset indicator in DCI format 1\_X/0\_X,* * *2 bits if at least one of the cells is configured with ‘dynamic’, otherwise ‘0’ bit.*

*Proposal 12: For CSI request in DCI format 0\_X,* * *Field size is dimensioned to accommodate CSI report on any of the cell in the set and an indication of the cell on which the CSI is to be transmitted. It indicates the cell on which the CSI is to be transmitted and the CSI trigger state for that cell.*

*Proposal 13: For UL-SCH indicator in DCI format 0\_X, field size is 1-bit to indicate whether there is UL-SCH (or not) on the cell(s) for which CSI report/SRS transmission is requested.* *Proposal 14: For DCI format 1\_X/0\_X, RV field size is explicitly configurable (0/1/2 bits per cell).* *Proposal 21: Support 1-bit UL/SUL scheduling indicator in DCI format 0\_X as in the legacy procedures.* |

### Moderator summary and proposals based on contributions

In RAN1#112 meeting, regarding the types for the remaining fields, companies’ views are summarized in below Table 1 and Table 2.

Table 1: Types for remaining fields in 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  |
| Indicator of co-scheduled cells | CT,  | SPRD, ZTE, Lenovo, |  |  |  |  |
| Time domain resource assignment | LG,  | SPRD, CATT, Lenovo, Samsung, QC, DCM, |  |  |  |  |
| Priority indicator | HW, SPRD, ZTE, Nokia, CATT, LG, Lenovo, Samsung, DCM, | Intel, |  |  |  |  |
| ChannelAccess-Cpext | HW, SPRD, Nokia, CATT, LG, Samsung, QC, DCM, |  | Lenovo,  |  |  |  |
| Enhanced Type 3 codebook indicator  | HW, SPRD, ZTE, Nokia, CATT, LG, DCM, |  |  |  |  | Lenovo, Samsung, |
| HARQ-ACK retransmission indicator  | ZTE, CATT, Nokia, LG, DCM, |  |  |  |  | HW, SPRD, Lenovo, |
| PDCCH monitoring adaptation indication  | DCM, |  | HW,  |  |  | SPRD, CATT, Lenovo, Samsung, |
| PUCCH Cell indicator  | HW, ZTE, Nokia, CATT, LG, DCM, |  |  |  |  | SPRD, Lenovo, |
| Minimum applicable scheduling offset indicator | HW, QC, DCM, |  |  |  |  | SPRD, CATT, Lenovo, Samsung, |
| SCell dormancy indication | HW, LG, DCM, |  |  |  |  | CATT, Samsung, Lenovo, |
|  |  |  |  |  |  |  |

Table 2: Types for remaining fields in 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  |
| Indicator of co-scheduled cells | CT,  | SPRD, Lenovo, |  |  |  |  |
| Time domain resource assignment |  | SPRD, CATT, Lenovo, Samsung, QC, DCM, |  |  |  |  |
| Priority indicator | HW, SPRD, ZTE, Nokia, CATT, Lenovo, Samsung, DCM, | Intel,  |  |  |  |  |
| UL-SCH indicator | HW, DCM, | CATT, | SPRD, ZTE, Nokia, Lenovo, Intel, Samsung, |  |  | SPRD, |
| CSI request | DCM, | CATT, | HW, SPRD, ZTE, Nokia, Lenovo, Intel, Samsung, |  |  |  |
| beta\_offset indicator | Nokia, CATT, Intel, DCM, | HW, SPRD, | ZTE, Lenovo, Samsung, |  |  |  |
| ChannelAccess-Cpext | SPRD, Nokia, CATT, Samsung, QC, DCM, | Lenovo,  |  |  |  |  |
| UL/SUL indicator | Samsung, |  | Nokia, Intel, ITRI, Apple, QC, | Xiaomi, CATT, CT, CMCC,  | HW, SPRD, | QC, |
| Open-loop power control parameter set indication |  |  |  |  |  | CATT, |
| DFI flag | DCM, |  |  |  |  | Lenovo, |
| Invalid symbol pattern indicator | HW, Samsung, |  |  | DCM, |  | CATT, |
| PDCCH monitoring adaptation indication | DCM, |  | HW, |  |  | SPRD, Lenovo, Samsung, |
| Minimum applicable scheduling offset indicator | HW, QC, DCM, |  |  |  |  | SPRD, CATT, Lenovo, Samsung, |
| Scell dormancy indication | HW, DCM, |  |  |  |  | CATT, Samsung, Lenovo, |
| SRS resource set indicator | Nokia,  |  |  |  |  |  |

* On DCI field types

Based on above summary, for the detailed field types, majority companies’ views are listed below:

Type-1A field:

* Priority indicator, ChannelAccess-Cpext, enhanced Type-3 codebook indicator, HARQ-ACK retransmission indicator, PUCCH Cell indicator, SCell dormancy indication, beta\_offset indicator, Invalid symbol pattern indicator

Type-1B field:

* Indicator of co-scheduled cells, TDRA,

Type-1C field:

* UL-SCH indicator, CSI request, UL/SUL indicator

Omitted fields:

* PDCCH monitoring adaptation indication, Minimum applicable scheduling offset indicator, DFI flag,
* On the applied cell for Type-1C field

For CSI request, in current spec, a UE is not expected to receive more than one DCI with non-zero CSI request field per slot per cell. Hence, the CSI request field in DCI format 0\_X belongs to Type 1C field and is applied to one of co-scheduled cells. As proposed by 7 companies [Speadtrum, ZTE, Nokia, Lenovo, Fujitsu, Intel, LG], the CSI request indicator is applied to the cell with smallest serving cell index within the co-scheduled cells. However, one company [Ericsson] propose using 2 bits to indicate which cell the indicator is applied. Hence, a proposal is provided to reflect majority companies’ views.

For UL-SCH indicator, it is used for CSI reporting on PUSCH without UL-SCH so that it belongs to Type-1C field and is applied to the cell carrying the CSI report, which is same to the CSI request field.

For beta offset indicator, it is used for UCI multiplexing on one PUSCH. For multi-cell PUSCH scheduling by a DCI format 0\_X, up to one PUSCH is used for UCI multiplexing so that the beta offset indicator is only applied to the cell where the UCI is multiplexed. Therefore, beta offset indicator should belong to Type 1C is applied to the cell with multiplexed UCI.

* On UL/SUL indicator

Regarding UL/SUL indicator, companies’ views are summarized as below:

* *UL/SUL indicator belongs to Type-1A field*
	+ *Supported by Samsung*
* *UL/SUL indicator belongs to Type-1C field*
	+ *Supported by Nokia, Intel, ITRI, Apple, QC,*
* *UL/SUL indicator belongs to Type-2 field*
	+ *Supported by Xiaomi, CATT, CT, CMCC,*
* *UL/SUL indicator belongs to Type-3 field*
	+ *Supported by HW, SPRD*

This issue has been extensively discussed in previous RAN1 meeting and no consensus is reached. For this meeting, moderator intend to propose this field as Type 3 for sake of progress, i.e., configurable between Type-1A and Type-2 based on gNB configuration.

* On DCI field size

For Type-1A field, as mentioned in R1-2212924, it is straightforward to determine the size based on maximum field size among all co-scheduled cell combinations within the set of cells. The indicated field is interpreted independently for all co-scheduled cells. One open issue is how to determine the field size for a cell when it is smaller than the determined field size in the DCI format 0\_X/1\_X. It makes sense to interpret the field for the cell according to LSB of the field as proposed by 4 companies [Spreadtrum, Intel, LG, Samsung].

For Type-1B field, as mentioned in R1-2212924, a Type-1B field in DCI format 0\_X/1\_X indicates one row of a configured table which contains combination of indication for each cell in the corresponding set of cells so that the field size is dependent on number of rows in the configured table which contains information for each cell in the set of cells. Indicated bit is interpreted as pointing to one row in the configured table and an element is interpreted in the same way as the same field in legacy DCI format. One open issue is whether each row in the table contains information for all the cells within the set of cells and independent of actually co-scheduled cells or only for all the actually co-scheduled cells. 6 companies [Spreadtrum, Nokia, China Telecom, Intel, Samsung, Qualcomm] propose each row in the configured table contains indications for each cell in the set of cells.

For Type-1C field, as mentioned in R1-2212924, a Type-1C field in DCI format 0\_X/1\_X indicates information only for a sing cell within the set of cells. A simple rule is needed to determine which cell the Type-1C field is applicable to and it is also dependent on the concrete field, e.g., CSI request, UL-SCH indicator.

For Type-2 field, as mentioned in R1-2212924, a Type-2 field in DCI format 0\_X/1\_X indicates cell-specific information for each cell and indicated bits for each cell is interpreted as legacy formats for the cell independently. One open issue is how to determine the size of a Type-2 field according to the maximum number of cells in the set or maximum number of co-scheduled cells among all co-scheduled cell combinations. There are several alternatives proposed by 6 companies [Spreadtrum, OPPO, xiaomi, Intel, LG, Samsung]. Different co-scheduled cells may have different configurations, which may lead to different field sizes. To ensure field size alignment between gNB and UE and avoid unnecessary bit overhead, the size of a Type-2 field in DCI format 0\_X or DCI format 1\_X is determined as the maximum size among sum of per cell field size among all co-scheduled cell combinations configured for multi-cell scheduling.

### 1st round of discussions

#### Proposal 3-1:

* Priority indicator in DCI format 1\_X/0\_X belongs to Type-1A field.
* The indicated priority is applied to all the co-scheduled PUSCHs/PDSCHs by DCI 0\_X/1\_X.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support |
| Qualcomm | UL intra-UE multiplexing/prioritization is per-FS feature and therefore, typically a UE supports the feature for one (or maybe some but not all) CC in a CA configuration. Does this proposal mean that the priority indicator in DCI format 0\_X/1\_X is enabled only if the UE supports the feature for all the CCs in the set of cells in the CA configuration? |
| Apple | Support |
| Spreadtrum | We support the main bullet. But for the sub-bullet, the interpretation of this field for every co-scheduled cell, there are still some need to consider.* + The existence of Priority indicator. When there is a cell do not support dynamic indication of priority level for dynamic PDSCH/PUSCH with a single DCI format, whether or not it is in DCI 1\_X/0\_X. Two alternatives are listed.
* Alt 1: This field is exist only if each cell in the set of cells has this field in the legacy DCI.
* Alt 2: This field is exist if any cell in the set of cells has this field in the legacy DCI.

