**3GPP TSG RAN WG1 Meeting #119 R1-240XXXX**

**Orlando, US, November 18th – 22nd, 2024**

**Source: Moderator (Lenovo)**

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

**Agenda item:** **9.12.1**

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

# Introduction

This document summarizes the open issues on multi-cell scheduling from contributions submitted under the agenda item of “**9.12 Multi-Carrier Enhancements for NR Phase 2**” for Rel-19 WI Multi-carrier enhancements.

The Rel-19 WI Multi-carrier enhancements was approved during RAN#105 meeting in RP-242408, where the objective is targeted to specify the support of multi-cell PUSCH/PDSCH scheduling with a single DCI including scheduling of different SCS/carrier types and one or multiple PUSCHs/PDSCHs per scheduled cell. The detailed objectives in the WID are listed below:

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| ***1. Specify the support of the following for multi-cell PUSCH/PDSCH scheduling with a single DCI [RAN1]**** ***Different SCS/carrier type among co-scheduled cells by the single DCI.***
* ***One or multiple PUSCHs/PDSCHs per scheduled cell by the single DCI.***
	+ ***The maximum number of PUSCHs/PDSCHs per scheduled cell is [4 or 8].***
	+ ***Note: Type-1 HARQ-ACK codebook is not enhanced for Rel-19 multi-cell scheduling.***
	+ ***Note: The maximum number of sub-codebooks for Type-2 HARQ-ACK codebook is not increased for Rel-19 multi-cell scheduling.***
	+ ***Note: UE does not expect to be configured with both single-cell multi-PUSCH/PDSCH scheduling and multi-cell multi-PUSCH/PDSCH scheduling on the same or different cells within a same PUCCH group.***
* ***Note: No new DCI format is introduced.***
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In this contribution, the related issues and proposals are summarized based on the contributions submitted in RAN1#118bis under the agenda item 9.12 [1]-[21]. The whole feature lead summary is structured as follows:

From section 2 to 4, the main issues raised by company contributions are divided into 3 sections. In each section, the background and related proposals submitted in this meeting are listed firstly in the corresponding sub-section, then summary on one or several sub-issues is provided in the next sub-section 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 5, some proposals are selected for discussion in the online/offline sessions.

In Section 7, the agreements made in previous RAN1/RAN meetings on multi-cell scheduling 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 general aspects

## Background and submitted proposals

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| **Huawei:***Proposal 1: Unlicensed band is deprioritized in Rel-19 MC enhancement.* *Proposal 2: 480/960 kHz SCS is deprioritized in Rel-19 MC enhancement.**Proposal 3: The maximum number of different SCS that can be scheduled by a DCI format 0\_3/1\_3 depends on the UE capability.***Lenovo:***Proposal 1: Rel-19 supports a DCI format 0\_3/1\_3 schedules one cell with multiple PUSCHs or PDSCHs on the cell.* **ZTE:***Proposal 1: Consider the case involving three different SCS can be scheduled by a DCI format 0\_3/1\_3 in Rel-19.** *Case 7: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed FDD cell(s) with SCS1, TDD cell(s) with SCS2 and FR2-1 cell(s) with SCS3.*
	+ *SCS1, SCS2 and SCS3 can be same or different.*

**Samsung:***Proposal 1: RAN1 to proceed the WI discussions with consideration of Cases 1, 2, and 3, as captured in RAN1#118bis, for MC-DCI with different SCS or different carrier types.**Proposal 4: The following can be discussed for multi-PDSCH/PUSCH scheduling with MC-DCI formats:** *A UE does not expect a DCI format 0\_3/1\_3 to schedule multiple PUSCHs/PDSCHs on only one cell;*
* *RAN1 to consider the supported scenarios in Rel-17 52.6GHz WI (e.g., FR2-2 or 120 kHz for FR2-1) as baseline for multi-PUSCH/PDSCH scheduling with DCI format 0\_3/1\_3.*

**Spreadtrum:***Proposal 1: Clarify the cases of scheduling cell and scheduled cells if scheduling cell is out of set of cells, including the SCS and carrier type of scheduling cell.**Proposal 3: SCS combinations of scheduling cell and scheduled cells affects the number of DCI.**Proposal 4: For the same SCS and same carrier type of the scheduled cell, support at least the following cases for scheduled cells:* * *Multi-cell multi-PDSCH scheduling by DCI format 1\_3 is applicable to cells with 120kHz SCS*
* *Multi-cell multi-PUSCH scheduling by DCI format 0\_3 is applicable to FR1 unlicensed TDD cells and cells with 120kHz SCS*

*Proposal 5: For the different SCS and different carrier type of the scheduled cell, support at least the cases of green box in Table 3.***vivo:***Proposal 1: The case 1 to case 6 for the scheduled cells can be supported in Rel-19 MCE.**Proposal 2: In Rel-19, if there is no additional spec impact, support the following cases for scheduled cells:** *Case 7: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed FDD cell(s) with SCS1 and FR1 unlicensed TDD cell(s) with SCS2.*
	+ *SCS1 can be same or different to SCS2.*
* *Case 8: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed TDD cell(s) with SCS1 and FR1 unlicensed TDD cell(s) with SCS2.*
	+ *SCS1 can be same or different to SCS2.*
* *Case 9: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 unlicensed TDD cell(s) with different SCSes.*

*Proposal 3: Support at least the case that up to two different SCSes can be scheduled by a DCI format 0\_3/1\_3 in Rel-19. If there is no additional spec impact, support more than two different SCSes from 15kHz to 960kHz among the cells co-scheduled by a DCI format 0\_3/1\_3.**Proposal 6: In Rel-19 MCE, consider the following scenarios:* * *Multi-cell multi-PDSCH scheduling by DCI format 1\_3 is applicable to 120kHz SCS for FR2-1 cells.*
* *Multi-cell multi-PDSCH scheduling by DCI format 1\_3 is applicable to FR2-2 cells.*
* *Multi-cell multi-PUSCH scheduling by DCI format 0\_3 is applicable to FR1 cells.*
* *Multi-cell multi-PUSCH scheduling by DCI format 0\_3 is applicable to 120kHz SCS for FR2-1 cells.*
* *Multi-cell multi-PUSCH scheduling by DCI format 0\_3 is applicable to FR2-2 cells.*

**Nokia:***Proposal 3.1: On multi-PUSCH/PDSCH support with DCI formats 0\_3/1\_3, consider the following modifications in red on top of the latest discussed RAN1#118bis moderator proposal:*

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| **Proposal 1-3 rev2:*** Multi-cell multi-PDSCH scheduling by DCI format 1\_3 is applicable to FR 2-1 cells with 120kHz SCS in Rel-19.
* Multi-cell multi-PUSCH scheduling by DCI format 0\_3 is applicable to FR1 cells and FR2-1 cells.
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*Proposal 3.2: Support scheduling using DCI format 0\_3 of multiple cells, where a subset of the co-scheduled cells may be configured for multi-PUSCH scheduling and the remaining co-scheduled cells may be configured with (single) PUSCH scheduling including repetitions & TBoMS (using numberOfSlotsTBoMS, AvailableSlotCounting, numberOfRepetitions or pusch-AggregationFactor).* *Proposal 3.3: Support scheduling using DCI format 1\_3 of multiple cells, where a subset of the co-scheduled cells may be configured for multi-PDSCH scheduling and the remaining co-scheduled cells may be configured with (single) PDSCH scheduling including aggregation (using pdsch-AggregationFactor or repetitionNumber).* **Apple:***Proposal 1: RAN1 to consider supporting multiple reference cells within the set of cells corresponding to each of the different SCS associated with the cells within the set**Proposal 2: RAN1 consider supporting up to two different SCS associated with the cells within the set of cells**Proposal 3: For a UE, overall BD/CCE budget is not increased relative to Rel-18, even with support of different SCS for cells within the set**Proposal 4: RAN1 to study the procedure to determine the maximum number of unicast DCIs that the UE is expected to process within the monitoring slot**Proposal 5: For co-scheduled cells with different SCS, reference PDSCH can be determined as follows:** *Step 1: Determine the last co-scheduled PDSCH for each of the configured SCS, i.e. if there are 2 different SCS, then 2 corresponding last co-scheduled PDSCHs are determined*
* *Step 2: Determine the timing for PUCCH for transmission of corresponding HARQ-ACK (for all co-scheduled PDSCHs) for each of the last co-scheduled PDSCH with each of the SCS*
* *Step 3: Compare the timelines and determine the reference PDSCH that results in the most the relaxed timing for PUCCH corresponding to the overall last co-scheduled PDSCH*

**CATT:***Proposal 1: For supported FR and SCS for multi-cell multi-PUSCH/PDSCH, support at least follows:* * *Multi-cell multi-PUSCH scheduling by DCI format 0\_3 is applicable to FR1 and 120 kHz SCS in FR2-1.*
* *Multi-cell multi-PDSCH scheduling by DCI format 1\_3 is applicable to 120 kHz SCS in FR2-1.*

*Proposal 2: For multi-cell/multi-PUSCH scheduling, consider following options for the maximum number of PUSCHs per scheduled cell with 1TB and the maximum number of cell supporting multi-PUSCH scheduling in a cell set:** *Option 1: the maximum number of PUSCHs per scheduled cell is 4, and the maximum number of cell supporting multi-PUSCHs scheduling is 4.*
* *Option 2: the maximum number of PUSCHs per scheduled cell is 8, and the maximum number of cell supporting multi-PUSCHs scheduling is 2.*

*Proposal 3: For multi-cell multi-PDSCH scheduling, consider following options for maximum number of PDSCHs per scheduled cell with 2TBs and the maximum number of cell supporting multi-PDSCH scheduling in a cell set:** *Option 1: the maximum number of PDSCHs per scheduled cell is 4, and the maximum number of cell supporting multi-PDSCHs scheduling is 2.*
* *Option 2: the maximum number of PDSCH per scheduled cell is 8, and the maximum number of cell supporting multi-PDSCHs scheduling is 1.*

**China Telecom:***Proposal 2: For the support of multiple PUSCHs/PDSCHs scheduled in a cell within multiple co-scheduled cells by DCI format 0\_3/1\_3 in Rel-19, there is no extension beyond the applicable FR/SCS of multiple PUSCHs/PDSCHs scheduling by a DCI in previous release.***TCL:***Proposal 1: For Rel-19 multi-cell PUSCH/PDSCH scheduling with a single DCI, the following cases can be supported:* * *Case 1: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed FDD cell(s) with SCS1 and FR1 licensed TDD cell(s) with SCS2.*
	+ *SCS1 can be same or different to SCS2.*
* *Case 2: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed FDD cell(s) with SCS1 and FR2-1 cell(s) with SCS2.*
	+ *SCS1 can be same or different to SCS2.*
* *Case 3: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed TDD cell(s) with SCS1 and FR2-1 cell(s) with SCS2.*
	+ *SCS1 can be same or different to SCS2.*
* *Case 4: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed FDD cell(s) with different SCS.*
* *Case 5: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed TDD cell(s) with different SCS.*
* *Case 6: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR2-1 cell(s) with different SCS.*

**OPPO:***Proposal 2: Whether to support multi-PDSCH scheduling per scheduled cell by DCI format 1\_3 in FR1 should be discussed.***NTT DOCOMO:***Proposal 2: Simple capability structure is preferable and should be discussed in UE feature discussion.**Proposal 3: Specification impacts to support different SCS/carrier type among co-scheduled cells include at least followings.** *reference PDSCH for HARQ-ACK timing determination (See section 2.1.)*
* *updating TS38.300 to remove the restriction*
* *introducing new UE capability(es) for the support of different SCS/carrier type among co-scheduled cells*

*Proposal 4: Single-cell multiple PUSCHs/PDSCHs scheduling by DCI format 0\_3/1\_3 should be supported as a starting point.***Qualcomm:***Proposal 6:** *Do not put supported scenario(s) restriction in RAN1 normative specifications.*
	+ *Restrictions of SCS/carrier-type combinations can be specified in RAN1 only if RAN1 specification work is identified to support the SCS/carrier-type combinations.*
* *Support SCS 480/960kHz on the scheduling cell / scheduled cell(s) if no specification work is identified.*

**MediaTek:***Proposal 1: Maintain the restriction for multi-PDSCH scenario applicability as for Rel-18, i.e. multi-PDSCH scheduling is only applicable for FR2 120kHz SCS for MC-DCI.**Proposal 2: Avoid optimising the feature for the theoretical highest order scenarios of cells x PxSCHs. Focus on identifying the real commercial deployment needs before considering further compression of the MC-DCI.***Ericsson:***Proposal 10: Repetition and TB transmission over multiple slots are not supported for the enhanced DCI 0\_3/1\_3.**Proposal 11: The discussion on supported scenarios should be postponed after adequate progress or competition of the feature design due to the limited TU.**Proposal 12: Case 1, Case 2 and Case 3 are supported for Rel-19 operation of DCI 0\_3/1\_3.* |

## Moderator summary and proposals based on contributions

* On supported cases for co-scheduled PUSCHs/PDSCHs with different SCS or carrier type:

Rel-18 multi-cell scheduling via DCI formats 0\_3/1\_3 has restriction of same SCS and same carrier type (TDD/FDD, or FR1/FR2, licensed/unlicensed) among the co-scheduled cells.

For Rel-19, regarding different SCS or carrier types among co-scheduled cells, below agreement is made in RAN1#118bis meeting:

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| **Agreement:** * Consider at least the case that up to two different SCS can be scheduled by a DCI format 0\_3/1\_3 in Rel-19.
* Consider at least the following cases for scheduled cells in Rel-19:
* Case 1: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed FDD cell(s) with SCS1 and FR1 licensed TDD cell(s) with SCS2.
	+ SCS1 can be same or different to SCS2.
* Case 2: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed FDD cell(s) with SCS1 and FR2-1 cell(s) with SCS2.
	+ SCS1 can be same or different to SCS2.
* Case 3: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed TDD cell(s) with SCS1 and FR2-1 cell(s) with SCS2.
	+ SCS1 can be same or different to SCS2.
* Case 4: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed FDD cell(s) with different SCS.
* Case 5: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed TDD cell(s) with different SCS.
* Case 6: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR2-1 cell(s) with different SCS.
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With above agreement made after a long time spent on use cases, the discussion on supported scenarios can be deprioritized after adequate progress of the feature design due to the limited TU, or triggered if clear RAN1 spec impact is needed. Further details can be considered during the UE features discussions.

# DCI field design

## Background and submitted proposals

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| **Huawei:***Proposal 4: The maximum number of PUSCHs/PDSCHs per scheduled cell by a single joint-DCI is 4 in Rel-19 MC enhancement.* * *Further limit can be discussed per each/total co-scheduled cell(s).*

*Proposal 5: For type-2 field, the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 when the scheduled cell set is not configured.* *Proposal 6: For NDI field, Option 2 is supported when the scheduled cell set is configured.* *Proposal 8: For RV field, Option 2 is supported when the scheduled cell set is configured.* *Proposal 7: For multi-PUSCH/PDSCH scheduling using a DCI format 0\_3/1\_3, redundancy version is determined according to Table 7.3.1.2.3-1 of TS 38.212.***Lenovo:***Proposal 2: For each block of NDI field in DCI format 0\_3/1\_3, the number of bits is equal to the actual number of scheduled PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.**Proposal 3: For each block of RV field in DCI format 0\_3/1\_3, the number of bits is determined based on the actual number of scheduled PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.* *Proposal 4: The maximum number of PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3 in Rel-19 is 8.**Proposal 5: For a UE, the maximum number of PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3 can be smaller than or equal to 8.**Proposal 6: It is up to gNB to guarantee the payload size of a DCI format 0\_3/1\_3 not exceeding 140.**Proposal 7: Define the maximum number of schedulable TBs by a DCI format 0\_3/1\_3 in Rel-19.***CMCC:***Proposal 1. In DCI format 0\_3/1\_3, for each block of NDI field, support Option 1:** *Option 1: the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.*

*Proposal 2. In DCI format 0\_3/1\_3, for each block of RV field, support Option 1:** *Option 1: the number of bits is determined based on the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.*

**ZTE:***Proposal 2: For the HARQ process number field in DCI format 0\_3,* * *Each block of HPN in DCI format 0\_3 is 4 or 5 bits determined by higher layer parameter harq-ProcessNumberSizeDCI-0-3-r19 configured for the cell corresponding to the block and configured with multi-PUSCH scheduling.*

*Proposal 3: For each block of NDI/RV fields in DCI format 0\_3/1\_3, Option 2 is preferred. FFS compression or sharing indication.** *Option 2: the number of bits is determined based on the actual number of scheduled PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.*

*Proposal 10: The maximum number of PUSCHs/PDSCHs per scheduled cell is 8.**Proposal 11: The maximum number of PUSCHs/PDSCHs per DCI can be predefined or configured if needed.***Samsung:***Proposal 3: Discuss whether to update the field type of the ‘minimum scheduling offset indicator’ field (e.g., from Type-1A to Type-1B).**Proposal 5: On the number of PUSCHs/PDSCHs for MC-DCI in Rel-19:** *the maximum number of PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3 is 4.*

*Proposal 6: Adopt Option 1 in the RAN1#118bis agreement for determining the number of bits for NDI and RV in case of multi-PXSCH scheduling by DCI formats 0\_3/1\_3:** *[For NDI] Option 1: the number of bits for each block of the NDI field is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.*
* *[For RV] Option 1: the number of bits for each block of the RV field is determined based on the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits configured for RV for the corresponding cell.*

*Proposal 7: For TDRA field in DCI format 0\_3/1\_3 with multi-PUSCH/PDSCH scheduling:** *Clarify that both contiguous and non-contiguous time-domain allocations are supported;*
* *Clarify that “the TDRA table applicable for multi-PUSCH/PDSCH scheduling by DCI format 0\_3/1\_3 for the corresponding cell” does not apply to DCI formats 0\_1/1\_1;*
* *Further discuss the need for increasing the bit-width of the TDRA field compared to Rel-18.*

**Spreadtrum:***Proposal 6: Consider following option to support multi-cell multi-PUSCH/PDSCH scheduling** *Rel-18 multi-PDSCH/PUSCH TDRA table is not applied to DCI format 0\_1/1\_1 when DCI format 0\_3/1\_3 is configured.*

*Proposal 7: One maximum number of PUSCH/PDSCH per scheduled cell in multi-cell multi-PUSCH/PDSCH scheduling is 4.**Proposal 8: In DCI format 0\_3/1\_3, for each block of NDI field, Option1 is supported:** *Option 1: the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.*

*Proposal 9: In DCI format 0\_3/1\_3, for each block of RV field, Option1 is supported :** *Option 1: the number of bits is determined based on the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.*

*Proposal 10: It needs to decide the impact to UL-SCH indicator field in DCI format 0\_3 for multi-cell multi-PDSCH/PUSCH.***vivo:***Proposal 7: The maximum number of PUSCHs/PDSCHs per scheduled cell is 8.* *Proposal 8: In DCI format 0\_3/1\_3, for each block of NDI/RV fields, option 1 is adopted if the scheduled cells are indicated by FDRA, while option 2 is adopted if the scheduled cells are indicated by scheduled cell indicator.* **Nokia:***Proposal 3.4: Adopt the RAN1#118bis moderator on the maximum number of PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3, i.e.*

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| **Proposal 2-5:*** For Rel-19, the maximum number of PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3 is 8.
* For a UE, the maximum number of PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3 can be smaller than or equal to 8.
* It is up to gNB to guarantee the payload size of a DCI format 0\_3/1\_3 not exceeding 140.
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*Proposal 3.5: Adopt Option 1 for the NDI field definition, i.e.* * *In DCI format 0\_3/1\_3, for each block of NDI field, the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.*

*Proposal 3.6: Adopt the principle of Option 1 for the RV field definition but limit to 1bit RV per PDSCH/PUSCH in case of multi-PUSCH/PDSCH on a cell aligned with the Rel-16/17 multi-PUSCH/PDSCH scheduling principle, i.e.* * *In DCI format 0\_3/1\_3, for each block of RV field,*
	+ *if the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell is larger than 1 (i.e. configured for multi-PDSCH/PUSCH scheduling), the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.*
	+ *otherwise (i.e. NOT configured for multi-PDSCH/PUSCH scheduling), the number of bits for RV configured for the corresponding cell (i.e. 1 or 2 bits)*