We suggest to adopt Alt 1. Since if the priority indication is not configured in the legacy DCI format, priority 0 is assumed. There is no reason to support dynamic indication only on DCI 0\_X/1\_X, but not with DCI 0\_1/1\_1.  |
| Xiaomi | Support |
| CATT | We support this proposal in principle. One clarification is that the indicated priority is applied to the cell(s) have 1bit for this field in legacy format.  |
| ZTE | Support |
| vivo | Support.  |
| Samsung | OK  |
| ITRI | Support. |

#### Proposal 3-2:

* ChannelAccess-Cpext in DCI format 1\_X/0\_X belongs to Type-1A field.
* The indicated channel access information is applied to all the co-scheduled PUSCHs/PDSCHs by DCI 0\_X/1\_X.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support |
| Qualcomm | OK |
| Apple | Support |
| Xiaomi | Fine |
| CATT | Support |
| ZTE | Support |
| vivo | Support.  |
| Samsung | OK  |
| ITRI | Support. |

#### Proposal 3-3:

* CSI request in DCI format 0\_X belongs to Type-1C field.
* This field is applied to the cell with smallest serving cell index among the co-scheduled cells.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support |
| Qualcomm | OK |
| Apple | Fine |
| Xiaomi | We prefer it to be a type 1A but can accept a type 1C if it is the majority view |
| CATT | OK |
| ZTE | Support |
| vivo | Support.  |
| Samsung | OK  |
| ITRI | Support. |

#### Proposal 3-4:

* UL-SCH indicator in DCI format 0\_X belongs to Type-1C field.
* This field is applied to the cell with smallest serving cell index among the co-scheduled cells.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support |
| Qualcomm | OK |
| Apple | Fine |
| Xiaomi | Fine |
| CATT | OK |
| ZTE | Support |
| vivo | Support.  |
| Samsung | OK for progress (the cell with the largest index is probably a better choice).  |
| ITRI | Support. |

#### Proposal 3-5:

* Beta\_offset indicator in DCI format 0\_X belongs to Type-1C field.
* This field is applied to the cell where the UCI is multiplexed.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | According to our understanding, should be Type-1A, as there could be more than one PUSCH scheduled where UCI is to be mapped on (in case of more than one PUCCH overlapping with different scheduled PUSCHs).  |
| Qualcomm | OK |
| Apple | Fine |
| Spreadtrum | As we commented before, for the cases that PUSCHs of the co-scheduled cells are scheduled in at least one different slot, there would be a possibility that more than one TDM PUCCHs might overlap with multiple PUSCHs. In this case, there would be ambiguity of the cell that the Beta\_offset field applied to. Would Feature leader clarify this case, how to decide the beta\_offset of UCI multiplexing for the CSI1/2/3 in slot 1/2/3, if CC1/2/3 all configured as dynamic beta-offset?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 　 | slot 0 | slot 1 | slot 2 | slot 3 |
| CC0 | PUSCH0 | CSI1 PUCCH | CSI2 PUCCH | CSI3 PUCCH |
| CC1 | 　 | PUSCH1 | 　 | 　 |
| CC2 | 　 | 　 | PUSCH2 | 　 |
| CC3 | 　 | 　 | 　 | PUSCH3 |

 |
| CATT | OK |
| ZTE | Support |
| vivo | Support. the proposal seems to assume that there will be at most one PUSCH overlapped with UCI PUCCH |
| Samsung | OK  |
| ITRI | Share same view as Spreadtrum, we believe that if multiple PUSCHs are scheduled using DCI format 0\_X and more than one of them collide with PUCCH, there could be ambiguity. |

#### Proposal 3-6:

* Enhanced Type-3 codebook indicator in DCI format 1\_X belongs to Type-1A field.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support |
| Qualcomm | Not sure whether we need to classify the field as a Type. Isn’t it sufficient to say just supporting legacy indicator in DCI format 1\_X? |
| Apple | Fine |
| Xiaomi | Fine |
| CATT | Support |
| ZTE | Support |
| vivo | ok |
| Samsung | OK for progress. |
| ITRI | Support. |

#### Proposal 3-7:

* HARQ-ACK retransmission indicator in DCI format 1\_X belongs to Type-1A field.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support |
| Qualcomm | Not sure whether we need to classify the field as a Type. Isn’t it sufficient to say just supporting legacy indicator in DCI format 1\_X? |
| Apple | Fine |
| Spreadtrum | We do not see strong reason to support HARQ-ACK retransmission by DCI 1\_X. DCI 1\_X has large DCI payload size. If only want to indicate HARQ-ACK retransmission without any scheduling information, legacy DCI for any serving cell has more advantage over DCI 1\_X. So this field can be omitted.  |
| Xiaomi | Fine |
| CATT | Support |
| ZTE | Support |
| vivo | ok |
| Samsung | OK |
| ITRI | Support |

#### Proposal 3-8:

* PUCCH Cell indicator in DCI format 1\_X belongs to Type-1A field.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support |
| Qualcomm | Not sure whether we need to classify the field as a Type. Isn’t it sufficient to say just supporting legacy indicator in DCI format 1\_X? |
| Apple | Fine |
| CATT | Support |
| ZTE | Support |
| vivo | ok |
| Samsung | OK |
| ITRI | Support. |

#### Proposal 3-9:

* SCell dormancy indication in DCI format 0\_X/1\_X belongs to Type-1A field.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Actually, we are not sure this would be absolutely needed to be included in the DCI. But if included then clearly Type-1A.  |
| Qualcomm | We think the field is necessary for UE power saving.Intention seems to be OK, but not sure whether we need to classify the field as a Type. Isn’t it sufficient to say just supporting legacy indicator in DCI format 1\_X? |
| Apple | Fine |
| Spreadtrum | SCell dormany indication is only within the DCI of P(S)Cell, just because P(S)Cell do not go to dormancy BWP, but all other SCells would. So this principle can be reused. * SCell dormancy indication in DCI format 0\_X/1\_X of P(S)Cell belongs to Type-1A field when P(S)Cell is the reference cell for a set of cells.
 |
| Xiaomi | Support |
| CATT | This field is not related to the scheduling. Maybe it can be excluded from the DCI format 0\_X/1\_X. |
| ZTE | Support “SCell dormancy indication in DCI format 0\_X/1\_X”.From our view, we think there is no need to clarify the field type for SCell dormancy indication since it is not related to the co-scheduled cells. It has the same meaning as the legacy indication. |
| vivo | Not sure why this field is type1A. In legacy DCI, each bit of the bitmap of dormancy indication in a sc-DCI corresponds to a **group** of configured SCells from the number of groups of configured Scells, does this proposal mean that the dormancy indication in DCI format 0\_X/1\_X is supported only if the all co-scheduled cells in the set of cells are configured as Scell groups? And how many bits does this field cost? Can mc-DCI provide dormancy command for other non-coscheduled cells? For example, if a cell set have 4 cells, and these 4 cells are divided into two Scell groups, then the dormancy indicator in mc-DCI includes only 2 bits?It seems that it is sufficient to say this field is same as legacy indicator in sc-DCI. |
| Samsung | Prefer to omit the field, at least when MC-DCI schedules more than one cell. |
| ITRI | Support. |

#### Proposal 3-10:

* Invalid symbol pattern indicator in DCI format 0\_X belongs to Type-1A field.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Actually, we are not sure this would be absolutely needed to be included in the DCI. But if included then clearly Type-1A.  |
| Qualcomm | This indicator is for PUSCH repetition Type B. We think it makes sense to discuss firstly whether to support PUSCH repetition Type B for multi-cell scheduling. If yes, the next question is whether PUSCH repetition Type B can be enabled on a subset of cells for multi-cell scheduling by a DCI format 0\_X, or should be enabled on all the cells for multi-cell scheduling by the DCI format 0\_X.We think enabling PUSCH repetition Type B on a subset of cells for multi-cell scheduling by a DCI format 0\_X makes various aspects (invalid symbol pattern, frequency-hopping, PUSCH repetition, etc) complicated while the scenario is unclear. We propose to exclude this case.Considering the limited time of this WI, we also consider not supporting PUSCH repetition Type B for PUSCHs scheduled by DCI format 0\_X would also be a valid option. In this case, invalid symbol pattern indicator is not necessary. |
| Apple | We don’t see the need to support this field with DCI format 0\_X |
| Spreadtrum | Whether or not PUSCH/PDSCH repetition is supported by DCI 0\_X/1\_X can be discuss first.  |
| CATT | Share same view with Qualcomm and Spreadtrum. Whether supporting PUSCH repetition Type B for multi-cell scheduling should be discussed first. |
| ZTE | We think it can be Type-1A field (e.g. 1 bit). In addition, we also support it as Type 1B (e.g. 2 bits) or Type 2 (e.g. 4 bits). |
| vivo | we don’t see the motivation to support PUSCH repetition for mc-DCI |
| Samsung | Prefer to omit the field, at least when MC-DCI schedules more than one cell. |
| ITRI | Prefer not to include this field. |

#### Proposal 3-11:

* PDCCH monitoring adaptation indication is excluded from DCI format 0\_X/1\_X.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support |
| Qualcomm | Not support.We consider the legacy indication field can be included in DCI format 0\_X/1\_X.PDCCH monitoring adaptation indication is 0, 1, or 2 bits, and indicates SSSG or PDCCH skipping for Type-3 CSS and USS. We do not see any issue/concern to have the field in DCI format 0\_X1\_X. |
| Apple | Fine |
| Spreadtrum | SupportPDCCH monitoring adaptation can be in the legacy DCI format. |
| Xiaomi | We don’t see why this field is omitted. This field is to indicate the SS group switch or PDCCH skipping duration and it is associate with the scheduling cell, thus it should be a type 1C field |
| CATT | Support. |
| ZTE | We think it can be included in the DCI format 0\_X/1\_X so that the new DCI formats have more functions. Anyway, whether it is included is up to gNB configuration.Similar as the SCell dormancy indication, this field can be also support without to clarify the field type. |
| Xiaomi | We don’t see why this field is omitted. This field is to indicate the SS group switch or PDCCH skipping duration and it is associate with the scheduling cell, thus it should be a type 1C field |
| vivo | Support |
| Samsung | We would prefer some consistency for including/excluding optional fields. For example, we think that, for the use cases of MC-DCI, this field is more important than some other fields that are considered to be included (e.g. UL-SCH indicator, priority indicator, invalid symbol pattern indicator, …). For that reason, we think it would be better to have that field (as for SC-DCI).  |
| ITRI | We prefer to include this field in DCI format 0\_X/1\_X. |