*Proposal 3.7: The redundancy version corresponding to a scheduled PUSCH/PDSCH of multi-PUSCH/PDSCH scheduling using DCI format 0\_3/1\_3 is determined according to Table 7.3.1.2.3-1 (supporting RV0 & RV3)** *Note: This is aligned with the Rel-18 DCI format 0\_3/1\_3 operation of cells configured with 1bit RV by numberOfBitsForRV-DCI-0-3/1-3.*

*Proposal 3.11: Support new configurable TDRA tables per scheduled cell for multi-PxSCH scheduling of DCI format 0\_3/1\_3 having the same structure as the existing configurable TDRA tables for multi-PxSCH of DCI formats 0\_1/1\_1.** *e.g. pdsch-TimeDomainAllocationListForMultiPDSCH-DCI-1-3 and pusch-TimeDomainAllocationListForMultiPUSCH-DCI-0-3 to differentiate from pdsch-TimeDomainAllocationListForMultiPDSCH-DCI-r17 and pusch-TimeDomainAllocationListForMultiPUSCH-DCI-r16.*
* *FFS: number of rows*
	+ *In case of a maximum of 8 PDSCH/PUSCHs per scheduled cell, 64 rows should be supported as for single cell multi-PxSCH operation using DCI format 0\_1/1\_1*

*Proposal 3.12: Support a maximum TDRA field size of 8 bits (i.e. max. ITDRA=256) in DCI format 0\_3/1\_3**Proposal 3.13: Support new TDRA field index lists for DCI format 0\_3/1\_3 to (i) account for the needed increased scheduling flexibility for multi-PxSCH scheduling and (ii) to allow addressing larger underlying DL BWP specific TDRA tables for multi-PDSCH scheduling.* **Apple:***Proposal 6: RAN1 to consider support for scheduling up to 8 PUSCH/PDSCH with single-cell DCI format 0\_3/1\_3, provided there is no proportional increased in the DCI field size**Proposal 7: RAN1 to consider if any additional limitation on the maximum number of PUSCH/PDSCH across all the co-scheduled cells within the set is needed or not**Proposal 8: RAN to consider supporting only continuous scheduling of PUSCHS/PDSCHs per scheduled cell, i.e. without interleaving from other scheduled cells** *Simplifies HARQ-ACK feedback and corresponding timeline, especially in case of time-domain bundling*

*Proposal 9: In DCI format 0\_3/1\_3, for each block of NDI field, adopt option 1:** *Option 1: the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.*

*Proposal 10: In DCI format 0\_3/1\_3, for each block of RV field, adopt option 1:** *Option 1: the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.*

**NEC:***Proposal 1: For each block of NDI field and RV field, option 1 is supported, i.e., the number of bits is determined based on the maximum number of schedulable PUSCHs/PDSCHs.***CATT:***Proposal 4: In DCI format 0\_3/1\_3, for each block of NDI field, option 2 can be supported, i.e. the number of bits is equal to the actual number of scheduled PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.**Proposal 5: In DCI format 0\_3/1\_3, for each block of RV field, option 2 can be supported, i.e. the number of bits is determined based on the actual number of scheduled PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and the number of bits for RV configured for the corresponding cell.***China Telecom:***Proposal 3: In DCI format 0\_3/1\_3, for each block of NDI field, if the number of scheduled PUSCH/PDSCH is 1, then one bit NDI is applied; otherwise, the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.**Proposal 4: In DCI format 0\_3/1\_3, for each block of RV field, if the number of scheduled PUSCH/PDSCH is 1, then the number of bits is determined based on the number of bits for RV configured for the corresponding cell; otherwise, the number of bits is determined based on the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.**Proposal 5: For Rel-19 multi-cell PUSCH/PDSCH scheduling with a single DCI, the maximum number of PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3 is 8.***TCL:***Proposal 3: The maximum number of PUSCHs/PDSCHs per scheduled cell within the co-scheduled cells needs to take* *the DCI overhead into consideration.* **OPPO:***Proposal 3: From specification perspective, the maximum number of PUSCHs/PDSCHs per scheduled cell scheduled by DCI format 0\_3/1\_3 is 4.** *From UE perspective, the maximum number of PUSCHs/PDSCHS real scheduled per cell is up to UE capability.*

*Proposal 4: For NDI field design, option 1 (the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3) is preferred.**Proposal 5: For RV field, option 1 is preferred. One bit is used to indicate RV for a PUSCH/PDSCH on a cell when multiple PUSCHs/PDSCHs are scheduled on a cell, which is the same with Rel-16/17.**Proposal 6: The following two options can be considered for the TDRA table applicable for multi-PUSCH/PDSCH scheduling by DCI format 0\_3/1\_3:** *Option 1: Reuse the legacy TDRA table for multi-PUSCH/PDSCH scheduling by DCI format 0\_1/1\_1, and specify additional configuration/indication to determine the applicable DCI format when the legacy TDRA table is configured.*
* *Option 2: Define new TDRA tables for multi-PUSCH/PDSCH scheduling by DCI format 0\_3/1\_3, and the new TDRA table and the legacy TDRA table for multi-PUSCH/PDSCH scheduling by DCI format 0\_1/1\_1 are not configured simultaneously.*

**Panasonic:***Proposal 2: For the determination of the field size of NDI / RV field, the following options should be further studied.** *Option 1: Field size is based on the maximum number of schedulable cells and the maximum number of schedulable PUSCHs/PDSCHs on each corresponding cell by the DCI format 0-3/1-3.*
* *Option 1’: Field size is based on the maximum number of schedulable PUSCHs/PDSCHs across cells by the DCI format 0-3/1-3.*
* *Option 2: Field size is determined based on the actual number of scheduled PUSCHs/PDSCHs.*
* *Option 3: For each block of NDI/RV field, if the number of scheduled PUSCHs/PDSCHs is 1, then Option 2 is applied; otherwise, Option 1 is applied.*
* *Option 3’: If the number of scheduled PUSCHs/PDSCH across cells is 1, then Option 2 is applied; otherwise, Option 1’ is applied.*

*Proposal 3: Further DCI field size compression should be studied.** *At least for downlink, to apply common NDI / RV to the PDSCHs within the same bundling group should be studied.*

*Proposal 4:* * *RRC configuration in which DCI size determined based on the maximum number of cells and/or maximum number of PUSCHs/PDSCHs exceed 140 bits is allowed, as far as DCI size at each time, e.g., as far as maximum number of PUSCHs/PDSCHs is not scheduled, can be less than 140 bits.*
* *RRC can configure up to 8 PUSCHs/PDSCHs per scheduled cell.*
* *Instead of 140 bits of maximum DCI size, it can be considered to configure explicitly indication of its intended maximum size*

**LGE:***Proposal #1: On the TDRA table applicable for multi-PXSCH scheduling by DCI 0\_3/1\_3 for a cell (agreed in RAN1#118bis), clarify whether (multiple) TDRA information in each row is selected among those configured in the TDRA table applicable for single-PXSCH scheduling by DCI 0\_1/1\_1 for the cell, considering the complexity of Type-1 HARQ-ACK codebook generation.**Proposal #2: Among the three options for determination of each block of NDI/RV field in DCI 0\_3/1\_3 (agreed in RAN1#118bis), Option 2 is preferred in terms of reducing the DCI payload size.** *Clarify whether the size of whole NDI/RV field in the DCI is fixed (regardless of the number of scheduled PXSCHs) or varied (according to the number of scheduled PXSCHs).*

*Proposal #3: Discuss how to determine the size of UL-SCH field for the cell configured with multi-PUSCH scheduling (by DCI 0\_3).**Proposal #6: On the maximum number of PXSCHs per cell schedulable by a single DCI 0\_3/1\_3, support the following Proposal 2-5 (provided in RAN1#118bis).***NTT DOCOMO:***Proposal 5: Before deciding the maximum number of PUSCHs/PDSCHs per scheduled cell, restriction on DCI size should be carefully discussed.** *It’s up to gNB to guarantee the payload size of a DCI format 0\_3/1\_3 not exceeding 140 bits.*

*Proposal 6: Compression and/or sharing of indication (e.g., common RV indication among PDSCHs/PUSCHs for a scheduled cell) should be studied, e.g., to support scheduling 4 cells \* 4 PUSCHs/PDSCHs with keeping the flexibility of configurations.**Proposal 7: Option 1 and 2 in the agreement in #118bis should be updated as below.** *Option 1a: the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on each corresponding cell by the DCI format 0\_3/1\_3.*
* *Option 1b: the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs across cells by the DCI format 0\_3/1\_3.*
* *Option 2: the number of bits is equal to the actual number of scheduled PUSCHs/PDSCHs across cells by the DCI format 0\_3/1\_3.*
* *Option 3: If the number of scheduled PUSCH/PDSCH is 1, then one bit NDI is applied; otherwise, option 1 is applied.*

*Proposal 8: Either Option 1b or 2 should be supported for the determination of bit size of NDI/RV fields, i.e., based on Rel-18 Type-2 field principle, number of blocks for NDI/RV fields (or at least total DCI size) is determined based on maximum number of schedulable PDSCHs/PUSCHs according to RRC configuration (joint TDRA table entries).**Proposal 9: Separate new TDRA table for multi-PUSCH/PDSCH scheduling for each BWP of each cell to be referred by the joint TDRA table needs to be introduced.** *New joint TDRA tables and entries like tdra-FieldIndexListDCI-1-3-r18, tdra-FieldIndexListDCI-0-3-r18, TDRA-FieldIndexDCI-1-3-r18 and TDRA-FieldIndexDCI-0-3-r18 are necessary to refer separate new TDRA table for multi-PUSCH/PDSCH scheduling for each BWP of each cell instead of “TDRA table applicable for DCI format 1\_1”.*
* *Separate new TDRA tables for multi-PUSCH/PDSCH scheduling for each BWP of each cell from PUSCH-TimeDomainResourceAllocationList-r16 and MultiPDSCH-TDRA-List-r17 are necessary to be used for multi-cell multi-PDSCH/PUSCH scheduling via DCI format 1\_3/0\_3 instead of “single-cell multi-PDSCH/PUSCH scheduling via DCI format 1\_1/0\_1”.*

**Qualcomm:***Proposal 1:** *Support a maximum number of 8 PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3.*
* *Support a maximum number of 4 scheduled cells by a DCI format 0\_3/1\_3.*
* *Support a maximum number of 16 PUSCHs/PDSCHs over all scheduled cells by a DCI format 0\_3/1\_3.*
	+ *With this in mind, the maximum number of NDI/RV bits of a DCI format 0\_3/1\_3 is 16.*

*Proposal 2:** *Select Option 1 in the following agreements: (on NDI/RV indication)*

**Ericsson:***Proposal 1: For DCI format 0\_3/1\_3, for each block of NDI and RV field, support Option 1.**Proposal 2: For Rel-19, the maximum number of PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3 is N=8.**Proposal 3: For Rel-19, the maximum number of co-scheduled PUSCHs/PDSCHs by a DCI format 0\_3/1\_3 is M and provided by configuration.* * *The range value for M= {8, 16 or 32}.*
* *Note: It can be discussed whether additional capability is needed for M=16 or 32.*
 |

## Moderator summary and proposals based on contributions

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.

* On NDI field

Regarding NDI, the relevant agreement made in RAN1#118bis meeting is listed below:

|  |
| --- |
| Agreement* In DCI format 0\_3/1\_3, for each block of NDI field, consider the following options:
	+ Option 1: the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.
	+ Option 2: the number of bits is equal to the actual number of scheduled PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.
	+ Option 3: if the number of scheduled PUSCH/PDSCH is 1, then one bit NDI is applied; otherwise, option 1 is applied.
 |

For RAN1#119 meeting, regarding NDI indication, companies’ views are summarized as below:

* Option 1: the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.
	+ Supported by CMCC, Samsung, Spreadtrum, vivo (scheduled cells indicated by FDRA), Nokia, Apple, NEC, OPPO, Qualcomm, Ericsson,
* Option 2: the number of bits is equal to the actual number of scheduled PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.
	+ Supported by Huawei, Lenovo, ZTE, vivo (scheduled cells indicated by scheduled cells indicator), Apple, CATT, LGE, NTT DOCOMO
* Option 3: if the number of scheduled PUSCH/PDSCH is 1, then one bit NDI is applied; otherwise, option 1 is applied.
	+ Supported by China Telecom,

It is worth noting that the DCI payload size is determined based on the largest DCI size and not changed regardless of how many PDSCHs or PUSCHs are actually scheduled by the DCI format. Difference is field padding or DCI format padding with the prerequisite of same DCI payload size for 3 options. Furthermore, Option 2 and Option 3 for RV and NDI field handling increases UE complexity compared to Option1 as the UE needs to (i) first check the BWP field and the TDRA field in the DCI to (ii) determine the BWP specific TDRA index, then use the indicated TDRA index to (iii) determine the number of scheduled PUSCHs/PDSCHs per scheduled cell to finally determine the number of RV & NDI bits. Based on this, Option 1 seems the simplest one.

Hence, Proposal 2-1 is provided for further discussion.

* On RV field

Regarding RV, the relevant agreement made in RAN1#118bis meeting is listed below:

|  |
| --- |
| Agreement* In DCI format 0\_3/1\_3, for each block of RV field, consider the following options:
	+ Option 1: the number of bits is determined based on the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.
	+ Option 2: the number of bits is determined based on the actual number of scheduled PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.
	+ Option 3: if the number of scheduled PUSCH/PDSCH is 1, then option 2 is applied; otherwise, option 1 is applied.
 |

For RAN1#119 meeting, regarding RV indication, companies’ views are summarized as below:

* Option 1: the number of bits is determined based on the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.
	+ Supported by CMCC, Samsung, Spreadtrum, vivo (scheduled cells indicated by FDRA), Nokia, Apple, NEC, OPPO, Qualcomm, Ericsson,
* Option 2: the number of bits is determined based on the actual number of scheduled PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.
	+ Supported by Huawei, Lenovo, ZTE, vivo (scheduled cells indicated by scheduled cells indicator), Apple, CATT, LGE, NTT DOCOMO
* Option 3: if the number of scheduled PUSCH/PDSCH is 1, then option 2 is applied; otherwise, option 1 is applied.
	+ Supported by China Telecom,

To reuse similar design principle of NDI design, Proposal 2-2 is provided for further discussion.

In addition, as mentioned by 2 companies [Huawei, Nokia], one open issue for Rel-19 multi-cell scheduling using DCI format 0\_3/1\_3 is to reuse the 1-bit RV table for multi-PDSCH/PUSCH scheduling of DCI format 0\_1/1\_1 (using RV0/2) or from Rel-18 MC-DCI (using RV0/3).

As proposed the two companies, using table 7.3.1.2.3-1 (selecting between RV0 & RV3) is preferred as this is aligned with 1 bit RV operation of cells not configured with multi-PUSCH/PDSCH operation.

Based on the above analysis, Proposal 2-3 is provided for discussion.

* On maximum number of PUSCHs/PDSCHs per scheduled cell

Regarding maximum number of PUSCHs/PDSCHs per scheduled cell, companies’ views are summarized as below:

* Maximum number of PUSCHs/PDSCHs per scheduled cell is 4.
	+ Supported by Huawei, Samsung, Spreadtrum, OPPO
* Maximum number of PUSCHs/PDSCHs per scheduled cell is 8.
	+ Supported by Lenovo, ZTE, vivo, Nokia, Apple, China Telecom, Panasonic, LGE, Qualcomm, Ericsson

For Rel-16, up to 8 PUSCHs can be co-scheduled by one DCI format 0\_1 on same serving cell within FR1; furthermore, in Rel-17, up to 8 PUSCHs/PDSCHs can be co-scheduled by one DCI format 0\_1/1\_1 on same serving cell within FR2. For Rel-19 multi-cell scheduling, due to introduction of FR2 for co-scheduled cells, it is reasonable to maintain same maximum number of PUSCHs or PDSCHs as previous release so as to fully utilize the spectrum resource in FR2.

According to analysis on DCI payload size, 2-cell scheduling case can support maximum 8 PDSCHs per scheduled cell. In addition, by means of using larger granularity for FDRA field or scheduling at least one cell with narrower bandwidth, 4-cell scheduling can support maximum 4 PDSCHs per scheduled cell.

Hence, for Rel-19, the specification can support maximum 8 PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3. For a UE, the maximum number of PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3 can be smaller than or equal to 8. It is worth noting that it is up to gNB to guarantee the payload size of a DCI format 0\_3/1\_3 does not exceed the limitation of maximum 140 bits of DCI payload size, e.g., by configuring the proper number of co-scheduled cells, configuring larger granularity for FDRA, etc.

Hence, Proposal 2-4 is provided for discussion.

* On maximum number of co-scheduled PUSCHs/PDSCHs by a DCI

Regarding maximum number of PUSCHs/PDSCHs by a DCI, companies’ views are summarized as below:

* Confine the maximum number of schedulable PUSCHs/PDSCHs by a DCI format 0\_3/1\_3 in Rel-19
	+ Supported by Lenovo, ZTE, Apple, Qualcomm, Ericsson

For a set of cells which is configured for multi-cell scheduling via a single DCI format 0\_3/1\_3 with one or multiple PUSCHs or PDSCHs per scheduled cell, the maximum number of co-scheduled PUSCHs or PDSCHs on all the co-scheduled cells by the single DCI format 0\_3/1\_3 is determined based on the maximum number of cells which can be co-scheduled by one DCI format 0\_3/1\_3 and the maximum number of schedulable PUSCHs or PDSCHs per scheduled cell.

Considering the limitation of maximum 140 bits of DCI payload size, it may be impossible to use a single DCI format 0\_3/1\_3 to schedule maximum number of cells with maximum number of schedulable PUSCHs/PDSCHs per scheduled cell. For example, for a cell set including Cell 1, Cell 2, Cell 3 and Cell 4, assuming maximum 4 PUSCHs can be co-scheduled on Cell 1, maximum 4 PUSCHs can be co-scheduled on Cell 2, maximum 8 PUSCHs can be co-scheduled on Cell 3, and maximum 8 PUSCHs can be co-scheduled on Cell 4, however, it is impossible to jointly schedule 4 PUSCHs on Cell 1, 4 PUSCHs on Cell 2, 8 PUSCHs on Cell 3 and 8 PUSCHs on Cell 4 by a single DCI format 0\_3 due to DCI payload size limitation. It may be possible to jointly schedule the combination of 2 PUSCHs on Cell 1, 2 PUSCHs on Cell 2, and 4 PUSCHs on Cell 3, the combination of 1 PUSCH on Cell 1, 1 PUSCH on Cell 2, 4 PUSCHs on Cell 3 and 4 PUSCHs on Cell 4, or the combination of 8 PUSCHs on Cell 3 and 8 PUSCHs on Cell 4, or other combinations, by a single DCI format 0\_3. Similar case happens to DL joint scheduling by DCI format 1\_3. Certainly, it is up to gNB to guarantee the payload size of a DCI format 0\_3/1\_3 does not exceed the limitation of maximum 140 bits of DCI payload size.

In addition, the maximum number of schedulable PUSCHs/PDSCHs by a DCI format 0\_3/1\_3 is also relevant to the maximum number of NDI/RV bits in the DCI format 0\_3/1\_3 and the number of HARQ-ACK information bits for each DCI format 1\_3 in the second sub-codebook of Type-2 HARQ-ACK codebook. It is necessary to define the maximum number of schedulable PUSCHs/PDSCHs by a DCI format 0\_3/1\_3. With the help of the maximum number, the maximum number of NDI bits and the maximum number of RV bits in the DCI format 0\_3/1\_3 as well as the number of HARQ-ACK information bits per DCI format 1\_3 can be easily derived.

Hence, Proposal 2-5 is provided for discussion.

## 1st round of discussions

#### Proposal 2-1:

* In DCI format 0\_3/1\_3, for each block of NDI field, adopt Option 1 for NDI indication.
	+ Option 1: the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | We are OK with the Proposal. We are also fine with the proposal from [6, vivo] that the solution is Option 1 if the scheduled cell(s) is/are identified by valid/invalid FDRA, and is Option 2 if the scheduled cell(s) is/are identified by Scheduled cell indicator field. Note that, even if Option 2 is adopted, the total payload of the DCI is determined by the number of bits = maximum number of schedulable PUSCHs/PDSCHs on each cell. |
| Nokia | Support |
| CATT | For the total number of NDI field of DCI format 0\_3/1\_3, Option 1 requires more bits than Option 2.Assuming one case that the maximum number of PUSCH/PDSCH on each cell is 8 and the maximum number of scheduled cell of a DCI format 0\_3/1\_3 is 4, and the maximum number of PUSCH/PDSCH scheduled by a DCI format 0\_3/1\_3 is 12, then total number of NDI field of DCI format 0\_3/1\_3 for Option 1 equals to 32 bits which is the multiplication of the maximum number of scheduled PUSCH/PDSCH and the maximum number of scheduled cells. But, for option 2, total number of NDI field of DCI format 0\_3/1\_3 is 12 bit. Thus, Option 2 is our preference.  |
| Apple | Support |
| China Telecom | Can accept option 1. |
| TCL | Support |
| ZTE | We don’t support Option 1 as there is no clear benefit. Option 2 can have lower payload size compared with Option 1. An example is shown below, where Option requires 8 bits while Option 2 requires 6 bits. Considering that the main challenge of the DCI format 0\_3/1\_3 is DCI payload, Option 2 should be adopted.

|  |  |  |
| --- | --- | --- |
|  | **The number of PDSCH** | **{block size for cell 1, block size for cell 2}** |
| **Cell 1** | **Cell 2** | **Option 1** | **Option 2** | **Option 3** |
| **TDRA index 0** | 1 | 2 | {4, 4} | {1, 2} | {1, 4} |
| **TDRA index 1** | 4 | 2 | {4, 4} | {4, 2} | {4, 4} |
| **TDRA index 2** | 1 | 4 | {4, 4} | {1, 4} | {1, 4} |
| **TDRA index 3** | 3 | 3 | {4, 4} | {3, 3} | {4, 4} |
| **TDRA index 4** | not scheduled | 2 | {0, 4} Note | {0, 2} Note | {0, 4} Note |
| **Total size** |  |  | 8 | 6 | 8 |
| Note: The value ‘0’ means that there is no corresponding information block |

 |
| Panasonic | Option 1 may reserve DCI field size for unnecessary combination of the number of schedulable cells and number of schedulable PUSCHs/PDSCHs on the corresponding cell. Therefore, we think the total field size determination based on the maximum number of schedulable PUSCHs/PDSCHs across cells by the DCI format 0-3/1-3 should be considered. We are not ready to agree Option 1. |
| vivo | We agree that option 1 is simpler, however, with the cost of higher DCI overhead. Given that current spec already supports two different schemes to indicate the scheduled cells (i.e., FDRA based vs. scheduled cell indicator), it seems reasonable to apply different options for different schemes. Note that the scheduled cell indicator scheme is introduced to reduce the DCI overhead as much as possible, using a similar approach as the option 2. Thus, it is natural to combine with option 2 to reduce the DCI overhead.Consider the current situation, we think it is actually also a good compromise. |
| NTT DOCOMO | First of all, as we proposed in our contribution, we would like to clarify option 1 in the proposal means that the number of bits in each block is equal to the maximum number of schedulable PUSCHs/PDSCHs on each corresponding cell. In such case, it may require unnecessary bits only for impossible combinations. For example, if the maximum schedulable PUSCHs/PDSCHs on each of cells #1 and #2 is 4 while there is no combination in which both cells #1 and #2 are scheduled with 4 PUSCHs/PDSCHs at the same time, option 1 needs 8 bits for NDI field. On the other hand, if we consider option 2 or another option (1b in our contribution) in which NDI field size is determined based on maximum number of schedulable PUSCHs/PDSCHs across co-schedulable cells, DCI size can be saved by not having such unnecessary bits for impossible case. But in these options, number of bits in each block change dynamically according to actual scheduling, and UE needs to decode FDRA/TDRA/co-scheduled cell indicator fields first.Regarding DCI format size, we did similar discussion in Rel-18 between FDRA-based and co-scheduled cell indicator based schemes, and in case of co-scheduled cell indicator based scheme, DCI format size is determined based on the entry of scheduledCellComboList which results largest size among entries. Therefore, we also think option 1 (1a in our contribution) can be applied to FDRA-based scheduling case, while option 2 or 1b in our contribution can be applied to co-scheduled cell indicator based scheduling case, to follow the same principle as Rel-18. |
| OPPO | It seems this proposal has some relation with proposal 2-5, so it would be good we can discuss proposal 2-5 first and then determine which option to choose after consensus is made for proposal 2-5 |
| Ericsson | We support Option 1.As we explained in our contribution, the efforts in reducing DCI overhead causes complexity at UE and gNB. It is also not clear that considering the size alignment , etc.., it will be even useful. |
| LGE | OK with the proposal (i.e., Option 1) for the case of FDRA field based cell combination indication.For the case of RRC table based cell combination indication, Option 2 seems to be preferable if we need to consider the case that the maximum number of PXSCHs co-schedulable by a DCI 0\_3/1\_3 is not always equal to the sum of maximum number of PXSCHs schedulable per cell, as in the above ZTE’s example. And in this case, it may need to be clarified whether the size of whole NDI/RV field in the DCI is fixed or varied according to the number of scheduled PXSCHs. |
| Samsung  | Support.Agree with the analysis from FL. It is also clear that Option 2 has larger specification impact and cannot achieve DCI size compression (e.g., as in the CATT example) when the scheduled cells are indicated by valid/invalid FDRA, because MC-DCI will include 4 NDI block for 4 cells in that case, and each block considers the largest “PDSCH combination”. When the scheduled cell indicator field is present, DCI size saving is already achieved as the MC-DCI is expected to include less than 4 NDI blocks. |

#### Proposal 2-2:

* In DCI format 0\_3/1\_3, for each block of RV field, adopt Option 1 for RV indication.
	+ Option 1: the number of bits is determined based on the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | We are OK with the Proposal. We are also fine with the proposal from [6, vivo] that the solution is Option 1 if the scheduled cell(s) is/are identified by valid/invalid FDRA, and is Option 2 if the scheduled cell(s) is/are identified by Scheduled cell indicator field. However, even if Option 2 is adopted, the total payload of the DCI is determined by the number of bits = maximum number of schedulable PUSCHs/PDSCHs on each cell.  |
| Nokia | Support |
| CATT | Similar to proposal 2-1, Option 2 is preferred.  |
| Apple | Support |
| China Telecom | Can accept option 1. |
| TCL | Support |
| ZTE | See comments for Proposal 2-1. |
| Panasonic | Same comment as Proposal 2-1. |
| vivo | Similar to P2-1, we propose to adopt option 1 for FDRA based cell identification scheme, and option 2 for scheduled cell indicator based scheme. |
| NTT DOCOMO | Our view on RV field is same as on NDI field, i.e., option 1 (1a in our contribution) can be applied to FDRA-based scheduling case, while option 2 or 1b in our contribution can be applied to co-scheduled cell indicator based scheduling case, to follow the same principle as Rel-18. |
| Ericsson | Same comment as Proposal 2-1.Also, it s good to treat these together and not to have different solutions for different fields. |
| LGE | OK with the proposal (i.e., Option 1) for the case of FDRA field based cell combination indication.For the case of RRC table based cell combination indication, Option 2 seems to be preferable if we need to consider the case that the maximum number of PXSCHs co-schedulable by a DCI 0\_3/1\_3 is not always equal to the sum of maximum number of PXSCHs schedulable per cell, as in the above ZTE’s example. And in this case, it may need to be clarified whether the size of whole NDI/RV field in the DCI is fixed or varied according to the number of scheduled PXSCHs. |
| Samsung | Support.Same reasons as for P2-1. |

#### Proposal 2-3:

* For multi-PUSCH/PDSCH scheduling using a DCI format 0\_3/1\_3, RV is determined according to Table 7.3.1.2.3-1 of TS 38.212.
	+ Note: This is aligned with Rel-18 DCI format 0\_3/1\_3 for cells configured with 1 bit RV by *numberOfBitsForRV-DCI-0-3/1-3*.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | We don’t think agreement is necessary. Without any agreement, RV determination for DCI format 0\_3/1\_3 in Rel-18 (i.e., Table 7.3.1.2.3-1 of TS 38.212) is automatically carried over to Rel-19. |
| Nokia | Support |
| CATT | Support |
| Apple | We tend to agree with QC, but either way is okay for us |
| China Telecom | OK |
| TCL | Support |
| ZTE | We don’t support. We think RV0/2 should be supported since it is supported for legacy multi-PUSCH/PDSCH scheduling. Here we should follow the principle of legacy the multi-PUSCH/PDSCH since it is indicated for multi-PUSCH/PDSCH scheduling. |
| Panasonic | We agree to Qualcomm’s understanding, but we are also OK to make explicit agreement as Proposal 2-3. |
| NTT DOCOMO | As we also think Rel-18 principle can be reused for Rel-19, we are fine with this proposal for clarification. |
| Ericsson | Same view as DCM. |
| LGE | Agree with QC and Apple/Panasonic. |
| Samsung | Not essential.The RV field is already configurable, so there is no need for 1-bit restriction – already supported by *numberOfBitsForRV-DCI-1-3*. Also, if a cell from the set of cells does not have multi-PxSCH scheduling configuration, the cell can continue to have 2-bit RV. |

#### Proposal 2-4:

* For Rel-19, the maximum number of PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3 is 8.
* For a UE, the maximum number of PUSCHs/PDSCHs per scheduled cell by a DCI format 0\_3/1\_3 can be smaller than or equal to 8.
* It is up to gNB to guarantee the payload size of a DCI format 0\_3/1\_3 not exceeding 140.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | We agree with the first two bullets. The third bullet looks allowing gNB to configure a DCI format 0\_3/1\_3 exceeding 140, which must be not the intention. We suggest to reformulate the third bullet as follows.* DCI format 0\_3/1\_3 with the payload size exceeding 140 bits is not supported in Rel-19.
 |
| Nokia | Support |
| CATT | OK  |
| Apple | We agree with 1st 2 bullet and for 3rd bullet, prefer QC’s wording. We would prefer to jointly take proposal 2-4 and proposal 2-5For this focused WI, the intention is to provide support for practical cases. We don’t think there will be any practical scenario when gNB may schedule all of 4 cells with 8 PDSCHs/PUSCHs. We should try to limit the range to a more reasonable number. We are open to specific values |
| China Telecom | Support |
| TCL | We are fine with the first two bullets.For the third bullet, in our views, the payload size of DCI format 0\_3/1\_3 cannot exceed 140 bits. |
| ZTE | Support.  |
| Panasonic | We are fine with the first and second bullets.For the third bullet, we have similar view to Apple. In our view, if dynamic DCI field size variation as Option 2 and Option 3 for NDI/RV field size determination even if the DCI size determined based on the maximum number of PUSCHs/PDSCHs exceed 140 bits, as far as such maximum number of PUSCHs/PDSCHs is not scheduled, DCI size at each time may be less than 140 bits and then, such RRC configuration is allowed. Then, our proposal is as follows.* RRC configuration in which DCI size determined based on the maximum number of cells and/or maximum number of PUSCHs/PDSCHs exceed 140 bits is allowed, as far as DCI size at each time, e.g., as far as maximum number of PUSCHs/PDSCHs is not scheduled, can be less than 140 bits.
 |
| NTT DOCOMO | Support both the original proposal and one modified by QC. We think that 4-cell and 4 PUSCHs/PDSCHs scheduling is one of the main target use cases, which can be realized by e.g., larger granularity for FDRA as FL said above and clarified in our contribution. In addition, NDI/RV field compression/sharing method can also be considered to reduce such a restriction. |
| Ericsson | We support the intention. We think having a limit on maximum number of PUSCHs/PDSCHs scheduled by a DCI 0\_3/1\_3 is helpful and helps us to have a reasonable design. However, similar to QC, the formulation should change. * 1) If we agree on one maximum value, that would be hard-coded in sepc.
* 2) If we agree on multiple, maybe one is default and other, is provided by RRC, or both are provided by RRC.
 |
| LGE | Support. |
| Samsung | Do not support. The maximum should be set to 4 PxSCHs per cell. Although it is preferred to retain the same flexibility as in Rel-16/17, it may not be possible for th3e gNB to guarantee a size smaller than 140 bits if the MC-DCI were to schedule 4 cells, each with 8 PxSCHs. The latter can be realized by using 2 MC-DCIs, each with 4 cells and 4 PxSCHs per cell.  |

#### Proposal 2-5:

* Define the maximum number of schedulable PUSCHs/PDSCHs by a DCI format 0\_3/1\_3 in Rel-19.
	+ FFS detailed values, e.g., 8, 16.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | We agree with the proposal. Note that it is not yet sure where to define/capture the maximum number (e.g., RRC, UE capability, 38.300, etc). |
| Nokia | We are not convinced that an explicit upper limit needs to be specified. There is no such aggregate max limit for CA where multi-PxSCH is used individually in each cell either. |
| CATT | OK |
| Apple | Same comment as for proposal 2-4 |
| China Telecom | Since it is up to gNB to guarantee the payload size of a DCI format 0\_3/1\_3 not exceeding 140 as in proposal 2-4, can the maximum number of schedulable PUSCHs/PDSCHs by a DCI format 0\_3/1\_3 be implicitly determined by gNB configuration of the number of cells in the co-scheduled cell set and TDRA table applicable for multi-PUSCH/PDSCH scheduling of each cell? Then it is up to gNB to determine the maximum number of schedulable PUSCHs/PDSCHs based on BWP size, FDRA granularity, etc. |
| TCL | OK |
| ZTE | We are fine with this proposal. |
| Panasonic | Same comment as for Proposal 2-4. |
| vivo | The proposal is not clear. Is it intended to define the max number of UE capability, or to define some configuration restriction? If it is the later one, why it is needed?  |
| NTT DOCOMO | It is clear that there should be some restrictions regarding the number of schedulable PUSCHs/PDSCHs by a single DCI format due to the DCI bit size issue. However, it is up to gNB to guarantee the payload size of a DCI format 0\_3/1\_3 not exceeding 140 bits, and hence it may be unnecessary to define the maximum number of schedulable PUSCHs/PDSCHs in specification if the reason to define this maximum number is only for DCI size issue. |
| Ericsson | We support in general, but:* First bullet is OK.
* second bullet is not needed. It is clearly the consequence of the first bullet.

Third bullet, we prefer QC formulation. |
| LGE | Agree with DOCOMO and Nokia/vivo.As companies commented, to guarantee the DCI payload size not exceeding the maximum 140 bits is up to gNB as in Rel-18 (e.g., by configuring proper number of co-scheduled cells (or configuring proper number of cells within a set), configuring larger RBG granularity for FDRA field, configuring proper number of PXSCH SLIVs in TDRA table, etc.). Therefore, it is unnecessary to explicitly limit the total number of PXSCHs across co-scheduled cells by single DCI. |
| Samsung | Can be discussed after some progress on P2-4.No need for this proposal when a maximum of 4 PxSCHs per cell is supported. |

# HARQ enhancements

## Background and submitted proposals

|  |  |  |
| --- | --- | --- |
| **Huawei:***Proposal 8: Further study is necessary regarding the reference PDSCH used for determining the PUCCH carrying HARQ-ACK information in Rel-19 multi-carrier scheduling.**Proposal 4: In Rel-19 multi-carrier scheduling, the following issues related to Type-2 HARQ-ACK codebook need further discussion:** *Additional loop in pseudo-code in section 9.1.3.1 of TS 38.213*
* *Maximum number of HARQ-ACK information bits reported for a DCI format 1\_3.*

**Lenovo:***Proposal 8: 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 PDSCH and a second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling more than one PDSCH. Separate DAI counting is applied for DCI(s) with each scheduling a single PDSCH and DCI(s) with each scheduling more than one PDSCH.**Proposal 9: For the second sub-codebook, the number of HARQ-ACK information bits for each DCI format 1\_3 that schedules more than one PDSCH is equal to Z, where Z is the maximum number of TBs which can be co-scheduled by a DCI format 1\_3 in the PUCCH group for the UE.* *Proposal 10: HARQ-ACK information bits for a DCI format 1\_3 that schedules more than one PDSCH are ordered firstly according to increasing order of PDSCH reception starting time on a same serving cell, then ordered according to ascending order of associated serving cell indexes.* *Proposal 11: Time-domain HARQ-ACK bundling is configured per cell and the number of bundling groups can be configured per cell from the set of {1, 2, 4} .* *Proposal 12: For DCI indicating SPS PDSCH release, TCI update, or SCell dormancy, without scheduling PDSCH, the HARQ-ACK information bit for the DCI is included in the first sub-codebook.* *Proposal 13: for DCI which schedules only one PDSCH and indicates SCell dormancy by reinterpreting a set of fields (e.g., MCS/NDI/RV for TB1, HARQ process number, Antenna ports if configured as type-2), the HARQ-ACK information bits for the DCI are included in the second sub-codebook.* *Proposal 14: If more than one PDSCH ends last among the set of co-scheduled PDSCHs, the reference PDSCH is the PDSCH with the smallest SCS among the PDSCHs ending last. Alternatively, it is up to gNB to avoid scheduling the case where multiple PDSCHs end last among co-scheduled PDSCHs and having different SCS.***CMCC:***Proposal 3. Reuse the PDSCH reception preparation time defined in Rel-16 cross carrier scheduling with different SCS for Rel-19 different SCS/carrier type among co-scheduled cells by the single DCI.**Proposal 4. For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs with different SCS by a DCI format 1\_3, the reference PDSCH is the PDSCH ending last scheduled by DCI format 1\_3 among the set of co-scheduled PDSCHs.**Proposal 5. nrofHARQ-BundlingGroups is configured per set of co-scheduled cells.**Proposal 6. For Type-2 codebook, two sub-codebooks are generated, which** *When time domain HARQ-ACK bundling is not configured,*
	+ *the first sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling a single PDSCH.*
	+ *the second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling more than one PDSCH.*
* *When time domain HARQ-ACK bundling is configured,*
	+ *the first sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling a single PDSCH and PDSCH(s) scheduled by DCI(s) with each scheduling more than one PDSCH which the set of scheduled cell provided nrofHARQ-BundlingGroups with value of 1.*
	+ *the second sub-codebook comprising HARQ-ACK information bits PDSCH(s) scheduled by DCI(s) with each scheduling more than one PDSCH which the set of scheduled cell provided nrofHARQ-BundlingGroups with value larger than 1.*

**ZTE:***Proposal 4: For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_3, follow Rel-18 operation, i.e., the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs and the PUCCH slot is determined based on the last UL slot overlapping with the reference PDSCH.**Proposal 5: Type-1 HARQ-ACK codebook is supported for multi-cell scheduling with K1 extension for Rel-19 multi-cell scheduling.** *UE expects HARQ-ACK information for all co-scheduled PDSCHs by DCI format 1\_3 can be mapped in the Type-1 HARQ-ACK codebook.*

*Proposal 6: 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 PDSCH and a second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling multiple PDSCHs.** *Separate DAI counting for two sub-codebooks.*

*Proposal 7: The number of HARQ-ACK bits for each DCI format 1\_3 that schedules multiple PDSCHs can be determined by M, where M is the maximum number of PDSCHs which can be co-scheduled by a DCI format 1\_3 in the PUCCH group for the UE.**Proposal 8: The HARQ-ACK bits for each DCI format 1\_3 for the second sub-codebook should be ordered first in ascending order of the PDSCH reception time, second in ascending order of cell index.**Proposal 9: For Rel-19 multi-cell scheduling, the per cell configuration of HARQ-ACK bundling in time domain as Rel-17 can be reused as a baseline, FFS other enhancements.***Samsung:***Proposal 2: Rel-18 procedure for determination of PUCCH timing based on ‘PDSCH ending last’ can be reused for Rel-19 multi-cell scheduling with different SCS:** *At least for slot-based PUCCH, no need for additional rules (e.g., based on SCS) if more than one PDSCHs end last among the set of co-scheduled PDSCHs – determination of “PDSCH ending last” is on the DL slot level (slot* $n$ *is the last UL slot overlapping with DL slot* $n\_{D}$*);*
* *FFS whether any additional rule is needed for sub-slot-based PUCCH, e.g., a PDSCH ending last is on the co-scheduled cell with the smallest cell index.*
* *It is up to the gNB to ensure that the UE timelines for PDSCH processing and HARQ-ACK generation are met for all co-scheduled cells with (same or) different SCS.*