#### Proposal 3-12:

* Minimum applicable scheduling offset indicator is excluded from DCI format 0\_X/1\_X.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support |
| Qualcomm | Not support.We consider the legacy indication field can be included in DCI format 0\_X/1\_X. |
| Apple | We think that this field should be included |
| Spreadtrum | SupportIt can be in the legacy DCI format. |
| CATT | Support. |
| ZTE | Same as proposal 3-12, we think it can be included in the DCI format 0\_X/1\_X. We think it can be Type-1A, 1B or 2. |
| Samsung | Support, at least when MC-DCI schedules more than one cell.  |
| ITRI | We prefer to include this field in DCI format 0\_X/1\_X. |

#### Proposal 3-13:

* DFI flag is excluded from DCI format 0\_X/1\_X.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support |
| Qualcomm | Not to object, if the reason of this proposal for exclusion is the limited time for WI completion. |
| Apple | Fine |
| Spreadtrum | Support |
| CATT | Support |
| ZTE | We think it can be included in the DCI format 0\_X with DCI type 1A or 2.  |
| Samsung | Support, at least when MC-DCI schedules more than one cell.  |
| ITRI | Support. |

#### Proposal 3-14:

* UL/SUL indicator in DCI format 0\_X, belongs to Type-3 field, i.e., configurable between Type-1A and Type-2.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Disagree. According to our understanding should be 1bit of Type-1C |
| Qualcomm | Not supportAgree with Nokia – should be 1 bit (type-1C) or 0 bit. |
| Apple | We would be fine with type-1C, but would also as a compromise open to consider it as type-1B, where a joint indication can indicate SUL on one of the co-scheduled cells |
| Spreadtrum | Support |
| Xiaomi | We prefer to be a type 2 field, but fine to accept this compromise. |
| CATT | OK |
| vivo | It seems that a configurable size for this field is sufficient, no need to further agree on whether the field type is configurable or not. |
| Samsung | Not support. Type-1A is simplest and fully functional for the purposes of MC-DCI (as for BWP indicator).Any of Types 1B, 1C, and 2 may imply certain settings for the broader discussion on SUL configuration.  |
| ITRI | We prefer to be a Type-1C field. |

#### Proposal 3-15:

* For a set of cells configured for multi-cell scheduling using DCI format 0\_X/1\_X,
* the size of a Type-1A field in the DCI format 0\_X/1\_X is determined as maximum field size among all cells within the set of cells.
	+ If the field size for one of co-scheduled cells is smaller than the determined field size in the DCI format 0\_X/1\_X, LSB of the field is applied.
* the size of a Type-1B field in the DCI format 0\_X/1\_X is dependent on the number of rows in a configured table with each row containing combination of indication for each cell within the set of cells.
	+ The Type-1B field indicates one row of the configured table.
* the size of a Type-2 field in the DCI format 0\_X/1\_X is determined as the maximum size among sum of per cell field size among all the co-scheduled cell combinations for the set of cells.
	+ The per cell field in the DCI format 0\_X/1\_X is arranged in the ascending order of serving cell indexes for each of the co-scheduled cell combinations.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Partially support. * Type 1A: support
* Type 1B: agree on the size definition, but we would need to more specific on what is aactually configured. Are the values configured in the table directly - or are the table entries pointing to the possible values applied e.g. for DCI format 0\_1/1\_1 (which contain BWP specific elements)
* Type 2:
	+ based on what is described here, it seems that there is a single Type 2 field which is a concatenation of the DCI field sizes of the individual cells (i.e. individual bits per cell, but a single field). Our understanding has been that there would really be a DCI field per cell
	+ and it is a bit unclear why the cell order should be based on serving cell index and not on the order of the cells within the ‘indication of scheduled cells’ (which may not be in order of ascending serving cell indexes)?
 |
| Qualcomm | Clarification is necessary. We have similar questions/understandings on Type-1B/Type-2 as Nokia.For Type-1B, we need to be careful whether the “table” itself is configured by RRC, or each entry of the table is pointing to a parameter under BWP/serving cell configuration of each cell in the set of cells. The latter is the approach taken for DCI format 0\_1/1\_1/0\_2/1\_2, and works properly in case BWP-switching is performed. We are not sure how former works.For Type-2, our understanding is that the per-cell field for each cell in the cell-set is included. For example, if a DCI format 0\_X/1\_X is configured for CCs {1, 2, 3, 4}, the per-cell field for CC-1, CC-2, CC-3, and CC-4, are present in the DCI format 0\_X/1\_X. This (both presence and order) does not change, regardless of how the DCI format 0\_/1\_X actually co-schedules the cell(s). The proposal requires to “shuffle” the per-cell fields depending on the co-scheduled cell combination. Since the total payload is not dynamically changing, we do not think such shuffling is necessary.  |
| Apple | Type 1A: SupportType 1B: Agree with Nokia that clarification is needed and our understanding is that each entry of the table is pointing to a parameter under serving cell configuration of each cell in the set of cellsType 2: We are fine to have per-cell field for each cell in the set |
| Spreadtrum | We support to have more clarifications for each type, and with the following comments.1. For Type-1A field, ” maximum field size among all cells” is not clear. It needs to clarify which DCI format. So a sub-bullet is added for Type-1A. 2. For Type-1B field, it has some relations with Proposal 3-18, we think it is fine to clarify here. Such as index of single scheduling TDRA table only or whole information of K/SLIV/mapping type. We are also fine to include it in Proposal 3-18.3. For Type-2 field, we support to use the maximum size among sum of per cell field size among all the co-scheduled cell combinations for the set of cells. Just to save the payload. Since Type-2 field has cost too much bits, it is worth to do this.* For a set of cells configured for multi-cell scheduling using DCI format 0\_X/1\_X,
* the size of a Type-1A field in the DCI format 0\_X/1\_X is determined as maximum field size among all cells within the set of cells.
	+ If the field size for one of co-scheduled cells is smaller than the determined field size in the DCI format 0\_X/1\_X, LSB of the field is applied.
	+ The field is interpreted as same as this field in the legacy DCI format 0\_1/1\_1 of the current active BWP.
* the size of a Type-1B field in the DCI format 0\_X/1\_X is dependent on the number of rows in a configured table with each row containing combination of indication for each cell within the set of cells.
	+ The Type-1B field indicates one row of the configured table.
	+ The indications for each cell are interpreted as a part of its legacy DCI format 0\_1/1\_1.
* the size of a Type-2 field in the DCI format 0\_X/1\_X is determined as the maximum size among sum of per cell field size among all the co-scheduled cell combinations for the set of cells.
	+ The per cell field in the DCI format 0\_X/1\_X is arranged in the ascending order of serving cell indexes for each of the co-scheduled cell combinations.
 |
| Xiaomi | Type 1A: OKType 1B: we need to more design details regarding the table configuration. For some cases, even no table is configured.Type 2: more clarification is still needed. For example, if a DCI format 0\_X/1\_X is configured for CCs {1, 2, 3, 4}, and actually scheduled cell is cell 1 and cell4, how to interpret the type 2bit-field need to be clarified. |
| CATT | We are ok with the proposal in principle.Type 1A: OKType 1B: OKType 1C: We are ok with per-cell field for each cell in the cell-set. In this way, the size of DCI field is fixed regardless of the co-scheduled combinations configured for the UE.  |
| ZTE | For Type 1A, we understand the intention of sub-bullet is let each value of the field has a valid indication for each scheduled cell. We support this intention. However, we think the using LSB for indication may still not have a valid indication in some cases. For example, one of the co-scheduled cells does not have the size of 2^n. Assuming, a cell has 3 BWPs while the other cells have 4 BWPs. Then the value of ‘11’ is still invalid for the one cell with 3 BWPs. Therefore, we think the value of (DCI field mod N) should be applied, where N is the number of entries of the field that is smaller than the maximum number of the entries of the field. In addition, for the cell without relative RRC configuration which does not requires this field, should ignore this field. Therefore, we suggest the following updates.* the size of a Type-1A field in the DCI format 0\_X/1\_X is determined as maximum field size among all cells within the set of cells.
	+ If the number of entries for one of co-scheduled cells is smaller than the maximum number of entries among all the co-scheduled cells, (DCI field value mod N) is applied, where N is the number of entries for the one of co-scheduled cell .
	+ If one of co-scheduled cells does not have related configuration for this field, the UE ignore this field for the one of co-scheduled cells.

For Type 1B field, we think the table includes the configuration of all scheduled cells. The UE determine the indication by using this field together with the indication of co-scheduled cells.  |
| vivo | This is related to Proposal 3-16. Prefer to discuss proposal 3-16 first.As we commented to Proposal 2-1, the mc-DCI size should be determined based on active BWP, thus in this proposal it should also be clarified that the size of a field that is per BWPconfigured is also determined based on active BWPAdditionally, this proposal is to perform per field alignment for each type2 field. We think the field size should be determined as the actual number of bits required for the scheduled cell combination. At the end of the information bits of all fields, zero padding is preformed to align the DCI size for all cell combinations. Compared to zero padding at the end of all fields, per field alignment in the proposal results in intolerable mc-DCI overhead. For example, for combination 1, field 1 needs 6 information bits and field 2 needs 2 information bits, while for combination 2, field 1 needs 2 information bits and field 2 needs 6 information bits, then if per DCI alignment is performed, the final mc-DCI size is 8 bits, but if per field alignment is performed, the final mc-DCI size is 12 bits. Thus, per DCI alignment is preferred. Although the field size may change with cell combinations, as the size and position of the cell indicator /BWP indicator are fixed, UE can determine the bits for the remaining fields once it has successfully decoded the cell indication and BWP indicator. * For a scheduled cell combination, the size of a Type-2 field in the DCI format 0\_X/1\_X is determined as the ~~maximum size among~~ sum of per cell field size according to ~~among~~ active BWPs of ~~all~~ the co-scheduled cell combination~~s~~ for the set of cells.
	+ The per cell field in the DCI format 0\_X/1\_X is arranged in the ascending order of serving cell indexes for each of the co-scheduled cell combinations.
 |
| Samsung | Support the proposal in principle. * Type-1A: support.
	+ Suggest to revise as “the size of a Type-1A field or a field configured as Type-1A…”
* Type-1B: OK, except for TCI state field which has a slightly different structure in Rel-17 unified TCI framework.
* Type-2: support with modification
	+ Prefer to have **explicit configurability of the bit-width** (as in DCI 0\_2/1\_2) at least for RV and HPN, and also for SRI and TPMI when configured as Type-2;
	+ When such explicit configuration is not provided, support the FL proposal for size determination, which is consistent with the previous RAN1 agreement on the number of HARQ-ACK bits for a Type-2 CB, and avoids unnecessary wasting of DCI bits.
	+ For the ordering, OK with the ascending order of cells, but whether to use the serving cell index or to introduce a new indexing for cells within the set of cells can be further discussed (in RAN1 or RAN2) e.g., as part of RRC parameter discussion.
	+ Also, suggest to revise as “the size of a Type-2 field or a field configured as Type-2…”