*Proposal 8: [updates from FL Proposal 3-3 in RAN1#118bis is shown in red] For Type-2 HARQ-ACK codebook, when time domain HARQ-ACK bundling is not configured, 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 PDSCH and a second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling more than one PDSCHs.** *Separate DAI counting is applied for DCI(s) with each scheduling a single PDSCH and DCI(s) with each scheduling more than one PDSCHs.*
* *Type-2 HARQ-ACK codebook is generated by concatenating the first sub-codebook and the second sub-codebook.*
* *For the second sub-codebook, the number of HARQ-ACK information bits for each DCI format 1\_3 that schedules more than one PDSCH is equal to M, where M is:*
	+ *when time-domain HARQ-ACK bundling is not configured: the maximum total number of TBs which can be co-scheduled by a DCI format 1\_3, where the maximum is across different sets of serving cells scheduledCellListDCI-1-3 in the PUCCH group for the UE.*
	+ *FFS when time-domain HARQ-ACK bundling is configured.*
* *HARQ-ACK information bits for a DCI format 1\_3 that schedules more than one PDSCHs are ordered:*
	+ *when time-domain HARQ-ACK bundling is not configured: firstly according to ascending order of codeword index of one PDSCH, secondly according to ascending order of PDSCH reception starting time on a same serving cell, secondly according to codeword index of PDSCH receptions on a same serving cell, when applicable, then according to ascending order of associated serving cell indexes.*
	+ *FFS when time-domain HARQ-ACK bundling is configured.*
* *Note: For DCI having associated HARQ-ACK information without scheduling PDSCH reception, the HARQ-ACK information for the DCI is included in the first sub-codebook.*
* *Note: For providing HARQ-ACK information corresponding to SCell dormancy indication, the UE assumes that the UE receives a PDSCH on the serving cell associated with fields in DCI format 1\_3 used for SCell dormancy indication.*
* *FFS: the UE does not expect a DCI format 1\_3 to schedule multiple PDSCHs on only one cell from a set of cells scheduledCellListDCI-1-3, while no PDSCH scheduling on any other cell from the set of cells.*

*Proposal 9: For Type-2 HARQ-ACK codebook, support only 1 time-domain HARQ-ACK bundle (i.e., only 1 TBG) for each serving cell, as in the case of Rel-17 Type-1 HARQ-ACK codebook.***Spreadtrum:***Proposal 2: For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_3, follow Rel-18 operation, i.e., the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs.** *If more than one PDSCH ends last among the set of co-scheduled PDSCHs, the reference PDSCH is the PDSCH with the smallest SCS among the PDSCHs ending last.*

*Proposal 11: Consider following modifications:** *For Type-2 HARQ-ACK codebook, when time domain HARQ-ACK bundling is not configured for any cell, 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 PDSCH and a second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling more than one PDSCH.*
* *Separate DAI counting is applied for DCI(s) with each scheduling a single PDSCH and DCI(s) with each scheduling more than one PDSCH.*
* *Type-2 HARQ-ACK codebook is generated by concatenating the first sub-codebook and the second sub-codebook.*
* *For the second sub-codebook, the number of HARQ-ACK information bits for each DCI format 1\_3 that schedules more than one PDSCH is equal to M, where M is the maximum number of TBs which can be co-scheduled by a DCI format 1\_3 in the PUCCH group for the UE when harq-ACK-SpatialBundlingPUCCH is not configured. If harq-ACK-SpatialBundlingPUCCH is configured, M is the maximum number of PDSCHs which can be co-scheduled by a DCI format 1\_3 in the PUCCH group for the UE.*
* *HARQ-ACK information bits for a DCI format 1\_3 that schedules more than one PDSCH are ordered firstly according to ascending order of PDSCH reception starting time on a same serving cell, secondly according to ascending order of codeword index of each PDSCH reception on a same serving cell, then according to ascending order of associated serving cell indexes.*
* *Note: For DCI having associated HARQ-ACK information without scheduling PDSCH reception, the HARQ-ACK information for the DCI is included in the first sub-codebook.*
* *Note: For providing HARQ-ACK information corresponding to SCell dormancy indication, the UE assumes that the UE receives a PDSCH on the serving cell associated with fields in DCI format 1\_3 used for SCell dormancy indication.*

*Proposal 12: The granularity of TBG configuration is per scheduled cell.***vivo:***Proposal 4：In the case that more than one last PDSCHs ending in the same symbol, the reference PDSCH is determined by the one with the smallest serving cell index.* *Proposal 5: For multi carrier scheduling with mix SCSes, the number of unicast DCI(s) to be monitored is defined per N consecutive slots, where the N is based on the lowest SCS among the cells.**Proposal 9: For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs scheduled by a DCI format 1\_3, the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs including the invalid PDSCH due to collision with uplink symbol.**Proposal 10: For a DCI format 1\_3 scheduling one or more PDSCHs per cell, the type 2 HARQ-ACK sub-codebook is generated as:** *the following HARQ-ACK bits are contained in the first sub-codebook*
	+ *A DCI format 1\_3 having associated HARQ-ACK information without scheduling PDSCH reception, and*
	+ *PDSCH reception scheduled by a DCI format 1\_3 scheduling one PDSCH*
	+ *PDSCH reception with* $N\_{HARQ-ACK}^{TBG,max}=1$ *for TBG-based HARQ-ACK information on a serving cell scheduled by a DCI format 1\_3 when one cell is scheduled by a DCI format 1\_3*
* *the following HARQ-ACK bits are contained in the second sub-codebook*
	+ *PDSCH reception scheduled by a DCI format 1\_3 scheduling more than one cell*
	+ *PDSCH reception scheduled by a DCI format 1\_3 scheduling more than one PDSCHs on one cell*
	+ *PDSCH reception with* $N\_{HARQ-ACK}^{TBG,max}>1$ *for TBG-based HARQ-ACK information on a serving cell scheduled by a DCI format 1\_3 when one cell is scheduled by a DCI format 1\_3*
	+ *PDSCH reception scheduled by a DCI format 1\_3 indicating SCell dormancy with invalid FDRA*

*Proposal 11: For type 2 HARQ codebook generation, the number of HARQ-ACK bits per DCI is determined as follows:** *max(*$\sum\_{0}^{ M-1}Ni)$ *if the scheduledCellComboListDCI-1\_3 is configured, across all the schedulable cell combinations, M is the number of cells for a schedulable cell combination,* $Ni$ *is the number of HARQ-ACK bits for each scheduled cell in the cell combination, i=0,1……M-1.*
* $\sum\_{0}^{ Y-1}Xi$*if the scheduledCellComboListDCI-1\_3 is not configured, where* $Xi$ *the maximum number of HARQ-ACK bits for each scheduled cell , Y is the number of cells in a cell set, i=0,1……Y-1.*

*Proposal 12: For each serving cell, the HARQ-ACK bits is determined as follows:** *If harq-ACK-SpatialBundlingPUCCH is configured,*
	+ *If nrofHARQ-BundlingGroups is configured, the number of HARQ-ACK bits is* $N\_{HARQ-ACK}^{TBG,max}$
	+ *If nrofHARQ-BundlingGroups is not configured, the number of HARQ-ACK is the number of configured PDSCHs*
* *If harq-ACK-SpatialBundlingPUCCH is not configured,*
	+ *If maxNrofCodeWordsScheduledByDCI=2 for the serving cell*
		- *If nrofHARQ-BundlingGroups is configured, the number of HARQ-ACK bits is* $N\_{HARQ-ACK}^{TBG,max}$*\*2*
		- *If nrofHARQ-BundlingGroups is not configured, the number of HARQ-ACK is the number of configured PDSCHs \* 2*
	+ *If maxNrofCodeWordsScheduledByDCI=1 for the serving cell*
		- *If nrofHARQ-BundlingGroups is configured, the number of HARQ-ACK bits is* $N\_{HARQ-ACK}^{TBG,max}$
		- *If nrofHARQ-BundlingGroups is not configured, the number of HARQ-ACK is the number of configured PDSCHs*

*Proposal 13: For the HARQ-ACK feedback for the invalid PDSCH due to collision with semi-static TDD DL/UL configuration, the existing mechanisms can be reused:** *If HARQ bundling in time domain is not configured for a serving cell, the HARQ-ACK bit for an invalid PDSCH is set to NACK.*
* *If HARQ bundling in time domain is configured for a serving cell, Logical AND operation is applied to across all valid PDSCHs within the same bundling group to generate 1 HARQ-ACK bit per group, at least for 1-TB case.*
* *If the group is empty or filled with only invalid PDSCH(s), HARQ-ACK bit for the bundling group is set to NACK*

*Proposal 14: For multi-cell multi-PDSCH scheduling by a DCI format 1\_3 in Rel-19, the HARQ-ACK information bits for co-scheduled PDSCHs can be ordered by: First, in ascending order of codeword index for a PDSCH, second, in ascending order of the PDSCH reception starting time, and third, in ascending order of serving cell index.**Proposal 15: If a DCI format 1\_3 is transmitted with fields repurposed for SCell dormancy indication and schedules one or more PDSCHs, and if there are multiple SLIVs in the serving cell with smallest cell index with invalid FDRA, the HARQ-ACK bits for SCell dormancy indication is ACK for TB1. The remaining SLIVs are assumed with NACK.* **Nokia:***Proposal 2.1: Adopt the intention of RAN1#118 moderator proposal on the reference PDSCH for the HARQ-ACK timing for mixed SCS, 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\_3, follow Rel-18 operation, i.e., the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs.
* ~~FFS:~~ If more than one PDSCH ends last among the set of co-scheduled PDSCHs, the reference PDSCH is the PDSCH with the smallest SCS among the PDSCHs ending last.
 |

*Proposed Conclusion 3.1: The time-domain HARQ-ACK bundling for multi-PDSCH operation with DCI format 1\_3 is based on the legacy RRC parameter nrofHARQ-BundlingGroups(-r17).* *Proposed Conclusion 3.2: The HARQ-ACK spatial bundling configured for a cell group is also applicable to the second sub-codebook for multi-PDSCH operation with DCI format 1\_3.* *Proposal 3.8: As for Rel-18 DCI format 1\_3 scheduling, two sub-codebooks are generated for the Type-2 HARQ-ACK codebook also for multi-PDSCH scheduling using DCI format 1\_3** *Separate DAI counting is applied for the first and second sub-codebook.*
* *Type-2 HARQ-ACK codebook is generated by concatenating the first sub-codebook and the second sub-codebook.*

*Proposal 3.9: For Type-2 HARQ-ACK codebook, the HARQ-ACK information of a DCI format 1\_3 is included** *in the first HARQ-ACK sub-codebook if*
	+ *(i) only a single PDSCH is scheduled (on only one scheduled cell) or*
	+ *(ii) multiple PDSCHs are scheduled on (only) one scheduled cell provided nrofHARQ-BundlingGroups with value of 1*
* *and included in the second HARQ-ACK sub-codebook otherwise.*
* *Note: For DCI having associated HARQ-ACK information without scheduling PDSCH reception, the HARQ-ACK information for the DCI is included in the first sub-codebook.*
* *Note: For the purpose of providing HARQ-ACK information corresponding to SCell dormancy indication, the UE assumes that the UE receives a PDSCH on the serving cell associated with fields in DCI format 1\_3 used for SCell dormancy indication.*

*Proposal 3.10: For second Type-2 HARQ-ACK sub-codebook, the HARQ-ACK information bits for each DCI format 1\_3 is equal to M, where M is maximum number of HARQ-ACK bits generated by the UE across co-scheduled cell combinations by a DCI format 1\_3 in the PUCCH group for the UE.* * *For a serving cell configured with multi-PDSCH scheduling, to align with the Rel-17 multi-PDSCH framework the UE generated HARQ-ACK bits are determines as*
	+ $N\_{TB,c}^{DL}⋅N\_{HARQ-ACK,c}^{TBG,max}$ *HARQ-ACK bits for serving cell c provided with nrofHARQ-BundlingGroups*
	+ $N\_{TB,c}^{DL}⋅N\_{PDSCH,c}^{max}$ *HARQ-ACK bits for serving cell c not provided with nrofHARQ-BundlingGroups*
* *For cells not configured with multi-PDSCH scheduling, the UE generated HARQ-ACK bits are determined as* $N\_{TB,c}^{DL}$ *for serving cell c*
	+ *where* $N\_{TB,c}^{DL}$ *is the value of maxNrofCodeWordsScheduledByDCI for serving cell* $c$ *if harq-ACK-SpatialBundlingPUCCH is not provided; else,* $N\_{TB,c}^{DL}=1$

**Apple:***Proposal 11: For M counting for type-2 HARQ-ACK codebook construction, following procedure can be considered:**For the second sub-codebook, the number of HARQ-ACK information bits for each DCI format 1\_3 that schedules more than one PDSCH is equal to M, where M can be determined as follows and M is the number bits:** *Step 1: Identify the number of PDSCHs across all the co-scheduled cells*
* *Step 2: Determine whether for each co-scheduled cell, time domain bundling is configured or not, i.e. nrofHARQ-BundlingGroups is configured or not and if configured, what is the value*
* *Step 3: Effective number of PDSCHs, in terms of HARQ-ACK bit are determined per cell, such as M1\_1, M1\_2, M1\_3 and M1\_4 corresponding to 4 co-scheduled cells*
* *Where M1\_x <= number of PDSCHs per cell and for example, M1\_x = 1, if one bundle for a given co-scheduled cell is applied*
* *Step 4: Determine total effective number of HARQ-ACK bits, i.e. M = M1\_1+M1\_2 + ….*

*Proposal 12: For the exceptional association to sub-codebook 1 with multi-slot multi-cell scheduling DCI 1\_3, following cases can be considered:** *Case 1: When only single cell is scheduled with single PDSCH*
* *Case 2: when only single cell is scheduled with multiple PDSCHs, but with time domain bundling group equal to 1*

**NEC:***Proposal 2: Reference PDSCH determination when there are multiple PDSCHs with different SCS is not necessary.***CATT:***Proposal 6: For the second Type-2 HARQ-ACK information for PDSCH scheduled by a multi-cell multi-PDSCH DCI, the following alternatives can be considered for the time domain HARQ-ACK bundling mechanism:** *Alt-1: nrofHARQ-BundlingGroups is configured based on serving cell*
* *Alt-2: nrofHARQ-BundlingGroups is configured based on cell set*

*Proposal 7: For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of PDSCHs scheduled with different SCS by a DCI, the reference PDSCH is the PDSCH with the smallest serving cell index among the same latest PDSCHs ending.***China Telecom:***Proposal 1: For determining the timing of a slot-based PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_3, DL slot is the DL slot ending last among the set of slots containing the co-scheduled PDSCHs.**Proposal 6: For HARQ-ACK feedback of Rel-19 multi-cell scheduling with one or multiple PUSCHs/PDSCHs per scheduled cell, type-2 HARQ-ACK codebook is generated by concatenating the first sub-codebook and the second sub-codebook.** *the first sub-codebook comprises HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling a single PDSCH, or each scheduling multiple PDSCHs on one scheduled cell with nrofHARQ-BundlingGroups configured as 1.*
* *the second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling multiple co-scheduled cell, or each scheduling multiple PDSCH on one scheduled cell with nrofHARQ-BundlingGroups configured larger than 1, or each scheduling multiple PDSCH on one scheduled cell without nrofHARQ-BundlingGroups configured.*
* *Separate DAI counting is applied for DCI(s) associated with the first sub-codebook and DCI(s) associated with the second sub-codebook.*
* *Note: For DCI having associated HARQ-ACK information without scheduling PDSCH reception, the HARQ-ACK information for the DCI is included in the first sub-codebook.*
* *Note: For providing HARQ-ACK information corresponding to SCell dormancy indication, the UE assumes that the UE receives a PDSCH on the serving cell associated with fields in DCI format 1\_3 used for SCell dormancy indication.*

*Proposal 7: For the second sub-codebook of Rel-19 type-2 HARQ-ACK, the number of HARQ-ACK information bits for each DCI format 1\_3 is equal to M, where M is the maximum number of HARQ-ACK bits generated by the UE for all co-scheduled cell combinations scheduled by a DCI format 1\_3 in the PUCCH group. For serving cell c in the co-scheduled cell combinations,* * *If a UE is provided nrofHARQ-BundlingGroups with value* $N\_{HARQ-ACK}^{TBG,max}>1$*and is not provided harq-ACK-SpatialBundlingPUCCH, the UE generates* $N\_{TB,c}^{DL}⋅N\_{HARQ-ACK,c}^{TBG,max}$ *HARQ-ACK bits;*
* *If a UE is provided nrofHARQ-BundlingGroups with value* $N\_{HARQ-ACK}^{TBG,max}>1$*and harq-ACK-SpatialBundlingPUCCH, the UE generates* $N\_{HARQ-ACK,c}^{TBG,max}$ *HARQ-ACK bits;*
* *If a UE is provided pdsch-TimeDomainAllocationListForMultiPDSCH and neither provided nrofHARQ-BundlingGroups nor harq-ACK-SpatialBundlingPUCCH, the UE generates*$ N\_{TB,c}^{DL}∙N\_{PDSCH,c}^{max}$ *HARQ-ACK bits;*
* *If a UE is provided pdsch-TimeDomainAllocationListForMultiPDSCH and harq-ACK-SpatialBundlingPUCCH and not provided nrofHARQ-BundlingGroups, the UE generates* $N\_{PDSCH,c}^{max}$ *HARQ-ACK bits;*
* *where* $N\_{TB,c}^{DL}$ *is the value of maxNrofCodeWordsScheduledByDCI for serving cell* $c$ *and* $N\_{PDSCH,c}^{max}$ *is determined by the maximum number of SLIVs amongst all rows of the TDRA table configured by pdsch-TimeDomainAllocationListForMultiPDSCH.*

**TCL:***Proposal 2: For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs with different SCS/carrier type by a DCI format 1\_3, the reference PDSCH is the PDSCH with the smallest SCS and ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs.**Proposal 4: For Type-2 HARQ-ACK codebook, 2 sub-codebook are generated, the first sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI with each scheduling a single PDSCH, the second sub-codebook comprising HARQ-ACK information bits for PDSCH scheduled by DCI(s).* * *Separate DAI counting for DCI(s) with each scheduling a single PDSCH and DCI(s) with each scheduling multiple PDSCHs.*

*Proposal 5: For type-2 HARQ-ACK information bits, can be ordered as, the first, in ascending order of the PDSCH reception starting time for the same {serving cell, PDCCH monitoring occasion} pair, the second, in ascending order of serving cell index, and the third, in ascending order of PDCCH monitoring occasion index.***OPPO:***Proposal 1: For slot-based PUCCH and for determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs with different SCS by a DCI, the reference PDSCH is the PDSCH with the smallest SCS among the PDSCHs ending last.**Proposal 7: When time-domain HARQ-ACK bundling is configured for R19 multi-cell scheduling, HARQ-ACKs corresponding to multiple PDSCHs scheduled by a DCI within one cell are bundled as one or two bits depending on the configuration of maxNrofCodeWordsScheduledByDCI and harq-ACK-SpatialBundlingPUCCH.**Proposal 8: For R19 multi-cell scheduling, time-domain HARQ-ACK bundling is* *configured per cell.**Proposal 9: When type-2 HARQ-ACK codebook is used for* *multiple PDSCHs per cell scheduled by a DCI format 1\_3,** $N\_{sets}^{TB,max}$ *HARQ-ACK bits correspond to a DCI format 1\_3, where* $N\_{sets}^{TB,max}$ *is the maximum total number of TBs in PDSCH receptions on the cells without time-domain HARQ-ACK bundling configuration and TB-bundles in PDSCH receptions on the cells with time-domain HARQ-ACK bundling configuration, that can be scheduled by a DCI format 1\_3 over more than one serving cells in a set of serving cells across the number of sets of serving cells.*

*Proposal 10:* *At least for time-domain HARQ-ACK bundling is not configured, when type-2 HARQ-ACK codebook is used for multiple PDSCHs per cell scheduled by a DCI format 1\_3, HARQ-ACK bits in the second sub-codebook can be concatenated:** *First, in ascending order of codeword index for a PDSCH,*
* *Second, in ascending order of the PDSCH reception starting time for the same {serving cell, PDCCH monitoring occasion} pair,*
* *Third, in ascending order of serving cell index, and*
* *Fourth, in ascending order of PDCCH monitoring occasion index.*

**Panasonic:***Proposal 1: When determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1-3, the reference PDSCH is the last UL slot of PUCCH overlapping with PDSCHs as indicated in the DCI format 1-3 among the set of co-scheduled PDSCHs.**Proposal 5: or Type-2 HARQ-ACK codebook, when time domain bundling is not configured, 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 PDSCH and a second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling more than one PDSCH.** *Separate DAI counting is applied for DCI(s) with each scheduling a single PDSCH and DCI(s) with each scheduling more than one PDSCH.*
* *Type-2 HARQ-ACK sub-codebook is generated by concatenating the first sub-codebook and the second sub-codebook.*

*Proposal 6: For the second codebook, the number of HARQ-ACK information bits for each DCI format 1-3 that schedules more than one PDSCH is equal to* $M$*, where** + $M=\sum\_{c=0}^{N-1}M(c)$*, where*
		- $N$ *is the maximum number of cells which can be co-scheduled by a DCI format 1-3 in the PUCCH group for the UE.*
		- $M\left(c\right)=N\_{TB,c}^{DL}∙N\_{HARQ-ACK,c}^{TBG,max}$ *for serving cell* $c$ *provided with nrofHARQ-BundlingGroups*
		- $M\left(c\right)=N\_{TB,c}^{DL}∙N\_{PDSCH,c}^{max}$ *for serving cell* $c$ *not provided with nrofHARQ-BundlingGroups*
		- *where* $N\_{TB,c}^{DL}$ *is the value of maxNrofCodeWordsScheeduledByDCIfor serving cell* $c$*, if harq-ACK-SpatialBundlingPUCCH is not provided; else,* $N\_{TB,c}^{DL}=1$

*Proposal 7: HARQ-ACK information bits for a DCI format 1-3 that schedules more than one PDSCH are ordered firstly according to ascending order of codeword index of one PDSCH, secondly according to ascending order of PDSCH reception starting time on a same serving cell, then according to ascending order of associated serving cell indexes.***ETRI:***Proposal 1: The Type-2 HARQ-ACK codebook for multi-cell and multi-PDSCH scheduling can be designed based on the Type-2 codebook configuration mechanism utilized for multi-cell scheduling in Rel-18.** *- HARQ-ACK information for PDSCHs scheduled with only a single PDSCH or for which a single HARQ-ACK bundling group is configured can be included in the first sub-codebook*
* *- HARQ-ACK information for PDSCHs scheduled by a DCI that schedules more than one PDSCH can be included in the second sub-codebook.*

*Proposal 2: A study is needed on the size and ordering of HARQ-ACK bits for Type-2 HARQ codebook generation.***LGE:***Proposal #4: On the determination of HARQ-ACK timing for the PDSCHs scheduled by a DCI 1\_3, support the following Proposal 3-1 (provided in RAN1#118bis).*

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| **Proposal 3-1:*** For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_3, follow Rel-18 operation, i.e., the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs.
* If more than one PDSCH ends last among the set of co-scheduled PDSCHs, the reference PDSCH is the PDSCH with the smallest SCS among the PDSCHs ending last.
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*Proposal #5: On the construction of Type-2 HARQ-ACK codebook in case with multi-cell multi-PDSCH scheduling by DCI 1\_3, support the Proposal 3-3 (provided in RAN1#118bis) with following two updates:** *Exclude the case {one PDSCH + Scell dormancy indication} from the first sub-codebook.*
* *Add the condition as “when spatial HARQ-ACK bundling is not configured”.*

**NTT DOCOMO:***Proposal 1: Reference PDSCH in multi-cell scheduling with different SCS should be further considered.** *The reference PDSCH should be determined based on* $T\_{proc,1}$ *of each PDSCH.*

*Proposal 10: Time domain HARQ bundling as Rel-17 should be supported for multi-cell multi-PDSCH scheduling.** *For Type-1 HARQ ACK codebook, timeDomainHARQ-BundlingType-1 can be configured for each co-scheduled cell for multi-cell multi-PDSCH scheduling.*
* *For Type-2 HARQ ACK codebook, nrofHARQ-BundlingGroups can be configured for each co-scheduled cell for multi-cell multi-PDSCH scheduling.*

*Proposal 11: The proposal in #118bis below should be supported based on the design principle of the legacy.** *High level principles*
	+ *For Type-2 HARQ-ACK codebook, when time domain HARQ-ACK bundling is not configured, 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 PDSCH and a second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling more than one PDSCH.*
	+ *Separate DAI counting is applied for DCI(s) with each scheduling a single PDSCH and DCI(s) with each scheduling more than one PDSCH.*
	+ *Type-2 HARQ-ACK codebook is generated by concatenating the first sub-codebook and the second sub-codebook.*
	+ *For the second sub-codebook, the number of HARQ-ACK information bits for each DCI format 1\_3 that schedules more than one PDSCH is equal to M, where M is the maximum number of TBs which can be co-scheduled by a DCI format 1\_3 in the PUCCH group for the UE.*
* *Detailed principles*
	+ *HARQ-ACK information bits for a DCI format 1\_3 that schedules more than one PDSCH are ordered firstly according to ascending order of codeword index of one PDSCH, secondly according to ascending order of PDSCH reception starting time on a same serving cell, then according to ascending order of associated serving cell indexes.*
	+ *Note: For DCI having associated HARQ-ACK information without scheduling PDSCH reception, the HARQ-ACK information for the DCI is included in the first sub-codebook.*
	+ *Note: For providing HARQ-ACK information corresponding to SCell dormancy indication, the UE assumes that the UE receives a PDSCH on the serving cell associated with fields in DCI format 1\_3 used for SCell dormancy indication.*

**Qualcomm:***Proposal 3:** *For Type-2 HARQ-ACK codebook, when time domain HARQ-ACK bundling is not configured, 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 PDSCH and a second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling more than one PDSCH.*
	+ *Separate DAI counting is applied for DCI(s) with each scheduling a single PDSCH and DCI(s) with each scheduling more than one PDSCH.*
	+ *Type-2 HARQ-ACK codebook is generated by concatenating the first sub-codebook and the second sub-codebook.*
	+ *For the second sub-codebook, the number of HARQ-ACK information bits for each DCI format 1\_3 that schedules more than one PDSCH is equal to M, where M is the maximum number of TBs which can be co-scheduled by a DCI format 1\_3 in the PUCCH group for the UE.*
	+ *HARQ-ACK information bits for a DCI format 1\_3 that schedules more than one PDSCH are ordered firstly according to ascending order of codeword index of one PDSCH, secondly according to ascending order of PDSCH reception starting time on a same serving cell, then according to ascending order of associated serving cell indexes, and finally in ascending order of PDCCH monitoring occasion index.*

*Proposal 4:** *When time domain HARQ-ACK bundling is configured for one or multiple serving cells in the set of cells for a DCI format 0\_3/1\_3,*
	+ *Type-1 HARQ-ACK codebook generation:*
		- *The algorithm to generate Type-1 HARQ-ACK codebook from Rel. 18 can be re-used, but the new TDRA tables for Rel. 19 multi-cell multi-PDSCH scheduling need to be taken into account to report HARQ-ACK information bits corresponding to the (potentially) multiple PDSCH receptions in each cell for multi-cell multi-PDSCH scheduling.*
	+ *Type-2 HARQ-ACK codebook generation:*
		- *The current procedure for DCI format 1\_3 needs to be modified to generate the HARQ-ACK information bits corresponding to the first and second transport blocks in every PDSCH reception for cells scheduled by such DCI format in Rel. 19.*
		- *If time domain bundling is configured, the HARQ-ACK information bits corresponding to each transport block in every PDSCH reception can be bundled together in transport block groups (TBGs) for PDSCH receptions in a given cell.*
		- *If spatial bundling is configured, the HARQ-ACK information bits corresponding to the first and, if applicable, second transport blocks in every PDSCH reception in a given cell can be bundled together, where bundling can be performed for the transport blocks received in a PDSCH reception if time bundling is not configured, or for the transport block groups corresponding to the first transport block and the second transport block group, if applicable, if time bundling is configured.*
		- *If more than a DCI format 1\_3 is received in the same monitoring occasion, HARQ-ACK information bits can be reported in ascending order of PDSCH reception time, either for the first and, if applicable, second transport blocks in a PDSCH reception, if spatial bundling is not configured, or simply in ascending order of PDSCH reception time by bundling the HARQ-ACK information bits corresponding to the first and second transport blocks in each PDSCH reception, if spatial bundling is configured. If time bundling is configured, HARQ-ACK information bits for the different PDSCHs scheduled by different DCIs with format 1\_3 can be bundled together for each cell that is configured with time bundling.*

*Proposal 5:** *For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_3, follow Rel-18 operation, i.e., the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs, regardless of whether the co-scheduled PDSCHs use the same or different SCS.*

**MediaTek:***Proposal 3: Agree the following and update TS38.214 clause 5.3.1 accordingly:** *The PDSCH with the latest Xn+Tproc.1,n is used as the reference for processing timeline, where Xn is the last symbol of the nth PDSCH, and Tproc.1,n is the processing timeline for the nth PDSCH.*

**Ericsson:***Proposal 4: Type 1 and Type 3 HARQ-ACK codebook construction for Rel-18 DCI 0-3/1\_3, are applied to the enhanced DCI 0\_3/1\_3.**Proposal 5: (FL proposal 3-3) For Type-2 HARQ-ACK codebook, when time domain HARQ-ACK bundling is not configured, 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 PDSCH and a second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling more than one PDSCH.* * *Separate DAI counting is applied for DCI(s) with each scheduling a single PDSCH and DCI(s) with each scheduling more than one PDSCH.*
* *Type-2 HARQ-ACK codebook is generated by concatenating the first sub-codebook and the second sub-codebook.*
* *For the second sub-codebook, the number of HARQ-ACK information bits for each DCI format 1\_3 that schedules more than one PDSCH is equal to M, where M is the maximum number of TBs which can be co-scheduled by a DCI format 1\_3 in the PUCCH group for the UE.*
* *HARQ-ACK information bits for a DCI format 1\_3 that schedules more than one PDSCH are ordered firstly according to ascending order of codeword index of one PDSCH, secondly according to ascending order of PDSCH reception starting time on a same serving cell, then according to ascending order of associated serving cell indexes.*
* *Note: For DCI having associated HARQ-ACK information without scheduling PDSCH reception, the HARQ-ACK information for the DCI is included in the first sub-codebook.*
* *Note: For providing HARQ-ACK information corresponding to SCell dormancy indication, the UE assumes that the UE receives a PDSCH on the serving cell associated with fields in DCI format 1\_3 used for SCell dormancy indication.*

*Proposal 6: (FL proposal 3-1) For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_3, follow Rel-18 operation, i.e., the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs.** *If more than one PDSCH ends last among the set of co-scheduled PDSCHs, the reference PDSCH is the PDSCH with the smallest SCS among the PDSCHs ending last.*

*Proposal 7: HARQ-ACK time domain bundling is supported similarly to Rel-18, meaning that if the HARQ-ACK information corresponding to any PDSCH in a bundle is determined to be NACK, a NACK is considered for all the PDSCHs in the bundle.**Proposal 8: For Type-1 HARQ-ACK codebook, number of bundling group per scheduled cell is one as Rel-17.**Proposal 9: For Type-2 HARQ-ACK codebook, maximum one bundle per scheduled cell can be configured when M=8 is configured. Otherwise, when M=16 or 32, maximum 2 or 4 bundling groups per scheduled cell can be configured.** *Note: M the maximum number of co-scheduled PUSCHs/PDSCHs by a DCI format 0\_3/1\_3 is M and provided by configuration.*
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## Moderator summary and proposals based on contributions

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.

* On HARQ-ACK feedback timing

For Rel-18 multi-cell scheduling, for determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_3, the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs. Thus, the PUCCH slot is determined based on the reference PDSCH and the indicated K1 value.

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| **Agreement**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. |

During RAN1#118bis meeting, below proposal is provided for determining the reference PDSCH for PUCCH transmission.

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| **Proposal 3-1:**For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_3, follow Rel-18 operation, i.e., the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs.* If more than one PDSCH ends last among the set of co-scheduled PDSCHs, the reference PDSCH is the PDSCH with the smallest SCS among the PDSCHs ending last.
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For RAN1#119 meeting, based on companies’ inputs, all the companies agree to follow Rel-18 operation, i.e., the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs. One divergent point is whether to resolve the issue when more than one PDSCH ends last among the set of co-scheduled PDSCHs.

Companies’ views are summarized as below:

* Reference PDSCH is the PDSCH with the smallest SCS among the PDSCHs ending last
	+ Supported by Spreadtrum, vivo, Lenovo, Nokia, CATT, TCL, OPPO, LGE, Ericsson
* Follow Rel-18 operation, i.e., reference PDSCH is the PDSCH ending last:
	+ Supported by CMCC, ZTE, Samsung, NEC, China Telecom, Panasonic, Qualcomm,
* FFS reference PDSCH for Rel-19
	+ Supported by Huawei, NTT DOCOMO,
* The PDSCH with the latest Xn+Tproc.1,n is used as the reference for processing timeline, where Xn is the last symbol of the nth PDSCH, and Tproc.1,n is the processing timeline for the nth PDSCH.
	+ Supported by MediaTek

According to Rel-18 spec, for determining HARQ-ACK feedback timing, UE will generate corresponding HARQ-ACK information in a PUCCH transmission within UL slot *n*+*k*, where the value of k is indicated by DCI and the value of *n* is the last UL slot overlapping with the DL slot $n\_{D}$ for the reference PDSCH reception. In Rel-18, the reference PDSCH is the latest PDSCH ending among the PDSCHs scheduled by a DCI format 1\_3.

Since for slot-based PUCCH transmission, slot n is defined as last UL slot overlapping with the slot containing the reference PDSCH, one open issue is how to select the reference PDSCH in case more than one PDSCH with different SCS ends last. Selecting different PDSCH as the reference PDSCH leads to different slot n.

To resolve this issue, a simple rule is to select the PDSCH with smallest SCS among the PDSCHs ending last as the reference PDSCH so that UE can have more processing time for preparing HARQ-ACK feedback.

Based on above analysis, Proposal 3-1 is provided for discussion with main bullet same as Rel-18 agreement and sub-bullet to resolve the aforementioned issue.

* On time domain HARQ-ACK bundling

In Rel-17, for multi-PDSCH scheduling, time domain HARQ-ACK bundling is supported by configuring the number of bundling groups, i.e., *nrofHARQ-BundlingGroups*. For Rel-19, since multiple PDSCHs can be scheduled on the same cell, time domain HARQ-ACK bundling may be necessary to compress the number of HARQ-ACK bits per scheduled cell, similar as Rel-17 multi-PDSCH scheduling. Therefore, time domain HARQ-ACK bundling needs to be supported for Rel-19 multi-cell multi-PDSCH scheduling as well.

RAN1 has agreed that time domain HARQ-ACK bundling is supported with details FFS. One issue is how to configure the number of bundling groups.

Companies’ views are summarized as below:

* Time domain bundling is configured per cell as Rel-17.
	+ Supported by Lenovo, ZTE, Spreadtrum, Nokia, CATT, OPPO
* Time domain bundling is configured per cell set.
	+ Supported by CMCC, CATT,
* Only single bundle group per cell.
	+ Supported by Samsung, Ericsson (for maximum 8 scheduled PUSCHs/PDSCHs by a DCI 0\_3/1\_3)

Based on the inputs, it is straightforward to follow R17 multi-PDSCH scheduling mechanism, i.e., whether to support the time domain bundling is configured per cell.

Hence, Proposal 3-2 is provided for discussion.

* On Type-2 HARQ-ACK codebook

For Type-2 HARQ-ACK codebook, the main agreements for Rel-18 multi-cell scheduling with one PDSCH per cell are listed below for reference.

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| **Agreement (RAN1#110)*** 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(RAN1#110bis)*** 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.
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During RAN1#118bis meeting, below proposal is provided for triggering the discussion.

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| **Proposal 3-3:*** For Type-2 HARQ-ACK codebook, when time domain HARQ-ACK bundling is not configured, 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 PDSCH and a second sub-codebook comprising HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling more than one PDSCH.
* Separate DAI counting is applied for DCI(s) with each scheduling a single PDSCH and DCI(s) with each scheduling more than one PDSCH.
* Type-2 HARQ-ACK codebook is generated by concatenating the first sub-codebook and the second sub-codebook.
* For the second sub-codebook, the number of HARQ-ACK information bits for each DCI format 1\_3 that schedules more than one PDSCH is equal to M, where M is the maximum number of TBs which can be co-scheduled by a DCI format 1\_3 in the PUCCH group for the UE.
* HARQ-ACK information bits for a DCI format 1\_3 that schedules more than one PDSCH are ordered firstly according to ascending order of codeword index of one PDSCH, secondly according to ascending order of PDSCH reception starting time on a same serving cell, then according to ascending order of associated serving cell indexes.
* Note: For DCI having associated HARQ-ACK information without scheduling PDSCH reception, the HARQ-ACK information for the DCI is included in the first sub-codebook.
* Note: For providing HARQ-ACK information corresponding to SCell dormancy indication, the UE assumes that the UE receives a PDSCH on the serving cell associated with fields in DCI format 1\_3 used for SCell dormancy indication.
 |

For RAN1#119 meeting, based on companies’ inputs, above proposal is divided into several simple proposals to address the issue of time domain bundling configuration, and HARQ-ACK information bit ordering and size determination per DCI format 1\_3 for the second sub-codebook.

Hence, Proposal 3-3, Proposal 3-4 are provided for discussion.