Also, suggest to add a note applicable to Type-1A and Type-2 fields, for the case that a cell in the set of cells is deactivated:When a cell from the set of cells configured for multi-cell scheduling is deactivated, the UE determines a bit-width of a field that is Type-1A or Type-2 or configurable between Type-1A and Type-2 in a DCI format 0\_X/1\_X, based on a reference BWP for the cell as adopted in Rel-17 DSS. |
|  |  |

## Indication of co-scheduled cells

|  |  |
| --- | --- |
| **Huawei:***Proposal 5: Both the set of cells, if multiple sets of cells are configured for a scheduling cell, and combination of co-scheduled cells should be determined by the indicator of co-scheduled cells in DCI format 0\_X/1\_X.***Spreadtrum:***Proposal 14: For a set of cells which is configured for multi-cell scheduling, support an indicator for indicating co-scheduled cells 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 DCI format 0\_X/1\_X.*
	+ *For DL and UL, there are separate tables*
* *The size of the indicator is determined based on the number of rows in the table.*
* *Repurposing any field in the DCI format 0\_X/1\_X based on the indicator is not supported in Rel-18.*

**OPPO:***Proposal 1: For multi-cell PDSCH/PUSCH scheduling,** *Multiple cell sets are allowed for a UE.*
* *For multi-cell scheduling in a cell set, 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.*

**ZTE:***Proposal 3: The indicator of co-scheduled cells should belong to Type-1B field and jointly indicate the co-scheduled cells.***Nokia:***Proposal 2.2.2: Adopt the following part of the RAN1#111 moderator Proposal 3-2 with the proposed additions in red:*

|  |
| --- |
| **Proposal 3-2:*** 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 of co-scheduled cells 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.
* A new DCI field *Indicator of co-scheduled cells* is included in DCI format 0\_X / 1\_X as indicator (i.e. CIF is not reused)
 |

 **Vivo：***Proposal 12. For a set of cells that 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.***Xiaomi:***Proposal 11: 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.***CATT:***Proposal 3：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.***China Telecom:***Proposal 6: For the indication of actual co-scheduled cells within a set, the type 2 FDRA field is divided in to bit parts mapped respectively to each cell within the associated set, and a code point of a bit part is used to indicate the mapped cell is not scheduled.***Lenovo:***Proposal 1: 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 for the set of cells.* **Intel:***Proposal 1** *Co-scheduled cells are indicated by a cell indicator in DCI format 0\_X/1\_X which points to one row of a configured table.*
	+ *The size of the cell indicator is determined based on the number of rows in the table.*

**CMCC:***Proposal 5. Considering the indication of co-scheduled cells within a set of cells, 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.*

**LGE:***Proposal #12: Support the following Proposal 3-5rev7 in the FL summary at RAN1#110bis-e.** *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.*

**Samsung:***Proposal 2: RRC configures cell-set-indicator field (CSIF) values that correspond to configured combinations of co-scheduled cells (Option 1).** *The size of CSIF is determined based on the number of configured combinations of co-scheduled cells.*
* *A table defining combinations of co-scheduled cells is explicitly configured.*
* *Separate tables can be configured for multi-cell PDSCH scheduling and multi-cell PUSCH scheduling.*

**Langbo:***Proposal 3: 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 4: Separate tables are configured respectively for multi-cell PDSCH scheduling and multi-cell PUSCH scheduling.***Apple:***Proposal 5: 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*

**Qualcomm:***Proposal 2:* * *Co-scheduled cell indicator is not supported for DCI format 0\_X/1\_X in Rel-18.*

**NTT DOCOMO:***Proposal 4: For multi-cell scheduling, co-scheduled cell indicator in DCI format 0\_X/1\_X should be Type-1A field.** *The payload size is up to 2 bits and is determined based on number of sets of cells configured for the UE.*

**Ericsson:***Proposal 5: Use a bitmap for indication of co-scheduled cells by DCI format 0\_X/1\_X.* **MediaTek:***Proposal 3: For scheduled cells indication in the multi-carrier scheduling DCI, since only up to 4 cells can be configured in one set, introduce a bitmap in the DCI as below:** *Bitmap size = number of configured scheduled cells for this set (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)*
 |

### Moderator summary and proposals based on contributions

Regarding the indicator of co-scheduled cells, there are three options on the table for down-selection. After extensive discussion in previous RAN1 meetings the proposal is formulated as below Proposal 3-2 rev3 for further discussion.

|  |
| --- |
| RAN1#109e AgreementFor 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.
 |
| RAN1#112Proposal 3-2 rev3:* 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.
* Repurposing any field in the DCI format 0\_X/1\_X based on the indicator is not supported in Rel-18.
 |

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

Option 1:

* Supported by 14 companies [Huawei, Spreadtrum, OPPO, ZTE, Nokia, vivo, xiaomi, CATT, Lenovo, Intel, CMCC, LG, Samsung, Langbo]

Option 2:

* Supported by 2 companies [Ericsson, MediaTek]

Option 3:

* Supported by 4 companies [China Telecom (using FDRA), Qualcomm (using FDRA), Apple (using TDRA), NTT DOCOMO (using TDRA)]

Based on above, vast majority companies prefer 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 can implicitly indicate whether a cell is scheduled or not via inapplicable TDRA or FDRA.

Hence, moderator suggests going with Proposal 3-2 rev3 in previous meeting for further discussion.

### 1st round of discussions

#### Proposal 3-16:

* 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.
* Repurposing any field in the DCI format 0\_X/1\_X based on the indicator is not supported in Rel-18.
* The indicator belongs to Type-1B field.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Partially support**We think the table should be independently configured for DCI format 0\_X and 1\_X** **for a set of cells**, as (a) the DCI field size may be unnecessarily large and (b) the DCI size (especially for DCI format 0\_X) may be unnecessarily large (if e.g. the gNB does not intend to support many combinations for UL scheduling) and (c) we would need to define what happens for a scheduling cell combination in the table that is not valid e.g. for PUSCH scheduling (as only DL CA configured)  |
| Qualcomm | Not support. Firstly, we have a concern to keep opening the possibility for repurposing field in the DCI format 0\_X/1\_X depending on the actual co-scheduled cell combinations. The 3rd sub-bullet is good for us. But then as we questioned at the last meeting, benefit of having explicit co-scheduled cell indicator field in the DCI format is unclear. |
| Apple | We don’t support the proposal.Considering that up to 4 cells can be configured, we think that a simple bitmap should be sufficient |
| Spreadtrum | Agree with Nokia, we also think the table should be independently configured for DCI format 0\_X and 1\_X for a set of cells. |
| Xiaomi | Don’t support. We think the most straightforward way is to reuse the legacy CCS framework. The multi-cell scheduling can be realized by defining the linkage between the one-to-multiple scheduling ID and CIF values. No need to define additional table. |
| CATT | Agree with Nokia and Spreadtrum, that the table should be independently configured for DCI format 0\_X and 1\_X for a set of cells. Because the number of UL carrier and DL carrier may be different. |
| ZTE | We support this proposal. |
| vivo | Partially supportWe are ok with explicit cell indicator and corresponding RRC table. However, we are not sure of the benefits for prohibiting repurposing fields, which can result in a very large DCI size if the co-scheduled cells are configured with different functions or DCI fields. |
| Samsung | Partially support.Agree with Nokia on separate configuration of tables for DL and UL. This is an FFS from RAN1#109-e: “*FFS: Separate tables can be configured for multi-cell PDSCH scheduling and multi-cell PUSCH scheduling*.”Prefer to omit the third sub-bullet: “*Repurposing any field in the DCI format 0\_X/1\_X based on the indicator is not supported in Rel-18*”. As certain fields may be omitted from DCI 0\_X/1\_X when scheduling more than one cell, those fields can be re-enabled when DCI 0\_X/1\_X is used for scheduling a single cell, by treating DCI 0\_X/1\_X same as a DCI 0\_1/1\_1. So, we suggest the following change.* ~~Repurposing any field in the DCI format 0\_X/1\_X based on the indicator is not supported in Rel-18.~~
* When DCI format 0\_X1/1\_X is used for scheduling a single cell, the UE interprets DCI format 0\_X1/1\_X as DCI format 0\_1/1\_1.
 |
| ITRI | Share the same view as Nokia and Spreadtrum, the table should be independently configured for DCI format 0\_X and 1\_X for a set of cells. |

## TDRA and FDRA

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Huawei:*****Proposal 5:*** *Both the set of cells, if multiple sets of cells are configured for a scheduling cell, and combination of co-scheduled cells should be determined by the indicator* *of co-scheduled cells in DCI format 0\_X/1\_X.****Proposal 6:*** *The RBG granularity configuration can be different for the BWP of the same scheduled cell which belongs to different combination of co-scheduled cells.****Proposal 7:*** *New joint TDRA table can be configured and each row of TDRA table corresponds to one set of cells.***Spreadtrum:***Proposal 15: Configure a RBG granularity for DCI format 0\_X/1\_X, separately for RA type 1 and 2.***OPPO:***Proposal 3: RAN1 considers the following methods to restrict DCI 1\_X size to be no more than 164.** *Use larger resource allocation granularity to compress the FDRA field size; and*
* *Disable TB2 in DCI 1\_X when the maximum co-scheduled cells number given by the co-scheduled cell table is 4.*

*Proposal 4: RAN1 considers the following methods to restrict DCI 0\_X size to be no more than 164.** *Use larger resource allocation granularity to compress the FDRA field size, together with some other methods such as limiting Type-1B field sizes.*

*Proposal 6: Joint TDRA table defined per cell set is adopted.***ZTE:***Proposal 4: For the TDRA table design, the network should configure a new TDRA table, with each row including separate configurations for multiple scheduled cells.**Proposal 5: Reuse the configurable larger RBG size in Rel-16 for frequency resource indication of DCI format 0\_X/1\_X.***Nokia:***Proposal 3.1.3.3: For Type 0 frequency domain resource allocation for DCI formats 0\_X/1\_X, the RBG granularity is configured per set of cells using rbg-Size-DCI-0-X/ rbg-Size-DCI-0-X from the set of {config1, config2, config3}. A third RBG size configuration ‘Configuration 3’ is added with the following values (addition in red):* Table 5.1.2.2.1-1 / Table 6.1.2.2.1-1: Nominal RBG size *P*

|  |  |  |  |
| --- | --- | --- | --- |
| Bandwidth Part Size | Configuration 1 | Configuration 2 | Configuration 3 |
| 1 – 36  | *2* | 4 | 8 |
| 37 – 72 | 4 | 8 | 16 |
| 73 – 144 | 8 | 16 | 32 |
| 145 – 275 | 16 | 16 | 32 |

*Proposal 3.1.3.4: For Type 2 frequency domain resource allocation using DCI format 0\_X / 1\_X, a larger resource allocation granularity can be configured with a new RRC parameter resourceAllocationType1GranularityDCI-0-X / resourceAllocationType1GranularityDCI-1-X (as is done for DCI format 0\_2 / 1\_2 using resourceAllocationType1GranularityDCI-0-2 / resourceAllocationType1GranularityDCI-1-2 in PUSCH-Config / PDSCH-Config).* **Vivo：***Proposal 17. For Type0 FDRA, the following options for determining RBG size- Option1. The RBG size for all co-scheduled cells in a set of cell is determined based on the maximum total number of RBs of the active BWP for all cell combinations.- Option2. The RBG size for a co-scheduled cell is determined based on the number of RB of the active BWP of the co-scheduled cell, and times a scaling factor K.**Proposal 18. For Type1 FDRA, RBG-based RIV for RA type 1 is configurable, and the RBG size can be 2,4,8,16,32,64.**Proposal 19. 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 20. For detailed TDRA table design, the following option can be considered:- Option1. each entry in the TDRA table for mc-scheduling always points to SLIV(s) for all configurable cells, which cells are actually scheduled by a DCI format 1\_X/0\_X are indicated by the cell indicator. - Option 2. If cell indicator is not included in DCI format 1\_X/0\_X, each entry in the TDRA table for mc-scheduling points to a cell combination and the corresponding SLIV(s).***Xiaomi:***Proposal 5: For RA type 0, larger RBG size such as 32 can be configured to reduce the required bit-length for FDRA.**Proposal 6: For RA type 1, new configurations such as resourceAllocationType1GranularityDCI-1-X and resourceAllocationType1GranularityDCI-0-X with configurable granularities {n2, n4, n8, n16} can be introduce to reduce the required bit-length for FDRA.***CATT:***Proposal 6: A larger RBG size 32 PRB can be introduced for multi-cell scheduling, and the RBG size determination table for multi-cell scheduling can be defined as following:* Nominal RBG size P for multi-cell scheduling

|  |  |  |
| --- | --- | --- |
| **Total Bandwidth Part Size across the cell in the cell set** | **Configuration 1** | **Configuration 2** |
| **1 – 36** | **2** | **4** |
| **37 – 72** | **4** | **8** |
| **73 – 144** | **8** | **16** |
| **145 – 275** | **16** | **16** |
| **276-1100** | **32** | **32** |

**China Telecom:***Proposal 3: For frequency domain resource assignment, reuse the current RBG division way within each cell without cross cell RBG.** *For resource allocation type 0, the RBG size is based on the total bandwidth of the BWPs for all the cells can be co-scheduled within a set. Larger RBG sizes than the existing maximum value are introduced as 32, 48, 64.*
* *For resource allocation type 1, the RBG size is configured from {1, 2, 4, 8, 16, 32, 48, 64}.*

**Lenovo:***Proposal 2: RBG size of 32 is supported for frequency resource allocation type 0 for DCI format 0\_X/1\_X.**Proposal 3: For a set of cells configured for multi-cell scheduling, the TDRA table includes multiple entries and each entry comprises multiple TDRA indices with each TDRA index corresponding to one cell of the set of cells and pointing to one entry of the PUSCH-TimeDomainAllocationList or PDSCH-TimeDomainAllocationList.* *Proposal 4: When DCI format 0\_X/1\_X schedules a single cell, the TDRA indicator points to one entry of the PUSCH-TimeDomainAllocationList or PDSCH-TimeDomainAllocationList configured for the cell.* **Intel:***Proposal 5** *For FDRA field for multi-cell scheduling:*
	+ *For resource allocation type 0, a scaling factor can be separately configured for each co-scheduled cell and applied on the RBG size.*
	+ *For resource allocation type 1, RBG based RIV with configured scheduling granularity can be reused.*

**CMCC:***Proposal 6. For FDRA field, to support the separate indicator for each co-scheduled cell, the following detailed designing of DCI payload compression can be considered.* * *For resource allocation type 0, a larger RBG size determined based on the total number of RBs of co-scheduled BWPs or the maximum BWP size among the co-scheduled cells can be adopted.*
* *For resource allocation type 1, separate indication of RIV based on RBG granularity can be used for each co-scheduled cell.*

**LG:***Proposal #10: Following three points are required to be considered for efficient reduction of Type 2 based FDRA field size in the multi-cell DCI.** *Size of the RBG needs to be scaled based on legacy RBG size table (defined according to BWP size) to reduce the total number of RBGs per cell.*
	+ *For this, a scaling factor applied to the legacy RBG size table is configured per BWP or per cell or per UE by RRC.*
* *Maximum number of RBGs available for the multi-cell DCI based scheduling is able to be limited by gNB to support (configuration of) reasonable RBG size to be suitable for efficient FDRA together with reduction of the FDRA field size.*
	+ *For this, the maximum available RBG number can be configured by RRC.*
* *Not allocating 1-bit to partial RBG (with less RBs at the edge of BWP) solely needs to be considered for more reduction of FDRA field size in the multi-cell DCI.*
	+ *For this, the partial RBG can be excluded from FDRA via the multi-cell DCI or merged with adjacent (normal) RBG.*

**Samsung:***Proposal 11: Conclude on TDRA as a Type-1B field.** *A single joint multi-cell TDRA table is configured by RRC with each row including a combination of TDRA information for a number of cells from the set of cells configured for multi-cell scheduling.*
* *TDRA field in DCI format 0\_X/1\_X indicates a row index from the joint multi-cell TDRA table.*

*Proposal 20: For the FDRA field in DCI format 0\_X/1\_X, the UE can have different resource allocation types among the co-scheduled cells.***Apple:***Proposal 5: 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*

*Proposal 6: For FDRA determination with DCI format 0\_X/1\_X, UE can be configured by network with a set of RBG sizes for resource allocation type 0 for a cell and the nominal RBG size is determined corresponding to the number of RBs in the active BWP and the number of actual scheduled cells** *This can be used for both RA type 0 and RIV calculation for RA type 1*

**Qualcomm:***Proposal 6:** *For FDRA Type-0:*
	+ *Support RBG size of 32 for BWP size of equal to or larger than 145*
		- *This is for the case where rbg-Size in PUSCH-Config or PDSCH-Config is set to ‘config 2’*

*Proposal 9:** *TDRA field is Type-1B*

**NTT DOCOMO:***Proposal 5: For multi-cell scheduling, TDRA in DCI format 0\_X/1\_X should be Type-1B field.** *The payload size is up to 4 bits.*

*Proposal 6: For multi-cell scheduling, if RA Type 0 is applied for FDRA, RBG granularity can be extended for 32 when the BWP size is larger than 144 RBs, if necessary.***Ericsson:***Proposal 6: For each cell, support separate configuration of RBG size(s) for resource allocation used for PUSCH/PDSCH scheduling using mc-DCI.**Proposal 7: For Type 0 resource allocation for mc-DCI, support an additional RBG size configuration:* * *RBG size of 8 for BWP size 1-36 PRBs*
* *RBG size of 16 for BWP size 37-72 PRBs*
* *RBG size of 32 for BWP size >72 PRBs*

*Proposal 8: For DCI format 1\_X/0\_X, a joint TDRA index table is configured for each set of cells with each row in the table containing TDRA index(es) for the respective cells in the set.* * *TDRA index for a cell points to a corresponding TDRA in the higher layer configured TDRA table for the cell.*
 |

* On FDRA

As for FDRA field, RAN1#112 meeting has agreed FDRA is a Type-2 field, i.e., cell specific frequency domain resource allocation for each cell of the set of cells configured for multi-cell scheduling. One open issue is whether to support larger RBG granularity than existing maximum specified or configured value for RA type 0 and how to determine the RBG granularity for the set of cells.

In RAN1#112 meeting, companies’ views on larger RBG size are summarized as below:

*Whether to support larger RBG granularity than existing maximum specified or configured value for FDRA?*

* *Yes: Nokia, vivo, xiaomi, CATT, China Telecom, Lenovo, Qualcomm, NTT DOCOMO, Ericsson*

Companies’ views on RBG size determination are summarized as below:

*The RBG granularity is configured per set of cells*

* *Supported by Nokia*

*The RBG granularity is configured per cell*

* *Supported by Ericsson*

*The RBG granularity is common to all cell combinations determined based on the maximum total number of RBs of the active BWPs for all cell combinations*

* *Supported by vivo, CATT, China Telecom, CMCC*

*The RBG granularity is separately determined per cell based on the number of RB and a scaling factor*

* *Supported by vivo, Intel, LG*

*The RBG size is determined corresponding to the number of RBs in the active BWP and the number of actual scheduled cells size*

* *Supported by Apple*

For resource allocation type 0, the FDRA in DCI format 1\_X/0\_X uses a bitmap to indicate the RBG allocation to the UE. For overhead reduction, larger RBG granularity should be considered for multi-cell scheduling. For Type 0 resource allocation, in legacy spec, the *rbg-Size* can be configured per BWP between two configurations given by ‘Configuration 1’ and ‘Configuration 2’. From moderator’s perspective, reusing legacy mechanism can be a baseline solution: For overhead reduction purpose, a new RBG size “configuration 3” can be added with larger size. For scheduling flexibility, RBG size for DCI format 1\_X/0\_X can be configured individually per cell. Thus, Proposal 3-8 is provided for further discussion.