## 1st round of discussions

#### Proposal 3-1:

* For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_3, follow Rel-18 operation, i.e., the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs.
* If more than one PDSCH ends last among the set of co-scheduled PDSCHs, the reference PDSCH is the PDSCH with the smallest SCS among the PDSCHs ending last.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | We think the proposal is very confusing and is not agreeable. We should look at the spec 38.213, as suggested by [4, Samsung]. For sub-slot based PUCCH, n is the last UL slot that overlaps with a PDSCH reception in DL slot nD, where DL slot nD is the slot where a number of scheduled PDSCHs ends. In other words, n is the UL slot that overlaps with the end of the last PDSCH reception scheduled by the DCI. If more than one PDSCH with different SCS ends last among the set of co-scheduled PDSCHs, they indicate the same UL slot as the UL slot n. Therefore, we think the current spec for sub-slot based PUCCH works for multi-cell PDSCH scheduling with different SCSs among co-scheduled PDSCHs for sub-slot based PUCCH.For slot based PUCCH, n is the last UL slot that overlaps with the DL slot nD, where DL slot nD is the DL slot where a number of scheduled PDSCHs ends. If more than one PDSCH with different SCSs are scheduled by the same DCI and are in DL slots that end last at the same time, they indicate the same UL slot as the UL slot n. Therefore, we think the current spec for slot based PUCCH works for multi-cell PDSCH scheduling with different SCSs among co-scheduled PDSCHs.38.213 9.2.3 |
| Nokia | Support |
| CATT | As discussed in our Tdoc, we think the reference PDSCH can be defined as the PDSCH with the smallest serving cell index among the same latest PDSCHs ending. It’s a unified design with the reference cell of last DCI format determination and DAI counting for DCI format 0\_3.Proposal 3-1:* For determining the timing of a PUCCH carrying HARQ-ACK information corresponding to a set of co-scheduled PDSCHs by a DCI format 1\_3, follow Rel-18 operation, i.e., the reference PDSCH is the PDSCH ending last as indicated in the DCI format 1\_3 among the set of co-scheduled PDSCHs.
* If more than one PDSCH ends last among the set of co-scheduled PDSCHs, the reference PDSCH is the PDSCH with the smallest serving cell index ~~SCS~~ among the PDSCHs ending last.
 |
| Apple | We agree with the intention of the proposal, but would like further check in the current specification |
| China Telecom | For sub-slot based PUCCH, n is the last UL slot for PUCCH transmission that overlaps with a PDSCH reception as in the speciation. PDSCH ending last is the symbol level ending last. In case more than one PDSCH with different SCS end last, they lead to same slot n, no needing of the sub-bullet to resolve the issue. For slot based PUCCH, n is the last UL slot for PUCCH transmission that overlaps with the DL slot nD for the PDSCH reception as in the speciation. If it is clarified PDSCH ending last is understood as its DL slot nD has the last ending among the set of slots containing the co-scheduled PDSCHs, the sub-bullet is also not needed and UE can have more processing time for preparing HARQ-ACK feedback.  |
| TCL | SupportIn the current specification, for determining HARQ-ACK feedback timing, UE will generate corresponding HARQ-ACK information in a PUCCH transmission within UL slot *n*+*k*, where the value of k is indicated by DCI, if UE is not provided *subslotLengthForPUCCH,* $n$ is the last UL slot for PUCCH transmission that overlaps with the DL slot $n\_{D}$ for the PDSCH reception. When more than one PDSCH with different SCS ending in last among the co-scheduled PDSCHs, which could lead to varying reference points for determining the PUCCH for HARQ-ACK, ambiguity between UE and gNB will be caused. |
| ZTE | We don’t support this proposal.If more than one PDSCH ends last among the set of co-scheduled PDSCHs, the same solution should be applied to the sub-slot based PUCCH feedback and the slot-based PUCCH feedback. The PUCCH slot should be the last PUCCH slot overlapping with the reference PDSCH. |
| Panasonic | We are fine with the proposal, but it would be better to check whether the intention in the proposal is already covered by the current specification or not. |
| vivo | We also think the text cited by Samsung and QC needs to be clarified.On the other hand, if reference PDSCH is needed to be clarified, we prefer the one proposed by CATT, i.e., using the smallest serving cell index. It is similar to the existing procedure in DAI counting and last DCI determination, in which case the PDSCH in the serving cell with the smallest index among these PDSCHs ending in the same symbol is used as the reference PDSCH. This approach is more flexible. |
| NTT DOCOMO | After re-checking the specification and reading the contribution/comments from QC, we support QC. When checking 38.213, n is the last UL slot that overlaps with a PDSCH reception. Even if SCS is different between PDSCHs, if the ending time of each PDSCH is same, n is the same value. The case in this proposal is already covered in the current spec. |
| OPPO | Support the proposal.Regarding the comments from Qualcomm, we share different views that the current spec can lead to the interpretation expressed by Qualcomm for slot based HARQ-ACK. In current spec, it says that “$n$ *is the last UL slot for PUCCH transmission that overlaps with the DL slot* $n\_{D}$ *for the PDSCH reception or with the DL slot* $n\_{D} $*for the PDCCH reception in case of a DCI format that triggers a HARQ-ACK information report and does not schedule a PDSCH reception*” and here “*the* *DL slot* $n\_{D}$” is the DL slot where a number of PDSCH receptions ends, here the “ends” is from the actual ending time perspective, instead of slot perspective. When DCI format 1\_3 schedules a number of PDSCH receptions with different SCS and there are more than one PDSCH ends last, i.e., the last symbol of the more than one PDSCHs ends at the same time, then different *DL slot* $n\_{D}$would be determined, resulting is different PUCCH slot. |
| Ericsson | We think the proposal is needed for the case the UE is not provided with *subslotLengthForPUCCH*- The issue is the corresponding DL slots (nd) that can be different for these PDSCHs ending in the same time for the case that PCell has a larger SCS than one of the DL cells.

|  |
| --- |
| **TS 38.213, Clause 9.2.3**The following apply to the PCell if the UE is provided *pucch-sSCellPattern*; otherwise, the following apply to the serving cell of the PUCCH transmission. If the UE is provided *subslotLengthForPUCCH*, 𝑛 is the last UL slot for PUCCH transmission that overlaps with a PDSCH reception or with a PDCCH reception providing a DCI format having associated HARQ-ACK information without scheduling a PDSCH reception; otherwise, 𝑛 is the last UL slot for PUCCH transmission that overlaps with the DL slot 𝑛𝐷 for the PDSCH reception or with the DL slot 𝑛𝐷 for the PDCCH reception in case of a DCI format that triggers a HARQ-ACK information report and does not schedule a PDSCH reception. |

 |
| LGE | Fine with the proposal.On the current spec related to the QC’s comment, we have same understanding with TCL and OPPO, i.e., when more than one PDSCH with different SCS ending in last, different DL slot $n\_{D}$ would be determined, resulting different PUCCH slot. |
| Qualcomm2 | We do not agree with OPPO’s following statement.In current spec, it says that “$n$ *is the last UL slot for PUCCH transmission that overlaps with the DL slot* $n\_{D}$ *for the PDSCH reception or with the DL slot* $n\_{D} $*for the PDCCH reception in case of a DCI format that triggers a HARQ-ACK information report and does not schedule a PDSCH reception*” and here “*the* *DL slot* $n\_{D}$” is the DL slot where a number of PDSCH receptions ends, here the “ends” is from the actual ending time perspective, instead of slot perspective.The ”ends” is from the slot perspective, not the actual ending time perspective. For slot-based PUCCH, UL slot n is determined from DL slot perspective.We are fine to make a simple clarification on which slot is the “DL slot nD” when there are multiple PDSCHs in different carriers with different SCSs scheduled by a DCI format 1\_3. It should be the DL slot ends last, among the DL slots where PDSCHs are scheduled by the DCI format 1\_3. It does not matter which PDSCH ends last.Having said that, we are fine with following:* If the UE is not provided *subslotLengthForPUCCH*, the DL slot 𝑛𝐷 is the DL slot ending last, amongst the DL slots where the PDSCH receptions are scheduled by the DCI format 1\_3.
* If the UE is provided *subslotLengthForPUCCH*, no spec change is necessary.
 |
| Samsung | Support the main bullet. Do not support the sub-bullet. Current specifications suffice.The UE procedure in Rel-18 for determination of PUCCH timing based on ‘PDSCH ending last’ is on a slot-level, not on a symbol-level, (i.e., “PDSCH ending last” is the PDSCH with corresponding DL slot ending last). Moreover, even if the above was not the case, the specifications already support ordering based on cell index in case the ending time is identical (e.g. for PDCCH MOs). |

#### Proposal 3-2:

* Time-domain HARQ-ACK bundling is configured per cell as Rel-17.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Agree with the proposal. |
| Nokia | Support |
| CATT | Support |
| Apple | Support |
| China Telecom | Support |
| TCL | Support |
| ZTE | Support |
| Panasonic | Support |
| NTT DOCOMO | Support |
| OPPO | Support |
| Ericsson | Support |
| LGE | Support |
| Samsung | Simpler solution can be pursued as, with the proposal, the HARQ-ACK codebook construction becomes more complex to implement.In order to simplify the TBG support for DCI format 1\_3, one time-domain HARQ-ACK bundle (i.e., one TBG) can be defined for each serving cell, as for the Rel-17 Type-1 HARQ-ACK codebook. |

#### Proposal 3-3:

* Type-2 HARQ-ACK codebook is generated by concatenating a first sub-codebook and a second sub-codebook.
* The first sub-codebook comprises HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling a single PDSCH, or each scheduling a single cell with multiple PDSCHs on it and *nrofHARQ-BundlingGroups* configured as 1, and HARQ-ACK information bit(s) for DCI(s) having associated HARQ-ACK information without scheduling PDSCH reception.
* The second sub-codebook comprises HARQ-ACK information bits for PDSCHs scheduled by DCI(s) with each scheduling more than one cell, or each scheduling a single cell with multiple PDSCHs on it without *nrofHARQ-BundlingGroups* or *nrofHARQ-BundlingGroups* configured larger than 1.
* Separate DAI counting is applied for DCI(s) associated with the first sub-codebook and DCI(s) associated with the second sub-codebook.
* Note: For providing HARQ-ACK information corresponding to SCell dormancy indication, the UE assumes that the UE receives a PDSCH on the serving cell associated with fields in DCI format 1\_3 used for SCell dormancy indication.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | OK with the proposal. We suggest to add “same as in Rel-18 or no change from Rel-18” on the 3rd and 4th bullets for clarifications. |
| Nokia | Support |
| CATT | Support |
| Apple | Support |
| China Telecom | Support |
| TCL | Support |
| ZTE | Support |
| Panasonic | Support |
| NTT DOCOMO | Fine with the proposal and suggestions from Qualcomm. |
| OPPO | Fine with the intention, However, since the number of HARQ bundling groups supported for DCI format 1\_3 has not been agreed and company views are a little bit divergent, it is not appropriated to say something like “*nrofHARQ-BundlingGroups* configured larger than 1…” |
| Ericsson | Support. OK with QC addition. |
| LGE | It seems some clarification may be necessary.For example, regarding the yellow part for the 1st sub-CB in below, is the intention that only the DCIs scheduling multiple PDSCHs on the cell configured with nrofHARQ-BundlingGroups = 1 are included in the 1st sub-CB? rather than the DCIs scheduling one bundled PDSCH group on the cell configured with any nrofHARQ-BundlingGroups value?In other words, is the DCI in the 1st sub-CB determined based on the configured nrofHARQ-BundlingGroups value or according to the number of actual scheduled (bundled) PDSCH groups?* The first sub-codebook comprises HARQ-ACK information bits for PDSCH(s) scheduled by DCI(s) with each scheduling a single PDSCH, or each scheduling a single cell with multiple PDSCHs on it and *nrofHARQ-BundlingGroups* configured as 1, and HARQ-ACK information bit(s) for DCI(s) having associated HARQ-ACK information without scheduling PDSCH reception.
 |
| Samsung | Generally OK, but some aspects should be further discussed/modified.* We understand that “scheduling a single cell with multiple PDSCHs” is excluded by the WID (but that can be further discussed).
* Need to further discuss *nrofHARQ-BundlingGroups* as it is not agreed yet (and the second sub-bullet does not imply that *nrofHARQ-BundlingGroups* has been agreed).
* HARQ-ACK for SCell dormancy needs more discussion. Is it assumed one PDSCH or multiple PDSCHs on the cell that provides the dormancy indication?
 |

#### Proposal 3-4:

* For the second sub-codebook, the number of HARQ-ACK information bits for each DCI format 1\_3 is equal to M, where M is the maximum number of HARQ-ACK information bits generated for a DCI format 1\_3 in the PUCCH group for the UE.
* For the second sub-codebook, the HARQ-ACK information bits for a DCI format 1\_3 are ordered firstly according to ascending order of PDSCH reception starting time on a same serving cell, secondly according to ascending order of codeword index of PDSCH receptions on a same serving cell, when applicable, then according to ascending order of associated serving cell indexes.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | OK with the 1st bullet. The 2nd bullet seems not correct.  |
| Nokia | We agree with two bullets proposed by moderator. For the first bullet we may also add particular number of bits in different cases following Rel.17 multi-PDSCH framework:Proposal 3-4:* For the second sub-codebook, the number of HARQ-ACK information bits for each DCI format 1\_3 is equal to M, where M is the maximum number of HARQ-ACK information bits generated for a DCI format 1\_3 in the PUCCH group for the UE.
	+ **For a serving cell configured with multi-PDSCH scheduling, to align with the Rel-17 multi-PDSCH framework the UE generated HARQ-ACK bits are determines as**
		- $N\_{TB,c}^{DL}⋅N\_{HARQ-ACK,c}^{TBG,max}$ **HARQ-ACK bits for serving cell *c* provided with *nrofHARQ-BundlingGroups***
		- $N\_{TB,c}^{DL}⋅N\_{PDSCH,c}^{max}$ **HARQ-ACK bits for serving cell *c* not provided with *nrofHARQ-BundlingGroups***
	+ **For cells not configured with multi-PDSCH scheduling, the UE generated HARQ-ACK bits are determined as** $N\_{TB,c}^{DL}$ **for serving cell *c***
	+ **where** $N\_{TB,c}^{DL}$ **is the value of *maxNrofCodeWordsScheduledByDCI* for serving cell** $c$ **if *harq-ACK-SpatialBundlingPUCCH* is not provided; else,** $N\_{TB,c}^{DL}=1$
* For the second sub-codebook, the HARQ-ACK information bits for a DCI format 1\_3 are ordered firstly according to ascending order of PDSCH reception starting time on a same serving cell, secondly according to ascending order of codeword index of PDSCH receptions on a same serving cell, when applicable, then according to ascending order of associated serving cell indexes.
 |
| CATT | We are fine with the intention of the proposal.  |
| Apple | We share somewhat similar intention as suggested by Nokia |
| China Telecom | Agree and also have fine with Nokia’s suggestion. |
| ZTE | We are fine with the proposal from FL.Regrading the details of the proposal 1 from Nokia, we have different understandings. The HARQ bits for each serving cell c should depends on the actual scheduled PDSCH instead of being the maximum number of the bits for this serving cell c. The reason is that not all the cells are scheduled with the maximum number of the PDSCH by a single DCI.  |
| Panasonic | We are fine with the first bullet with Nokia’s addition.For second bullet, we would like to clarify whether the HARQ-ACK information bits are ordered firstly according to ascending order of PDSCH reception starting time or codeword index of one PDSCH. The principles of Rel.18 multi-PDSCH scheduling feature and Rel.18 multi-carrier scheduling feature should be simply combined. |
| vivo | The 2nd bullet may need to be clarified. Our understanding on the current spec of the ordering is: first, in ascending order of codeword index for a PDSCH, second, in ascending order of the PDSCH reception starting time, and third, in ascending order of serving cell index. |
| NTT DOCOMO | We are generally fine with the 1st bullet as it is general enough to cover both cases with and without HARQ-ACK bundling. We are also fine to clarify M in case with and without HARQ-ACK bundling separately for further clarification once details on HARQ-ACK bundling is agreed.For the 2nd bullet, it seems companies have different understandings on the interpretation of current spec. Further clarification by referring specification would be necessary. |
| OPPO | The first and second bullet seems not related to each other and prefer to separately discuss the two issues. For the first bullet, further clarification on “M is the maximum number of HARQ-ACK information bits generated for a DCI format 1\_3 in the PUCCH group for the UE” is needed. |
| Ericsson | We are fine with intention of the proposal. It seems we need to work out some details to get the pseudo code correct. |
| LGE | OK with the proposal. |
| Samsung | OK with the first bullet.The second bullet can be simplified with clarification that the ordering is same as for the Rel-17 HARQ-ACK codebook:* For the second sub-codebook, the HARQ-ACK information bits for a DCI format 1\_3 are ordered firstly according to the same ordering as in Rel-17 multi-PDSCHs scheduling for ~~ascending order of PDSCH reception starting time on a same serving cell, secondly according to ascending order of codeword index of~~ PDSCH receptions on a same serving cell~~, when applicable~~, then according to ascending order of associated serving cell indexes
 |

# Proposals for online/offline discussion

# References

1. [R1-2409484](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2409484.zip) Discussion on multi-cell scheduling with a single DCI Lenovo
2. [R1-2409532](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2409532.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI CMCC
3. [R1-2409541](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2409541.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI ZTE Corporation, Sanechips
4. [R1-2409619](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2409619.zip) Enhancements for multi-cell PUSCH/PDSCH scheduling Samsung
5. [R1-2409655](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2409655.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI Spreadtrum, UNISOC
6. [R1-2409703](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2409703.zip) Discussion on enhancement of multi-cell PUSCH/PDSCH scheduling with a single DCI vivo
7. [R1-2409716](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2409716.zip) On Rel-19 Multi-carrier enhancements for NR Phase 2 Nokia
8. [R1-2409828](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2409828.zip) On multi-cell PUSCH/PDSCH scheduling with single DCI Apple
9. [R1-2409868](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2409868.zip) Discussion on multi-cell scheduling with a single DCI NEC
10. [R1-2409931](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2409931.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI CATT
11. [R1-2410010](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2410010.zip) Discussion on multi-carrier enhancements for NR phase 2 China Telecom
12. [R1-2410066](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2410066.zip) Discussion on Multi-cell PUSCH/PDSCH scheduling with a single DCI TCL
13. [R1-2410100](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2410100.zip) Discussion of multi-cell scheduling with a single DCI OPPO
14. [R1-2410250](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2410250.zip) Discussion on multi-carrier enhancements for NR Phase 2 Panasonic
15. [R1-2410281](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2410281.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI ETRI
16. [R1-2410298](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2410298.zip) Discussion on single DCI based multi-cell scheduling for Rel-19 LG Electronics
17. [R1-2410408](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2410408.zip) Discussion on multi-cell PUSCH/PDSCH scheduling with a single DCI NTT DOCOMO, INC.
18. [R1-2410500](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2410500.zip) Multi-cell PUSCH/PDSCH scheduling with a single DCI Qualcomm Incorporated
19. [R1-2410509](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2410509.zip) Multi-cell PUSCH/PDSCH scheduling with a single DCI MediaTek Inc.
20. [R1-2410536](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2410536.zip) Multi-cell PxSCH scheduling with a single DCI Ericsson
21. [R1-2409404](file:///D%3A%5CRAN1%5CRAN1%23119%5Ctdocs%5CR1-2409404.zip) Discussion on Rel-19 Multi-carrier enhancements Huawei, HiSilicon

# 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/RAN1/RAN1%23112/tdocs/FL%20summary/R1-2212924.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

## Agreements made in RAN1#112

**Agreement**

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.

**Agreement**

* 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\_1/1\_2/1\_X are received in a same PDCCH monitoring occasion on a same scheduling cell for scheduling PDSCHs on same scheduled cell.

**Agreement**

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.

**Conclusion**

Type-1 HARQ-ACK codebook is supported for multi-cell scheduling without K1 extension.

* UE expects HARQ-ACK information for all co-scheduled PDSCHs 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.

**Agreement**

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 from the joint TDRA table.
* TDRA index for a cell points to a corresponding TDRA in the TDRA table applicable for DCI format 0-1/1-1.

**Agreement**

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.

**Agreement**

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.

**Agreement**

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

**Agreement**

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

**Agreementl**

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

**Agreement**

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 of active BWP among all cells within the set of cells.
* the size of a Type-1B field in the DCI format 0\_X/1\_X is equal to ceiling(log2(N)), where N is the number of rows in RRC-configured table with each row containing multiple indexes for all cells within the set of cells.
	+ The Type-1B field indicates one row of the configured table
	+ The Type-1B index for a cell points to a corresponding index in a RRC configured table applicable for DCI format 0\_1/1\_1 or MAC CE activated values.
* the size of a per cell Type-2 field in the DCI format 0\_X/1\_X is determined based on active BWP for each cell.

**Agreement**

For a set of cells which is configured for multi-cell scheduling using DCI format 0\_X and DCI format 1\_X, support the following:

* If table defining combinations of co-scheduled cells for the set of cells is configured,
	+ an indicator in the DCI is included and points to one row of the table.
	+ The table is configured by RRC signaling for the set of cells.
		- Separate tables are configured for downlink scheduling and uplink scheduling
	+ The size of the indicator is equal to ceil(log2(N)), where N is the number of rows in the table.
	+ The max number of rows in the table is 16
	+ The size of the per-cell Type 2 fields for each co-scheduled cell does not change according to the indicated co-scheduled cell combination
	+ The payload size of DCI format 1\_X is derived by UE based on RRC configuration of the active BWP(s) of co-scheduled cell combinations within the set of cells.
		- The payload size of DCI format 1\_X is the same for the active BWP(s) of all the co-scheduled cell combinations and equal to the largest payload size among the active BWP(s) of all the co-scheduled cell combinations determined by the co-scheduled cell combination table.
	+ The payload size of DCI format 0\_X is derived by UE based on RRC configuration of the active BWP(s) of 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) of all the co-scheduled cell combinations and equal to the largest payload size among the active BWP(s) of all the co-scheduled cell combinations determined by the co-scheduled cell combination table.
* Otherwise,
	+ The UE determines the actually scheduled cell(s) based on the FDRA field of each cell of the set of cells.
		- For Type 0 FDRA, all 0s indicates the cell is not scheduled.
		- For Type 1 FDRA, all 1s indicates the cell is not scheduled.
	+ The size of the Type 2 fields for each cell does not change according to actually co-scheduled cells.
	+ The payload size of DCI format 0\_X is derived by UE based on RRC configuration of the active BWP(s) of all cells within the set of cells.
	+ The payload size of DCI format 1\_X is derived by UE based on RRC configuration of the active BWP(s) of all cells within the set of cells.