* On TDRA

Regarding TDRA indication, RAN1 has agreed to use a single TDRA field to indicate the TDRA allocation of all the co-scheduled cells with FFS details on the TDRA table design:

|  |
| --- |
| **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
 |

In Rel-15/16/17 spec, the TDRA table is specifically configured per UL or DL BWP. One open issue is whether Rel-15/16/17 single-cell scheduling TDRA table can be reused for multi-cell scheduling considering the single-cell scheduling TDRA table per cell is inevitably needed for single cell scheduling as legacy. For reducing the signaling overhead for configuring separate {SLIV, mapping type, scheduling offset K0 (or K2)} for each of the co-scheduled cells, it is better to reuse the time domain resource allocations configured for single cell scheduling as much as possible.

In RAN1#112 meeting, 8 companies [Huawei, OPPO, ZTE, vivo, Lenovo, Samsung, Apple, Ericsson] show the preferred TDRA table design solutions. The majority view is to configure a new TDRA table for the set of cells for multi-cell scheduling and reuse the TDRA table for single-cell scheduling as much as possible. Hence, Proposal 3-9 is provided for further discussion.

### 1st round of discussions

#### Proposal 3-17:

* RBG size of 32 is supported for DCI format 0\_X/1\_X for RA type 0.
* A new RBG size configuration “Configuration 3” is added with the following values.
* RBG size is configured per BWP per cell.

 Table 5.1.2.2.1-1 / Table 6.1.2.2.1-1: Nominal RBG size *P*

|  |  |  |  |
| --- | --- | --- | --- |
| Bandwidth Part Size | Configuration 1 | Configuration 2 | Configuration 3 |
| 1 – 36  | *2* | 4 | 8 |
| 37 – 72 | 4 | 8 | 16 |
| 73 – 144 | 8 | 16 | 32 |
| 145 – 275 | 16 | 16 | 32 |

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support as a note, we still may need to discuss the Type 1 RA configurability as well (separate RRC parameter from 0\_2/1\_2, and if the keep the same range) |
| Qualcomm | We are supportive on having larger RBG size. However, we have a view on how to enable it. Configuration 2 does not require more than 10 FDRA bits for each cell with BWP size of < 145 RBs. The main issue is for a cell with BWP size of >= 145 RBs, FDRA size is up to 19 bits.Instead of introducing new larger RBG sizes for every BWP sizes, we prefer to introduce new larger RBG size only for BWP size >= 145 RBs. One of the following options can be considered:Opt.1: For configuration 2, if a PDSCH/PUSCH is scheduled by DCI format 0\_X/1\_X and the BWP size is >= 145 RBs, the RBG size is 32.Opt.2: Introduce configuration 3 with RBG sizes of {4, 8, 16, 32}, which is configurable only for DCI format 0\_X/1\_X |
| Apple | In principle, we are fine to have larger RBG size for DCI format 0\_X/1\_XHowever, we think that different granularity can be applied depending on the number of scheduled cells within the set rather than simply applying one value independent of the number of scheduled cells. An example could be:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bandwidth Part Size** | **1 Cell Scheduled** | **2 Cells Scheduled** | **3 Cells Scheduled** | **4 Cells scheduled** |
| 1 - 36 | 2 | 2 | 4 | 4 |
| 37 - 72  | 4 | 4 | 8 | 8 |
| 73 - 144 | 8 | 8 | 16 | 16 |
| 145 - 275 | 16 | 16 | 32 | 32 |

 |
| Xiaomi | First bullet: fineSecond bullet: Fine in principle to have a new configuration. However, the values can be further refined. We think the RBG size of 32 can be only needed in case the RB size is larger than 145. The size of the FDRA can stay relatively stable regardless of the number of the RBs.Third bullet: more Clarification is needed. Is the intention to have different RBG size configuration for different BWPs. We don’t see the reason to have this. |
| CATT | We are OK with the lager RBG. Instead of introducing a new configuration 3, we prefer to apply the new RBG size to the case that total PRB scheduled by a DCI format 0\_X/1\_X is larger than 275 PRB. In this way, the legacy RBG size determination can be followed as much as possible, that is, the RBG size is determined by the total number of PRB scheduled by DCI format 0\_X/1\_X. |
| ZTE | We support this proposal because it can reduce the FDRA size and has minimum spec impact. |
| vivo | we are fine to have larger RBG size for DCI format 0\_X/1\_X, but we don’t see the need to have different RBG size for the co-scheduled cells as they are of same SCS.Furthermore, we think that different RBG size can be derived depending on the total RBs of co-scheduled cells instead of per-cell bandwidth. ‘Bandwidth Part Size’ should be changed to ‘the total RB of co-scheduled cells’ |
| Samsung | OK with the proposal.Prefer to clarify any of RA type-0 or type-1 can be configured separately for each cell in the set of cells (e.g., cell#0 with RA type-0 and cell#1 with RA type-1).  |
| ITRI | Support to add one more configuration for reducing the FDRA size |

#### Proposal 3-18:

* For a set of cells which is configured for multi-cell scheduling using DCI format 0\_X/1\_X, a joint TDRA table is configured by RRC signaling for the set of cells with each row in the table containing TDRA indexes for all cells within the set of cells.
* TDRA field in the DCI format 0\_X/1\_X belongs to Type-1B field.
* TDRA field in the DCI format 0\_X/1\_X indicates a row index from the joint TDRA table.
* TDRA index for a cell points to a corresponding TDRA in the TDRA table configured for the cell for single cell scheduling.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support  |
| Qualcomm | Intention is OK, but as we are reaching to WI completion, we would like to remind that the wording “joint TDRA table” needs to be clarified (whether joint-multi-cell table is configured somewhere in RRC, or it is a joint table constructed by entries where each entry points to a (K0/K2, SLIV) for each of the multi-cell). Former requires a new RRC structure and furthermore, unclear how it works in case of BWP-switching. |
| Apple | Support. |
| Spreadtrum | Support, with clarificationOur understanding for the last sub-bullet is a joint table constructed by entries where each entry points to a (K0/K2, SLIV) for each of the multi-cell). TDRA table configured for the cell for single cell scheduling can be clarified into:* TDRA index for a cell points to a corresponding TDRA in the TDRA table configured for the cell for single cell scheduling DCI format 0\_1/1\_1.
 |
| Xiaomi | Support |
| CATT | Support |
| ZTE | Support |
| vivo | Similar view as Qualcomm. |
| Samsung | Support.In the last bullet, prefer to remove “*for single cell scheduling*” as the UE may not be configured with any single-cell scheduling DCI format for the cell. The wording “*TDRA table configured for the cell*” should be good/clear enough (TDRA table for a cell is independent of which DCI format is scheduled). |
| ITRI | Support |

# 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 12: 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 13: The PDSCH which ends last as indicated in the DCI format can be 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.**Proposal 14: No enhancement is needed for Type-1 HARQ-ACK codebook and additional restrictions can be considered such as 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.**Proposal 15: Multi-cell PDSCH/PUSCH scheduling and Rel-17 MBS are not expected to be configured simultaneously.**Proposal 16: HARQ-ACK codebook with different priorities for single-cell scheduling DCI and/or multi-cell scheduling DCI are not expected to be configured in the same PUCCH group in Rel-18.***Spreadtrum:***Proposal 16: Type-1 HARQ-ACK codebook is supported for multi-cell scheduling without K1 extension.** *HARQ-ACK information for all candidate PDSCHs scheduled by DCI format 1\_X can be mapped in the Type-1 HARQ-ACK codebook.*
* *Type-1 HARQ-ACK codebook is not enhanced for Rel-18 multi-cell scheduling.*

**OPPO：***Proposal 9: 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 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.**Proposal 11: 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 12: 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 13: 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 14: DCI format 1\_X should not be used to trigger HARQ-ACK retransmission.**Proposal 15: To trigger a Type-3 HARQ-ACK codebook, One-shot HARQ-ACK request field in DCI format 1\_X is set to “1”.* * *Furthermore, if no FDRA field is valid in the same DCI, no PDSCH is scheduled.*

*Proposal 16: 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.*

**ZTE:***Proposal 12: The PDSCH with the latest ending symbol and the corresponding k1 offset should be used to determine the PUCCH slot.* *Proposal 13: No additional specification efforts is needed for supporting the Type-1 codebook for multi-cell scheduling.**Proposal 14: 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 15: 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 16: For Type-2 codebook, the PDSCH with the smallest cell index should be used to determine the counter DAI order.* *Proposal 17: The last DCI issue should be resolved by gNB implementation.***Nokia:***Proposal 4.1.1: dl-DataToUL-ACK is used for operation of DCI format 1\_X.* *Proposal 4.1.2: The reference PDSCH is the PDSCH of the first cell in the table row of the indicated co-scheduled cells.* *Proposal 4.1.3: 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 4.2.1: The Type 1 HARQ-ACK codebook construction is not enhanced / changed for the purpose of multi-cell PDSCH scheduling:* *FFS: required additional restrictions* *Proposal 4.2.2: 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 22. 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 23. 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 24. 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 25. 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 26. If multiple sets of cells are supported, for type-2 codebook, the number of HARQ-ACK information bits is determined as following. - if multiple sets of cells which can be co-scheduled by DCI format 1\_X are supported, and if at least one cell in the multiple sets of cells 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 any 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. 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.**Proposal 27. For type-2 HARQ-ACK codebook, HARQ-ACK bits can be ordered first in ascending order of cell index and then second in ascending order of TB index similar as the legacy rule.**Proposal 28. The HARQ information bits of PDSCH in the deactivated cell or dormant cell or an occasion with TDD UL/DL collision should be placed in the ACK/NACK bit position determined according to the order of the cell indices and TB indices.***Xiaomi:***Proposal 12: 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 13: 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.**Proposal 14: It is up to gNB’s implementation to resolve the issue for PUCCH resource determination when multiple DCI formats are transmitted in same PDCCH monitoring occasion on same scheduling cell.**Proposal 15: 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.***CATT:***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.**Proposal 15: For DAI counting, the reference PDSCH is the PDSCH with the smallest serving cell index among the co-scheduled cells.**Proposal 16: For determine the last DCI, the reference PDSCH is the PDSCH with the smallest serving cell index among the co-scheduled cells.**Proposal 17: 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 18: 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.***Lenovo:***Proposal 14: The PDSCH ending last among a set of PDSCHs co-scheduled 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 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 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.***Intel:***Proposal 10**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 11**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, which is same as single cell scheduling.*

*Proposal 12**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*$ n\_{HARQ-ACK}$ *is determined based on the number of HARQ-ACK bits for both single-cell and multi-cell scheduling.*

*Proposal 13**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.***CAICT:***Proposal 5: 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 6: 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 7: 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 8: 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.***LG:***Proposal #21: Consider the following Proposal 4-1rev2 in the 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 #22: For Type-1 HARQ-ACK codebook in case with multi-cell PDSCH scheduling, any TDRA row is allowed by not mapping the SLIV(s) not corresponding to K1 values in non-enhanced Type-1 codebook without K1 extension.**Proposal #23: 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 #24: Support the following Proposal 4-4rev3 in the 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 #25: 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*

**Samsung:***Proposal 23: 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 24: 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 25: 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 26: 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 27: 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 28: 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 29: 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 30: 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 31: 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 32: 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.**Proposal 33: 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.***Qualcomm:***Proposal 10:** *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.*

**NTT DOCOMO:***Proposal 13: 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 14:**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.***Ericsson:***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 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 16: Type-1 HARQ-ACK codebook is supported when a DCI 1\_X schedules PDSCHs across cells.**Proposal 17: 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* $K\_{x}$ *(e.g.,* $K\_{x}=max\left(K\_{1}\right)$ *) in* $M\_{A,c}$ *is used for a co-scheduled PDSCH on cell c that ends earlier than* $max\left(K\_{1}\right)$ *UL slots from the corresponding PUCCH slot. In case of presence of other HARQ-ACK information corresponding to occasion* $K\_{x}$*, bundling of HARQ-ACK information is performed.**Proposal 18: 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).**Proposal 19: 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 20: 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 6: 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].* |

## 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.
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For RAN1#112 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, OPPO, ZTE, vivo, xiaomi, CATT, Lenovo, Intel, CAICT, LGE, NTT DOCOMO, Qualcomm, Ericsson, MTK,*
* *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 in RAN1#111 meeting.

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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.
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For RAN1#112 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 11 companies: OPPO, vivo, xiaomi, CATT, Lenovo, Intel, CAICT, LG, NTT DOCOMO, Samsung, Qualcomm,*
* *Using last PDSCH among co-scheduled PDSCHs for determining last DCI among multiple DCIs in same MO:*
	+ *Supported by 1 company: Huawei,*
* *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:*
	+ *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.*
	+ *Supported by 8 companies: ZTE, OPPO, xiaomi, CATT, Lenovo, Intel, CAICT, Ericsson*
* *Alt 2: define additional rules to resolve the issue of last DCI format.*
	+ *Supported by 3 companies: OPPO, Intel, LG,*

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 4-2 in RAN1#111 meeting, can be agreeable to majority 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#112 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 RAN1#111 meeting and polished as below Proposal 4-3.

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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.
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For RAN1#112 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 12 companies: OPPO, ZTE, vivo, xiaomi, CATT, Lenovo, Intel, CAICT, LGE, Samsung, NTT DOCOMO, Ericsson,*
* *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.*
	+ *Supported by 1 company: 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 and Proposal 4-3 in RAN1#111 meeting.

* On Type-1 HARQ-ACK codebook

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

|  |
| --- |
| **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.

|  |
| --- |
| 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.
 |

During RAN1#111 meeting, this issue has been discussed and the proposal is further polished like below:

|  |
| --- |
| Proposal 4-4 rev2:* Type-1 HARQ-ACK codebook is supported for multi-cell scheduling without K1 extension.
	+ HARQ-ACK information for all candidate PDSCHs scheduled by DCI format 1\_X can be mapped in the Type-1 HARQ-ACK codebook.
	+ Type-1 HARQ-ACK codebook is not enhanced for Rel-18 multi-cell scheduling.
 |

For RAN1#112 meeting, companies’ views on Type-1 HARQ-ACK codebook for multi-cell scheduling are summarized as below:

* *Type-1 HARQ-ACK codebook is supported for multi-cell scheduling without K1 extension/enhancement or with additional restriction.*
	+ *Supported by 8 companies: Huawei, Spreadtrum, OPPO, ZTE, Nokia, Lenovo, Intel, LG,*
* *Type-1 HARQ-ACK codebook is supported for multi-cell scheduling with K1 extension.*
	+ *Supported by 4 companies: OPPO, vivo, CATT, Intel,*
* *Type-1 HARQ-ACK codebook is supported for multi-cell scheduling with additional rules.*
	+ *Supported by 1 company: Ericsson*

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, the most feasible way is to support Type-1 HARQ-ACK codebook without any enhancement or 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 which is similar to Proposal 4-4 rev2 in RAN1#111 meeting.

## 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.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support We would have preferred the first cell in the list of cells, but could be fine with the PDSCH ending last as well for compromise.  |
| Qualcomm | OK |
| Apple | Support |
| Spreadtrum | Support |
| Xiaomi | Support |
| CATT | Support |
| ZTE | Support |
| vivo | Support |
| Samsung | Using the smallest cell index offers a unified solution for PUCCH resource determination, last DCI, and DAI determination and is the simplest approach for UE implementation and specification. There should no concern in terms of HARQ-ACK timeline as the gNB is aware of corresponding UE capability and can indicate the K1 value appropriately. Using the PDSCH ending last would not avoid additional specifications as multiple PDSCHs can end last (e.g. same SCS/intra-band). |
| ITRI | Support. |

#### 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.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support On the first bullet, we would have preferred the first cell in the list of cells, but could be fine with the PDSCH with the smallest serving cell index as well for compromise.  |
| Qualcomm | OK.In the 2nd bullet, there is a typo, it should be: “1\_0/1\_1/~~2\_1~~1\_2/1\_X”. |
| Apple | Support, with update from QC |
| Spreadtrum | Support with QC’s update |
| Xiaomu | Support |
| CATT | Support with QC’s update |
| ZTE | Support the update from QC |
| vivo | Support |
| Samsung | Support the first bullet. For the second bullet, we prefer to define the UE behaviour, e.g., based on Rel-17 rules for DAI ordering, for example, based on the starting symbols of PDSCHs. However, if majority of companies prefer to leave this to gNB implementation, we can be OK with that.  |
| ITRI | Support with QC’s update. |

#### 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.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support We would have preferred the first cell in the list of cells, but could be fine with the PDSCH with the smallest serving cell index as well for compromise.  |
| Qualcomm | OK |
| Apple | Support |
| Spreadtrum | Support |
| Xiaomi | Support |
| CATT | Support  |
| ZTE | Support |
| vivo | Support |
| Samsung | Support |
| ITRI | Support |

#### Proposal 4-4:

* Type-1 HARQ-ACK codebook is supported for multi-cell scheduling without K1 extension.
	+ HARQ-ACK information for all candidate PDSCHs scheduled by DCI format 1\_X can be mapped in the Type-1 HARQ-ACK codebook.
	+ Type-1 HARQ-ACK codebook is not enhanced for Rel-18 multi-cell scheduling.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia, NSB | Support  |
| Qualcomm | OK |
| Apple | Fine |
| Spreadtrum | Support |
| Xiaomi | Support |
| CATT | Considering the limited time, we are fine with the proposal. |
| ZTE | Support |
| vivo | Support |
| Samsung | Support in principle.Given the little time left to close the work item, OK to introduce restrictions and re-use legacy Type-1 CB. However, some modifications are needed to clarify the intention:* Type-1 HARQ-ACK codebook is supported for multi-cell scheduling without K1 extension (i.e., based on the K1 values for single-cell scheduling only).
	+ The UE expects HARQ-ACK information for all candidate PDSCHs scheduled by DCI format 1\_X can be mapped in candidate PDSCHs of the Type-1 HARQ-ACK codebook generated for single-cell scheduling DCI formats.
	+ Type-1 HARQ-ACK codebook is not enhanced for Rel-18 multi-cell scheduling.

  |
| ITRI | Support |

# Others

|  |  |
| --- | --- |
| **LGE:***Proposal #26: 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 #27: 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.***Nokia:***Proposal 5.2: The baseline multi-cell DCI configuration is to be done as part of the PhysicalCellGroupConfig configuration.* *Proposal 5.3: Apply the following RRC configuration structure for the configuration of multi-cell DCI scheduling:*

|  |
| --- |
| Within ***PhysicalCellGroupConfig:***MC-DCI-SetofCellsToAddModList-r16 SEQUENCE (SIZE(1..4)) OF MC-DCI-SetofCells OPTIONALMC-DCI-SetofCells ::= SEQUENCE {ListofCells SEQUENCE (SIZE(2..4)) OF ServCellIndex*... and other possible generic configurations for the set of cells such as* scheduling cell (in case of more than one set of cells), n\_CI, *...*dci-format-0-X DCI-0-X OPTIONALdci-format-1-X DCI-1-X OPTIONAL}DCI-0-X ::= SEQUENCE {priorityIndicatorDCI-0-X ENUMERATED {enabled}*... and other DCI format 0\_X specific configuration similarly such as table for indication of co-scheduled cells, rgb size, ...* pusch-TimeDomainAllocationListDCI-0-X ::= SEQUENCE (SIZE(1..256)) OF PUSCH-TimeDomainResourceAllocationDCI-0\_XPUSCH-TimeDomainResourceAllocationDCI-0\_X ::= SEQUENCE (SIZE (2..4) of INTEGER (0... maxNrofUL-Allocations-r16 -1)*.... and other Type 1 B DCI field specific configurations similarly* AntennaPorts\_presence ENUMERATED {common, cell-spec}*.... and for other Type 2 / Type 1A (i.e. common or cell-specific) DCI field configurations similarly*}DCI-1-X ::= SEQUENCE {priorityIndicatorDCI-1-X ENUMERATED {enabled}*... and other DCI format 1\_X specific configuration similarly, such as table for indication of co-scheduled cells,...*pdsch-TimeDomainAllocationListDCI-0-X ::= SEQUENCE (SIZE(1..256)) OF PDSCH-TimeDomainResourceAllocationDCI-0-XPDSCH-TimeDomainResourceAllocationDCI-0-X ::= SEQUENCE (SIZE (2..4)) of INTEGER (0... maxNrofDL-Allocations-1)*.... and other Type 1 B DCI field specific configurations similarly*AntennaPorts\_presence ENUMERATED {common, cell-spec}*.... and for other Type 2 / Type 1A (i.e. common or cell-specific) DCI field configurations similarly*} |