**Agreement**

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.
* Up to 4 sets of cells can be configured per PUCCH group.
* 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.
* Up to N sets of cells can be configured and respectively scheduled by DCI format 0\_X/1\_X from a same scheduling cell.
	+ The value of N is reported as UE capability.
	+ An indicator is included in the DCI to indicate the scheduled set of cells,
		- The size of the indicator is equal to ceil(log2(N)), where N is the number of sets of cells.
	+ Unique n\_CI value is configured for each set of cells.

**Agreement**

* A new RBG size configuration “Configuration 3” is added with the following values and only used for DCI format 0\_X/1\_X for RA type 0.
* RBG size is configured per BWP per cell.
* Independent RA type configuration is applied per BWP per cell for multi-cell scheduling DCI.

 **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 |

**Agreement**

DCI format 0\_X / 1\_X with CRC scrambled by C-RNTI and MCS-C-RNTI is supported.

**Agreement**

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 (after step 4C), UE applies zero padding to whichever of DCI formats 0\_X or 1\_X that has a smaller size to have equal size.

**Agreement**

* Separate search space sets for DCI format 0\_X/1\_X and legacy DCI formats are independently configured
* Separate search space sets for DCI format 0\_X and 1\_X can be independently configured

**Agreement**

If the UE is configured with two SRS resource sets with ‘codebook’ or ‘non-codebook’, a PUSCH scheduled by DCI format 0\_X is always associated with the first SRS resource set with ‘codebook’ or ‘non-codebook’.

**Conclusion**

PUSCH repetition Type B operation is not supported with DCI format 0\_X (i.e. UE cannot be configured with PUSCH repetition Type B applicable for DCI format 0\_1)

**Agreement**

New RRC parameter of RBG granularity for RA type 1 can be configured per BWP per cell for DCI format 0\_X/1\_X with same value range applicable for DCI 0\_2/1\_2.

**Agreement**

Size of RV field can be configured per BWP per cell for DCI format 0\_X/1\_X.

**Agreement**

Size of HPN field can be configured per BWP per cell for DCI format 0\_X/1\_X.

**Agreement**

Priority indicator in DCI format 0\_X belongs to Type-1A field.

* The indicated priority is applied to all the co-scheduled PUSCH(s)

Priority indicator in DCI format 1\_X belongs to Type-1A field.

* The indicated priority indicator is applied to the PUCCH.

RRC parameters is introduced to configure the presence of priority indicator in DCI format 0\_X/1\_X

* This parameter is per set of cells

**Agreement**

ChannelAccess-Cpext in DCI format 1\_X belongs to Type-1A field.

* The indicated channel access information is applied to the PUCCH and/or SRS (whichever is first).

ChannelAccess-Cpext-CAPC in DCI format 0\_X belongs to Type-1A field.

* The indicated code point is applied to all the co-scheduled PUSCHs and/or SRS (whichever is first) by DCI format 0\_X.

**Agreement**

Beta\_offset indicator in DCI format 0\_X belongs to Type-1A field.

* This field is applied to the scheduled PUSCH(s) where the UCI is multiplexed.

**Agreement**

Inclusion of SCell dormancy indication in DCI format 0\_X/1\_X is configurable

**Agreement**

Inclusion of PDCCH monitoring adaptation indication in DCI format 0\_X/1\_X is configurable

**Agreement**

Inclusion of minimum applicable scheduling offset indicator in DCI format 0\_X/1\_X is configurable

## Agreements made in RAN1#114bis

**Agreement**

For a serving cell included in *MC-DCI-SetofCells*, a UE does not expect to be configured to monitor PDCCH candidates on more than one scheduling cell for detection of DCI formats scheduling the serving cell.

**Agreement**

DCI format level padding is adopted for DCI format 0\_3 or DCI format 1\_3.

**Agreement**

For DCI format 0\_3, when *ScheduledCellCombo-ListDCI-0-3* is not configured, all '0's for FDRA Type 2 with μ=1 or all ‘1’s for FDRA Type 2 with μ=0 indicates the corresponding cell is not scheduled.

**Agreement**

Below TP on TS38.213-i00 is adopted.

* Reason for change: PDCCH monitoring adaptation indication is applicable for PDCCH monitoring on a serving cell and captured in DCI format 0\_3/1\_3 in 38.212-i00. However, TS38.213-i00 does not reflect it.
* Summary of change: Add DCI format 0\_3 and DCI format 1\_3 in Section 10 on PDCCH skipping and SSSG switching.
* Consequence if not approved: Inconsistency between TS38.212 and TS38.213.

|  |
| --- |
| **10.4 Search space set group switching and skipping of PDCCH monitoring**<Omit unchanged text>A UE can be provided a set of durations by *pdcch-SkippingDurationList* for PDCCH monitoring on an active DL BWP of a serving cell and, if the UE is not provided *searchSpaceGroupIdList-r17* on the active DL BWP of the serving cell, a DCI format 0\_1,~~and~~ a DCI format 0\_2 and a DCI format 0\_3 that schedule PUSCH transmission, and a DCI format 1\_1,~~and~~ a DCI format 1\_2 and a DCI format 1\_3 that schedule PDSCH receptions can include a PDCCH monitoring adaptation field of 1 bit or of 2 bits. <Omit unchanged text>A UE can be provided group indexes for a Type3-PDCCH CSS set or USS set by *searchSpaceGroupIdList-r17* for PDCCH monitoring on an active DL BWP of a serving cell and, if the UE is not provided *pdcch-SkippingDurationList* for the active DL BWP of the serving cell, a DCI format 0\_1,~~and~~ a DCI format 0\_2 and a DCI format 0\_3 that schedule PUSCH transmissions and a DCI format 1\_1,~~and~~ a DCI format 1\_2 and a DCI format 1\_3 that schedule PDSCH receptions can include a PDCCH monitoring adaptation field of 1 bit or of 2 bits for the serving cell. <Omit unchanged text>A UE can be provided a set of durations by *pdcch-SkippingDurationList* and group indexes for a Type3-PDCCH CSS set or USS set by *searchSpaceGroupIdList-r17* for PDCCH monitoring on an active DL BWP of a serving cell and, a DCI format 0\_1,~~and~~ a DCI format 0\_2 and a DCI format 0\_3 that schedule PUSCH transmissions, and a DCI format 1\_1,~~and~~ a DCI format 1\_2 and a DCI format 1\_3 that schedule PDSCH receptions can include a PDCCH monitoring adaptation field of 2 bits. <Omit unchanged text> |

**Agreement**

* The Minimum applicable scheduling offset indicator, if configured to be present in DCI format 0\_3/1\_3, is of Type-1A field with 1 bit.
* Below TP on TS38.212-i00 is adopted.
* Reason for change: RAN1 has agreed that inclusion of minimum applicable scheduling offset indicator is supported in DCI format 0\_3/1\_3 and this field is already captured in 38.212-i00. However, the bit size is not defined.
* Summary of change: Add the clarification to this field when the bit size is equal to 1.
* Consequence if not approved: Bit size of this field is not defined in TS38.212.

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| --- |
| **7.3.1.1.4 Format 0\_3**< Unchanged parts are omitted >- Minimum applicable scheduling offset indicator – 0 or 1 bit - 0 bit if higher layer parameter *minimumSchedulingOffsetK0DCI-0-3* is not configured; - ~~x~~ 1 bit~~s~~ otherwise. The 1 bit indication is used to determine the minimum applicable K2 for the active UL BWP and the minimum applicable K0 value for the active DL BWP, if configured respectively, according to Table 7.3.1.1.2-33. If the minimum applicable K0 is indicated, the minimum applicable value of the aperiodic CSI-RS triggering offset for an active DL BWP for each scheduled cell shall be the same as the minimum applicable K0 value.< Unchanged parts are omitted >**7.3.1.2.4 Format 1\_3**< Unchanged parts are omitted >- Minimum applicable scheduling offset indicator – 0 or 1 bit - 0 bit if higher layer parameter *minimumSchedulingOffsetK0DCI-1-3* is not configured;- ~~x~~ 1 bit~~s~~ otherwise. The 1 bit indication is used to determine the minimum applicable K0 for the active DL BWP and the minimum applicable K2 value for the active UL BWP, if configured respectively, according to Table 7.3.1.1.2-33. If the minimum applicable K0 is indicated, the minimum applicable value of the aperiodic CSI-RS triggering offset for an active DL BWP for each scheduled cell shall be the same as the minimum applicable K0 value.< Unchanged parts are omitted > |

**Agreement**

Simultaneous configuration of both multicast reception and multi-cell scheduling in the same PUCCH group is not supported in Rel-18.

**Agreement**

For an enhanced Type-3 HARQ-ACK codebook triggered by a DCI format 1\_3, if the enhanced Type-3 HARQ-ACK codebook indicator is not configured, the MCS field of TB1 corresponding to a cell with smallest serving cell index ~~among the co-scheduled cells~~ with invalid FDRA field values is used to indicate the index of the enhanced Type-3 HARQ-ACK codebook.

* Note: Cells with valid FDRA fields are scheduled

**Agreement**

For HARQ-ACK retransmission triggered by a DCI format 1\_3, the MCS field of TB1 corresponding to a cell with smallest serving cell index ~~among the co-scheduled cells~~ with invalid FDRA field values is used to indicate the value of slot level offset *l*.

* Note: Cells with valid FDRA fields are scheduled

**Agreement**

The value range of *SRS-RequestCombo* is BIT STRING (2..3).

**Agreement**

* Single joint table is configured per set of cells for each of Type-1B fields other than TDRA (i.e., rateMatchListDCI-1-3, zp-CSI-RSListDCI-1-3, tci-ListDCI-1-3, srs-RequestListDCI-1-3, srs-OffsetListDCI-1-3, srs-RequestListDCI-0-3, srs-OffsetListDCI-0-3).
	+ Entries for each CC are interpreted based on the new/target BWPs per cell that is indicated by the BWP indicator field of DCI 0\_3/1\_3.
* Single joint table is configured per set of cells for TDRA (i.e., TDRA-FieldIndexListDCI-1-3, TDRA-FieldIndexListDCI-0-3).
	+ Entries of the joint table for TDRA (i.e., TDRA-FieldIndexDCI-1-3) are configured for each BWP of each CC.
	+ Columns of the indicated entry corresponding to the new/target BWPs per cell that is indicated by the BWP indicator field of DCI 0\_3/1\_3 are applied.
* The maximum size of TDRA-FieldIndexListDCI-1-3 is 32.
* The maximum size of TDRA-FieldIndexListDCI-0-3 is 64.

**Agreement**

Below TP on TS38.212-i00 is adopted.

* Reason for change: RAN1 has agreed that inclusion of SCell dormancy indication is supported in DCI format 0\_3/1\_3 and this field is already captured in 38.212-i00. However, the bit size is not defined.
* Summary of change: Add the clarification on the bit size of this field in Section 7.3.1.14 in TS38.212.
* Consequence if not approved: Bit size of this field is not defined in TS38.212.

|  |
| --- |
| **7.3.1.1.4 Format 0\_3**<omitted text>- SCell dormancy indication – 0 bit if higher layer parameter *dormancyDCI-0-3* or *dormancyGroupWithinActiveTime* is not configured; otherwise ~~x bits~~ 1, 2, 3, 4, or 5 bits bitmap determined according to the number of different *DormancyGroupID(s)* provided by higher layer parameter *dormancyGroupWithinActiveTime,* where each bit corresponds to one of the SCell group(s) configured by higher layers parameter *dormancyGroupWithinActiveTime,* with MSB to LSB of the bitmap corresponding to the first to last configured SCell group in ascending order of *DormancyGroupID*. The field is only present when this format is carried by PDCCH on the primary cell within DRX Active Time and the UE is configured with at least two DL BWPs for an SCell.<omitted text>**7.3.1.2.4 Format 1\_3**<omitted text>- SCell dormancy indication – 0 bit if higher layer parameter *~~SCell-dormancy-indication-Present~~* *dormancyDCI-1-3* or *dormancyGroupWithinActiveTime* is not configured; otherwise ~~x bits.~~ 1, 2, 3, 4, or 5 bits bitmap determined according to the number of different *DormancyGroupID(s)* provided by higher layer parameter *dormancyGroupWithinActiveTime,* where each bit corresponds to one of the SCell group(s) configured by higher layers parameter *dormancyGroupWithinActiveTime,* with MSB to LSB of the bitmap corresponding to the first to the last configured SCell group in ascending order of *DormancyGroupID*. The field is only present when this format is carried by PDCCH on the primary cell within DRX Active Time and the UE is configured with at least two DL BWPs for an SCell.<omitted text> |

**Agreement**

For MC-DCI, SCell dormancy indication Case 1 (for both DCI format 0-3 and 1-3) and Case 2 (only for DCI format 1-3) are supported.

**Agreement**

For a UE configured with a set of cells by *MC-DCI-SetofCells*,

* If the scheduling cell is active while the reference cell is indicated dormant or deactivated, the UE does not monitor DCI format 0\_3/1\_3 on the scheduling cell for the set of cells.

## Agreements made in RAN1#115

**Conclusion**

There is no consensus to support TPI field for DCI format 0\_3 in Rel-18

**Agreement**

For a UE configured with a set of cells by *MC-DCI-SetofCells*,

* If an SCell within the set of cells is deactivated and its *firstActiveDownlinkBWP-Id* is not set to dormant BWP, the UE determines the sizes of fields in DCI format 1\_3 according to the DL BWP provided by *firstActiveDownlinkBWP-Id*.
* If an SCell within the set of cells is dormant, or if an SCell within the set of cells is deactivated and its *firstActiveDownlinkBWP-Id* is set to dormant BWP,
	+ the UE determines the sizes of fields in DCI format 1\_3 according to the DL BWP provided by *firstWithinActiveTimeBWP-Id* for the SCell if provided;
	+ otherwise, according to the DL BWP provided by *firstOutsideActiveTimeBWP-Id* for the SCell.
* If an SCell within the set of cells is deactivated, the UE determines the sizes of fields in DCI format 0\_3 according to the UL BWP provided by *firstActiveUplinkBWP-Id*.

**Agreement**

Adopt the following TP to 38.214 for the support of FDRA Type 2 for PUSCH scheduled by DCI format 0\_3:

**Agreement**

* When Antenna port(s) field in DCI format 1\_3 is configured as type1a, UE expects to be configured with a common table from Tables 7.3.1.2.2-1/2/3/4 in TS38.212 is used for all cells in set of cells.
	+ The DMRS mapping type should be the same across the cells in set of cells
* When Antenna port(s) field in DCI format 0\_3 is configured as type1a, UE expects to be configured with a common 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, 7.3.1.1.2-15, 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 cells in set of cells.
	+ The DMRS mapping type should be the same across the cells in set of cells
* When TPMI field in DCI format 0\_3 is configured as type1a, UE expects to be configured with a common 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 cells in set of cells.
* When SRI field in DCI format 0\_3 is configured as type1a, UE expects to be configured with a common 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 cells in set of cells.

**Agreement**

For a UE configured with DCI format 1\_3, the number of HARQ-ACK bits used for PUCCH power control is derived based on a summation of the corresponding numbers of HARQ-ACK bits in the two HARQ-ACK sub-codebooks.

**Agreement**

* Alt 2: For a DCI format 1\_3 transmitted on PCell, if one-shot HARQ-ACK request is not present or set to '0', and if HARQ-ACK retransmission indicator is not present or set to ‘0’, SCell dormancy indication is provided by repurposing below fields corresponding to one ~~or more~~ serving cell with the smallest cell index with invalid FDRA values ~~in ascending order of serving cell index~~:
	+ Modulation and coding scheme of transport block 1
	+ NDI of transport block 1
	+ Redundancy version of transport block 1
	+ HARQ process number
	+ Antenna port(s) if *AntennaPortsDCI1-3* is configured as ‘*type2*’
* Note: Cells with valid FDRA fields are scheduled.

**Agreement**

Rel-18 specifications support a DCI format 1\_3 is transmitted without scheduling any PDSCH for SCell dormancy indication.

* For Type-2 HARQ-ACK codebook, the corresponding HARQ-ACK information for the DCI format 1\_3 is included in the first Type-2 sub-codebook.

**Agreement**

For a cell provided in *MC-DCI-SetofCells*, when no search space set is configured for the cell, the cell is not counted as a scheduled cell for M\_total\_μ/C\_total\_μ calculation.

**Agreement**

* BWP indicator in a DCI format 0\_3/1\_3 applies only to the scheduled cell(s) with valid FDRA value(s).
* For a cell scheduled by DCI format 0\_3/1\_3 with valid FDRA value, if the BWP indicator indicates a code point that does not correspond to a configured BWP for the cell, the UE does not perform dynamic BWP switching based on the BWP indicator and transmits/receives data on the current active BWP of the cell.

**Agreement**

In case of BWP switching, for a Type-2 field in a DCI format 0\_3/1\_3, the existing procedure for DCI field parsing (via truncation or zero-padding) is applied per “block” of the Type-2 field in the DCI format 0\_3/1\_3.

**Agreement**

* For Type-2 HARQ-ACK codebook, if a DCI format 1\_3 is transmitted with fields repurposed for SCell dormancy indication and schedules one or more PDSCHs,
	+ the corresponding HARQ-ACK information for the one or more PDSCHs is included in the second Type-2 HARQ-ACK sub-codebook.
	+ HARQ-ACK information for the SCell dormancy indication is mapped to HARQ-ACK bit position for the serving cell with the smallest cell index with invalid FDRA and included in the second Type-2 HARQ-ACK sub-codebook.

## Agreements made in RAN1#116

**Agreement**

Adopt following TP for TS38.213.