**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* |

# Proposals for online/offline discussion

# References

1. [R1-2300130](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300130.zip) Discussion on multi-cell scheduling with a single DCI Huawei, HiSilicon
2. [R1-2300233](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300233.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI Spreadtrum Communications
3. [R1-2300289](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300289.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI OPPO
4. [R1-2300342](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300342.zip) Discussion on Multi-cell PUSCH/PDSCH scheduling with a single DCI ZTE
5. [R1-2300365](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300365.zip) On multi-cell PUSCH/PDSCH scheduling with a single DCI Nokia, Nokia Shanghai Bell
6. [R1-2300469](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300469.zip) Discussion on multi-cell scheduling vivo
7. [R1-2300591](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300591.zip) Discussion on the remaining issues for the multi-cell scheduling with a single DCI xiaomi
8. [R1-2300696](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300696.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI CATT
9. [R1-2300725](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300725.ZIP) Remaining issues on multi-cell scheduling with a single DCI China Telecom
10. [R1-2300731](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300731.zip) On multi-cell scheduling via a single DCI Lenovo
11. [R1-2300756](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300756.zip) CSI request in case of multi-cell PUSCH scheduling Fujitsu
12. [R1-2300830](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300830.zip) Discussion on Multi-cell PXSCH scheduling with a single DCI NEC
13. [R1-2300964](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2300964.zip) Discussions on multi-cell scheduling with a single DCI Intel Corporation
14. [R1-2301018](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301018.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI CMCC
15. [R1-2301062](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301062.zip) Discussions on multi-cell PUSCH/PDSCH scheduling with a single DCI CAICT
16. [R1-2301109](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301109.zip) Discussion on Multi-cell PUSCH/PDSCH scheduling LG Electronics
17. [R1-2301280](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301280.zip) On multi-cell PUSCH/PDSCH scheduling with a single DCI Samsung
18. [R1-2301315](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301315.zip) Remaining Issues on multi-cell PUSCH/PDSCH scheduling with a single DCI Langbo
19. [R1-2301321](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301321.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI ITRI
20. [R1-2301362](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301362.zip) On remaining issues for multi-cell PUSCH/PDSCH scheduling with a single DCI Apple
21. [R1-2301429](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301429.zip) Multi-cell PUSCH/PDSCH scheduling with a single DCI Qualcomm Incorporated
22. [R1-2301509](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301509.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI NTT DOCOMO, INC.
23. [R1-2301556](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301556.zip) Multi-cell PUSCH/PDSCH scheduling with a single DCI Ericsson
24. [R1-2301563](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301563.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI Google Inc.
25. [R1-2301601](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CR1-2301601.zip) On multi-cell PUSCH/PDSCH scheduling with a single DCI MediaTek Inc.

# 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., $M\_{PDCCH}^{max,slot,μ}, C\_{PDCCH}^{max,slot,μ}, M\_{PDCCH}^{total,slot,μ}$ and $C\_{PDCCH}^{total,slot,μ}$) 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., $M\_{PDCCH}^{max,slot,μ}, C\_{PDCCH}^{max,slot,μ}, M\_{PDCCH}^{total,slot,μ}$ and $C\_{PDCCH}^{total,slot,μ}$) 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.

## Agreements made in RAN1#111

**Proposal 2-1 rev3:**

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 reference cell.
* 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 reference cell.
* Same reference cell is used for both DCI format 0\_X and DCI format 1\_X.
* The reference cell is
	+ the scheduling cell if the scheduling cell is included in the set of cells and search space of the DCI format 0\_X/1\_X is configured only on the scheduling cell;
	+ one cell of the set of cells which search space of DCI format 0\_X/1\_X is configured on and associated with the search space of the scheduling cell with the same search space ID if search space of the DCI format 0\_X/1\_X is configured on the cell in addition to the scheduling cell.
		- It is up to gNB on which cell the SS of the DCI format 0\_X/1\_X is configured on.
* To address Rel-17 BD/CCE limit for any given cell (operating the feature under Rel-17 BD/CCE limit)
	+ For the reference cell, a total number of configured BD/CCEs for both DCI formats 0\_X/1\_X and legacy DCI formats (if configured) does not exceed the Rel-17 limits.
	+ For other cells in the sets of cells, Rel-17 limits for PDCCH/DCI monitoring and BD/CCE counting rules for legacy DCI formats (not including DCI formats 0\_X/1\_X) apply
* ~~Note: This does not mean a UE is required to support number of BDs/CCEs beyond the Rel-17 limits (i.e.,~~ $M\_{PDCCH}^{max,slot,μ}, C\_{PDCCH}^{max,slot,μ}, M\_{PDCCH}^{total,slot,μ}$ ~~and~~ $C\_{PDCCH}^{total,slot,μ}$~~) for PDCCH candidates for each scheduled cell.~~

**Agreement**

For a set of cells which is configured for multi-cell scheduling, up to 4 cells within the set of cells are supported.

* A DCI format 0\_X/1\_X can schedule PUSCH(s)/PDSCH(s) on a combination of co-scheduled cells among the same set of cells.

**Agreement**

For DCI format 1\_X/0\_X,

* Type-1 fields at least include below:
	+ ChannelAccess-Cpext
	+ TDRA
* Below fields are agreed to be supported for DCI format 0\_X/1\_X. FFS: Whether the fields are type1, type2, type configurable, or omitted. FFS: details on the fields (e.g. length, which legacy configurations are applicable), other fields.
	+ HARQ process number
	+ MCS (FFS: potential compression scheme)
	+ Bandwidth part indicator
	+ Frequency domain resource assignment (FFS: potential compression scheme)
	+ VRB-to-PRB mapping
	+ PRB bundling size indicator
	+ Rate matching indicator
	+ ZP CSI-RS trigger
	+ Antenna port(s)
	+ Transmission configuration indication
	+ DMRS sequence initialization
	+ Frequency hopping flag
	+ TPC command for scheduled PUSCH
	+ Precoding information and number of layers
	+ PTRS-DMRS association
	+ SRS request
	+ SRS resource indicator
	+ SRS offset indicator
	+ PTRS-DMRS association
	+ Open-loop power control parameter set indication
	+ UL/SUL indicator

Note: RAN1 strives to minimize the number of fields which are type configurable.

**Agreement**

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 by RRC signaling.

Agreement

The types for below fields in DCI format 1\_X are listed ([R1-2212924](file:///D%3A%5CRAN1%5CRAN1%23112%5Ctdocs%5CFL%20summary%5CR1-2212924.zip)):

|  |  |  |
| --- | --- | --- |
| **Field**  | **Type** | **Details(for information only)** |
| HARQ process number | Type 2 | Details in Section 7.1.1 |
| MCS  | Alt 1: Type 2 (without compression) | Details in Section 7.1.2 |
| BWP indicator | Type 1A | Details in Section 7.1.3 |
| FDRA | Type 2 * Further consider larger RBG granularity than existing maximum specified or configured value for RA type 0
* Use large RBG-based RIV for RA type 1 based on R16 configurable granularities for DCI format 1\_2
 | Details in Section 7.1.4 |
| VRB-to-PRB mapping | Type 1A | Details in Section 7.1.5 |
| PRB bundling size indicator | Type 1A | Details in Section 7.1.6 |
| Rate matching indicator | Type 1B (up to 4 bits) | Details in Section 7.1.7 |
| ZP CSI-RS trigger | Type 1B (up to 3 bits) | Details in Section 7.1.8 |
| Antenna port(s) | Configurable between Type 1A and Type 2 | Details in Section 7.1.9 |
| TCI | Type 1B (up to 4 bits) | Details in Section 7.1.10 |
| DMRS sequence initialization | Type 1A | Details in Section 7.1.11 |
| SRS request | Type 1B (up to 4 bits) | Details in Section 7.1.12 |
| SRS offset indicator | Type 1B (up to 3 bits) | Details in Section 7.1.13 |

This does not imply that payload of DCI can be larger than what is supported for polar code in Rel-17.

FFS: Details

**Agreement**

* The types for below fields in DCI format 0\_X are listed:

|  |  |  |
| --- | --- | --- |
| Field  | Type | **Details(for information only)** |
| HARQ process number | Type 2 | Details in Section 7.2.1 |
| MCS  | Alt 1: Type 2 (without compression) | Details in Section 7.2.2 |
| BWP indicator | Type 1A | Details in Section 7.2.3 |
| FDRA | Type 2 * Further consider larger RBG granularity than existing maximum specified or configured value for RA type 0
* Use large RBG-based RIV for RA type 1 based on R16 configurable granularities for DCI format 1\_2
 | Details in Section 7.2.4 |
| Frequency hopping flag | Type 1A | Details in Section 7.2.5 |
| TPC command for scheduled PUSCH | Type 2 | Details in Section 7.2.6 |
| Open-loop power control parameter set indication | Type 1A | Details in Section 7.2.7 |
| Antenna port(s) | Configurable between Type 1A and Type-2 | Details in Section 7.2.8 |
| Precoding information and number of layers | Configurable between Type 1A and Type-2 | Details in Section 7.2.9 |
| PTRS-DMRS association | Type 2 | Details in Section 7.2.10 |
| DMRS sequence initialization | Type 1A | Details in Section 7.2.11 |
| SRS request | Type 1B (up to 4 bits) | Details in Section 7.2.12 |
| SRS resource indicator | Configurable between Type 1A and Type-2 | Details in Section 7.2.13 |
| SRS offset indicator | Type 1B (up to 3 bits) | Details in Section 7.2.14 |
| UL/SUL indicator | FFS | Details in Section 7.2.15 |

This does not imply that payload of DCI can be larger than what is supported for polar code in Rel-17.

FFS: Details