* **Change reason:** Unicast DCI formats do not include DCI format 1\_3 and 0\_3.
* **Change summary:** Add DCI format 1\_3 and 0\_3 in unicast DCI format list.
* **Consequence if not approved:** Incomplete unicast DCI format list.

|  |
| --- |
| 9 UE procedure for reporting control information<text omitted>In the following, DCI formats with CRC scrambled by C-RNTI or CS-RNTI or MCS-C-RNTI are also referred to as unicast DCI formats and DCI formats with CRC scrambled by multicast-MCCH-RNTI, G-RNTI for multicast or G-CS-RNTI are also referred to as multicast DCI formats. Corresponding unicast DCI formats are DCI formats 0\_0/0\_1/0\_2/0\_3/1\_0/1\_1/1\_2/1\_3 and multicast DCI formats are DCI formats 4\_0/4\_1/4\_2 [4, TS 38.212]. PDSCH receptions scheduled by unicast or multicast DCI formats are referred as unicast or multicast PDSCH receptions. HARQ-ACK information associated with unicast or multicast DCI formats for PDCCH receptions in RRC\_CONNECTED state are also respectively referred as unicast or multicast HARQ-ACK information.<text omitted> |

**Agreement**

Adopt the following TP for sub-clause 9.1.2.1 in TS38.213.

|  |
| --- |
| **9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel**For a serving cell $c$, an active DL BWP, and an active UL BWP, as described in clause 12, the UE determines a set of $M\_{A,c}$ occasions for candidate PDSCH receptions for which the UE can transmit corresponding HARQ-ACK information in a PUCCH in slot $n\_{U}$. If serving cell $c$ is deactivated, the UE uses as the active DL BWP for determining the set of $M\_{A,c}$ occasions for candidate PDSCH receptions a DL BWP provided by *firstActiveDownlinkBWP-Id*. The determination is based:a) on a set of slot timing values $K\_{1}$ associated with the active UL BWP on the primary cell or, if the PUCCH transmission is indicated by a DCI format to be on the PUCCH-sSCell as described in clause 9A, on a set of slot timing values $K\_{1}$ associated with the active UL BWP on the PUCCH-sSCell- If the UE is configured to monitor PDCCH for DCI format 1\_0 and is not configured to monitor PDCCH for ~~either~~ DCI format 1\_1/ ~~or DCI format~~ 1\_2/1\_3 for serving cell $c$, or the active DL BWP for serving cell $c$ is dormant BWP, $K\_{1}$ is provided by the slot timing values {1, 2, 3, 4, 5, 6, 7, 8} for SCS configuration of PUCCH transmission $μ\leq 3$, {7, 8, 12, 16, 20, 24, 28, 32} for $μ=5$, and {13, 16, 24, 32, 40, 48, 56, 64} for $μ=6$- If the UE is configured to monitor PDCCH for DCI format 1\_1/1\_3 and is not configured to monitor PDCCH for DCI format 1\_2 for serving cell $c$, $K\_{1}$ is provided by *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-r17*- If the UE is configured to monitor PDCCH for DCI format 1\_2 and is not configured to monitor PDCCH for DCI format 1\_1/1\_3 for serving cell $c$, $K\_{1}$ is provided by *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-DCI-1-2-r17*- If the UE is configured to monitor PDCCH for DCI format 1\_1/1\_3 and DCI format 1\_2 for serving cell $c$, $K\_{1}$ is provided by the union of *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-r17* and *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-DCI-1-2-r17* - If an inapplicable value in dl-DataToUL-ACK-r16 or dl-DataToUL-ACK-r17 is provided, the value is excluded from $K\_{1}$ |

**Agreement**

A UE does not expect a DCI format 0\_3/1\_3 schedules an SCell with valid FDRA value and indicates the SCell to switch to dormant BWP.

**Conclusion**

For a cell scheduled by DCI format 0\_3 with valid FDRA value, UE does not expect that OLPC/CAPC/TPMI/SRI in the DCI format indicates a code point that does not correspond to a configuration for the cell.

* No spec impact

**Conclusion**

FDRA validity for a cell is determined based on the indicated BWP of the cell.

* No spec impact

**Agreement**

Adopt the following TP to 38.212 for DMRS sequence initialization in DCI format 0\_3:

|  |
| --- |
| **7.3.1.1.4 Format 0\_3**<omitted text>DMRS sequence initialization –1 bit if transform precoder is disabled at least for one cell configured by higher layer parameter ScheduledCell-ListDCI-0-3 in the scheduled cell set ~~is configured with disabled transform precoder~~; otherwise, 0 bit. This field is applied to all the scheduled cells with transform precoder disabled and indicated by Scheduled cells indicator field or Frequency domain resource assignment field independently.<omitted text> |

**Agreement**

TP1 in section 8 of [R1-2401589](https://lenovobeijing-my.sharepoint.com/personal/leihp1_lenovo_com/Documents/R1-2401589.zip) is agreed for TS38.214.

**Agreement**

Adopt the following TP covering multi-cell scheduling in TS38.300.

**10.X Multi-cell scheduling by a single DCI**

Multi-cell scheduling by a single DCI allows the PDCCH of a serving cell to schedule PDSCH(s)/PUSCH(s) on one or more serving cells with the single DCI but with the following restrictions:

* When a serving cell is configured with a PDCCH which schedules PDSCH(s)/PUSCH(s) on a cell set, the PUSCH/PDSCH on serving cells in the cell set is always scheduled by a PDCCH on the serving cell;
* When PCell is configured with a PDCCH which schedules PDSCH(s)/PUSCH(s) on serving cells in a cell set, that PCell’s PDSCH and PUSCH cannot be scheduled by a PDCCH on an SCell;
* When an SCell is configured with a PDCCH which schedules PDSCH(s)/PUSCH(s) on serving cells in a cell set, PCell is not included in the cell set;
* The scheduling PDCCH and the scheduled PDSCH(s)/PUSCH(s) can use the same or different numerologies;
* The co-scheduled PDSCH(s) with a PDCCH use the same numerology.
* The co-scheduled PUSCH(s) with a PDCCH use the same numerology.

Send an LS to RAN2 to convey the above TP. Final LS is in [R1-2401716](https://lenovobeijing-my.sharepoint.com/personal/leihp1_lenovo_com/Documents/R1-2401716.zip).

**Agreement**

TP2 in Section 8 for TS38.213 is agreed in principle. TS38.213 editor to provide final TP.

**Agreement**

* When a PDCCH MO that provides a DCI format 1\_3 is before active UL BWP change on the PUCCH cell, and the PUCCH indicated by the DCI format 1\_3 is to be transmitted after the active UL BWP change on the PUCCH cell, the corresponding HARQ-ACK information for the DCI format 1\_3 is skipped.
* FFS: When a PDCCH MO that provides a DCI format 1\_3 is before an active DL BWP change on a cell of co-scheduled cells by the DCI format 1\_3, and the DCI format 1\_3 does not trigger the active DL BWP change for the cell, and the PUCCH indicated by the DCI format 1\_3 is to be transmitted after the active DL BWP change on the cell,
	+ For type 2 codebook for generating the second sub-codebook, the corresponding HARQ-ACK information for that cell with BWP switching is generated with NACK bit
	+ For type 1 codebook and for type 2 codebook for generating the first sub-codebook, follow the legacy behaviour (the corresponding HARQ-ACK information for that cell with BWP switching is skipped)

## Agreements made in RAN1#116bis

**Agreement**

* Adopt following TP for TS38.214.

|  |
| --- |
| ***5.5 UE PDSCH reception preparation time ~~with cross carrier scheduling~~ with different subcarrier spacings for PDCCH and PDSCH in different cells***This clause applies only if the PDCCH carrying the scheduling DCI is received on one carrier with one OFDM subcarrier spacing (µPDCCH), and the PDSCH scheduled to be received by the DCI is on another carrier with another OFDM subcarrier spacing (µPDSCH).If the µPDCCH < µPDSCH, the UE is expected to receive the scheduled PDSCH, if the first symbol in the PDSCH allocation, including the DM-RS, as defined by the slot offset *K0* and the start and length indicator *SLIV* of the scheduling DCI starts no earlier than the first symbol of the slot of the PDSCH reception starting at least *Npdsch* PDCCH symbols after the end of the PDCCH scheduling the PDSCH, not taking into account the effect of receive timing difference between the scheduling cell and the scheduled cell.If the µPDCCH > µPDSCH, the UE is expected to receive the scheduled PDSCH, if the first symbol in the PDSCH allocation, including the DM-RS, as defined by the slot offset *K0* and the start and length indicator *SLIV* of the scheduling DCI starts no earlier than *Npdsch* PDCCH symbols after the end of the PDCCH scheduling the PDSCH, not taking into account the effect of receive timing difference between the scheduling cell and the scheduled cell.When the PDCCH reception includes two PDCCH candidates from two respective search space sets, as described in clause 10.1 of [6, TS 38.213], for the purpose of determining *Npdsch*, the PDCCH candidate that ends later in time is used. <omitted text> |

**Agreement**

The following TP is agreed in principle. Final TP to be decided by the editor.

TP2 on TS38.213:

|  |
| --- |
| **[TS 38.213 V18.2.0]**9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel< unchanged part omitted >A value of the counter downlink assignment indicator (DAI) field in DCI formats, each scheduling PDSCH receptions on respective single serving cells with associated HARQ-ACK information, or having associated HARQ-ACK information without scheduling a PDSCH reception, in a same HARQ-ACK codebook denotes the accumulative number of {serving cell, PDCCH monitoring occasion}-pairs in which PDSCH receptions that provide transport blocks with enabled HARQ-ACK information report, or HARQ-ACK information bits that are not in response for PDSCH receptions, associated with the DCI formats, excluding the SPS activation DCI, is present up to the current serving cell and current PDCCH monitoring occasion, - first, if the UE indicates by *type2-HARQ-ACK-Codebook* support for more than one PDSCH reception on a serving cell that are scheduled from a same PDCCH monitoring occasion, in increasing order of the PDSCH reception starting time for the same {serving cell, PDCCH monitoring occasion} pair, - second in ascending order of serving cell index, and - third in ascending order of PDCCH monitoring occasion index $m$, where $0\leq m<M$. A value of the counter DAI field in DCI formats, each scheduling PDSCH receptions on respective more than one serving cells with associated HARQ-ACK information in a same HARQ-ACK codebook, denotes the accumulative number of {serving cell with smallest index from the more than one serving cells, PDCCH monitoring occasion}-pairs in which PDSCH receptions are present up to the current more than one serving cells and current PDCCH monitoring occasion,- first, if the UE indicates by *type2-HARQ-ACK-Codebook* support for more than one PDSCH receptions on a serving cell that are scheduled from a same PDCCH monitoring occasion, in increasing order of the PDSCH reception starting time for the same {serving cell with smallest index from the more than one serving cells, PDCCH monitoring occasion} pair,- second in ascending order of the smallest serving cell index from the more than one serving cells, and - third in ascending order of PDCCH monitoring occasion index $m$, where $0\leq m<M$.< unchanged part omitted >The UE determines the $\tilde{o}\_{0}^{ACK}, \tilde{o}\_{1}^{ACK},\cdots ,\tilde{o}\_{O\_{ACK}-1}^{ACK}$, for a total number of $O\_{ACK}$ HARQ-ACK information bits in the second Type-2 HARQ-ACK sub-codebook according to the following pseudo-code. Set $N\_{cells,set}^{DL,max}$ to the maximum number of serving cells in *ScheduledCell-ListDCI-1-3* of a set of serving cells provided by *MC-DCI-SetofCells*, across the number of sets of serving cells, that can be scheduled PDSCH receptions by DCI format 1\_3Set $N\_{sets}^{TB,max}$ to the maximum total number of TBs in PDSCH receptions that can be scheduled by a DCI format 1\_3 over more than one serving cells in a set of serving cells across the number of sets of serving cellsSet $N\_{sets}^{DL}$ to the number of sets of serving cells *MC-DCI-SetofCells* in a PUCCH groupSet $N\_{cells}^{DL}$ to the number of serving cells, across $N\_{sets}^{DL}$ sets of serving cells in the PUCCH groupSet $c$ to the index of serving cells, $c=0,…, N\_{cells}^{DL}-1$, a lower index corresponds to a lower RRC index of a corresponding serving cell* if the UE indicates *type2-HARQ-ACK-Codebook,* and receives a number $N\_{PDSCH, c}^{m}>1$ of PDSCHs on a serving cell *c* that are scheduled by [$N\_{PDSCH, c}^{m}$] DCI formats 1\_3 in PDCCH receptions at a same PDCCH monitoring occasion *m*, wherein each of the DCI formats 1\_3 schedule more than one PDSCH receptions on respective more than one serving cells, and *c* is the same smallest cell index among the respective more than one serving cells across the [$N\_{PDSCH, c}^{m}$] DCI formats 1\_3, the serving cell *c* is counted $N\_{PDSCH, c}^{m}$ times for PDCCH monitoring occasion *m* in increasing order of the PDSCH reception starting time among the $N\_{PDSCH, c}^{m}$ PDSCHs
* if the UE indicates *type2-HARQ-ACK-Codebook,* and receives a number $N\_{PDSCH, c}^{m}>1$ of PDSCHs on a serving cell *c* that are scheduled by [$N\_{PDSCH, c}^{m}$] DCI formats 1\_3 in PDCCH receptions at a same PDCCH monitoring occasion *m*, wherein each of the DCI formats 1\_3 schedule more than one PDSCH receptions on respective more than one serving cells, and *c* is the smallest cell index among the respective more than one serving cells which is the same across the [$N\_{PDSCH, c}^{m}$] DCI formats 1\_3, the serving cell *c* is counted $N\_{PDSCH, c}^{m}$ times for PDCCH monitoring occasion *m* in increasing order of the PDSCH reception starting time among the $N\_{PDSCH, c}^{m}$ PDSCHs

Set $mc$ to the index of a serving cell, in a set of indexes of serving cells arranged in ascending order, from the set of $N\_{cells,set}^{DL,max}$ serving cells, $mc=0,…, N\_{cells,set}^{DL,max}-1$Set $m=0$ – PDCCH monitoring occasion index for detection of a DCI format 1\_3 scheduling PDSCH receptions on more than one serving cells from a set of serving cells: lower index corresponds to earlier PDCCH monitoring occasionSet $j=0$Set $V\_{temp}=0$Set $V\_{temp2}=0$Set $V\_{s}=∅$Set $M$ to the number of PDCCH monitoring occasions< unchanged part omitted > |

**Agreement**

For a UE configured with a set of cells by *MC-DCI-SetofCells*, when a cell in the set of cells is dormant or deactivated and the cell is neither the scheduling cell nor the reference cell for the set of cells, the UE can receive a DCI format 1\_3/0\_3 that schedules serving cells including the cell;

* The UE does not expect a PDSCH or a PUSCH scheduled on the cell.
* The fields of DCI format 1\_3 corresponding to the cell can be reinterpreted for indicating SCell dormancy indication, the index of the enhanced Type-3 HARQ-ACK codebook or the value of slot level offset *l.*
	+ The UE checks the field value of the cell in the DCI format 1\_3.
* Note: FDRA field of the cell in the DCI format 1\_3/0\_3 is set to invalid.

**Conclusion**

There is no consensus to support search space sharing for DCI format 0\_3/1\_3.

**Agreement**

The following TP is agreed for Rel-18 38.214.

-----------------------------Begin TP1 for 38.214, subclause 6.2.1.3-----------------------------

6.2.1.3 UE sounding procedure between component carriers

**<Unchanged parts are omitted>**

For an aperiodic SRS triggered in DCI format 1\_1 or 1\_2, if the UE is configured by *SRS-CarrierSwitching*, it transmits SRS on one serving cell not configured for PUSCH/PUCCH transmission scheduled by the DCI and the UE in the serving cell transmits the configured one or two SRS resource set(s) with higher layer parameter ~~usage~~ *usage* set to 'antennaSwitching' and higher layer parameter *resourceType* in *SRS-ResourceSet* set to 'aperiodic'.

For an aperiodic SRS triggered in DCI format 1\_3, if the UE is configured by *SRS-CarrierSwitching*,

for an SRS transmission in a scheduled cell not configured for PUSCH/PUCCH transmission, the UE transmits the configured one or two SRS resource set(s) with higher layer parameter *usage* set to 'antennaSwitching' and higher layer parameter *resourceType* in *SRS-ResourceSet* set to 'aperiodic'.

**<Unchanged parts are omitted>**

-----------------------------End TP1 for 38.214, subclause 6.2.1.3-----------------------------

**Agreement**

* Keep the wording of TS38.212-i20 unchanged in regards to the usage of invalid FDRA for determination of scheduled / non-schedueld cells.
* RAN1 confirms that repurposed-based indication of {SCell dormancy, enhanced Type-3 HARQ-ACK CB, HARQ retransmission} is supported regardless of whether *ScheduledCellCombo-ListDCI-1-3* is configured or not.
* No RAN1 spec impact

**Agreement**

Adopt TP3 in Section 8 of [**R1-2403479**](file:///D%3A/RAN1/RAN1%23117/tdocs/FL%20summary/R1-2403479.zip) for TS38.214.

**Conclusion**

For a cell scheduled by DCI format 0\_3/1\_3 with valid FDRA value, UE does not expect that a Type-1B field in the DCI format indicates a code point that does not correspond to a configuration for the cell.

* No RAN1 spec impact

## Agreements made in RAN1#117

**Agreement**

The TP in draft CR R1-2404235 for TS38.212 on correcting precoding information and number of layers in DCI format 0\_3 is agreed for **alignment CR. Editor to submit CR.**

**Agreement**

The TP in draft CR R1-2404856 for TS38.212 on correcting number of MCS/NDI/RV blocks for TB-2 in DCI 1\_3 is agreed for **alignment CR**. **Editor to submit CR.**

**Agreement**

Following TP is agreed for TS38.214. Final in CR in R1-2405734.

5.1.5 Antenna ports quasi co-location

<text omitted>

When *tci-PresentInDCI* is set as 'enabled' or *tci-PresentDCI-1-2* is configured for the CORESET, a UE configured with *dl-OrJointTCI-StateList* with activated *TCI-State* or *ul-TCI-StateList* with activated *TCI-UL-State* receives DCI format 1\_1/1\_2/1\_3 providing indicated *TCI-State(s)* and/or *TCI-UL-State(s)* for a CC or all CCs in the same CC list configured by *simultaneousU-TCI-UpdateList1-r17, simultaneousU-TCI-UpdateList2-r17, simultaneousU-TCI-UpdateList3-r17, simultaneousU-TCI-UpdateList4-r17*. The DCI format 1\_3 provides indicated *TCI state(s)* and/or*TCI-UL-State(s)* for the CC(s) in a *scheduledCellListDCI-1-3* if the UE is scheduled by the DCI format 1\_3 to receive PDSCH at least on one serving cell in the *scheduledCellListDCI-1-3*. The DCI format 1\_1/1\_2 can be with or without, if applicable, DL assignment. If the DCI format 1\_1/1\_2 is without DL assignment, the UE can assume the following:

- CS-RNTI is used to scramble the CRC for the DCI

- The values of the following DCI fields are set as follows:

- RV = all '1's

- MCS = all '1's

- NDI = 0

- Set to all '0's for FDRA Type 0, or all '1's for FDRA Type 1, or all '0's for dynamicSwitch (same as in Table 10.2-4 of [6, TS 38.213]).

After a UE receives an initial higher layer configuration of *dl-OrJointTCI-StateList* with more than one *TCI-State* and before application of an indicated TCI state from the configured TCI states:

- The UE assumes that DM-RS of PDSCH and DM-RS of PDCCH and the CSI-RS applying the indicated TCI state are quasi co-located with the SS/PBCH block the UE identified during the initial access procedure

\*\*\* Unchanged parts are omitted \*\*\*

**Agreement**

The TP in R1-2404855 for TS38.212 on correcting Type-2 field blocks in DCI 1\_3/0\_3 is agreed but without the addition of “counted towards $N\_{cell}^{UL}$”, “counted towards $N\_{cell}^{DL}$”. The TP is agreed for **alignment CR.**

## Agreements made in RAN1#118

**Agreement**

* When a PDCCH MO that provides a DCI format 1\_3 is before an active DL BWP change on a cell of co-scheduled cells by the DCI format 1\_3, and the active DL BWP change for the cell is not triggered in the PDCCH MO, and the PUCCH indicated by the DCI format 1\_3 starts at or after a slot for the active DL BWP change on the cell,
* For Type 1 codebook and for Type 2 codebook for generating the first sub-codebook, follow the legacy behaviour (the corresponding HARQ-ACK information for that scheduled cell with active DL BWP change is skipped)
	+ No spec impact
* For Type 2 codebook for generating the second sub-codebook,
	+ the HARQ-ACK information for that scheduled cell with active DL BWP change is generated with NACK bit.

**Agreement**

* The TP in draft CR [R1-2405930](file:///D%3A/RAN1/RAN1%23118/tdocs/R1-2405930.zip) for TS38.214 on corrections of DCI format 0\_3 is agreed as alignment CR.

**Agreement**

* The TP in draft CR [R1-2406796](file:///D%3A/RAN1/RAN1%23118/tdocs/R1-2406796.zip) for TS38.213 on corrections of UCI-onPUSCH for DCI format 0\_3 is agreed as alignment CR.

**Agreement**

* The TP in draft CR R1-2406620 for TS38.213 on correcting search space for DCI format 0\_3/1\_3 is agreed as alignment CR.

**Agreement**

* The TP in draft CR [R1-2407164](file:///D%3A/RAN1/RAN1%23118/tdocs/R1-2407164.zip) for TS38.212 on correcting table caption for DCI format 0\_3/1\_3 is agreed as alignment CR.

**Agreement**

* The TP in draft CR [R1-2406339](file:///D%3A/RAN1/RAN1%23118/tdocs/R1-2406339.zip) for TS38.213 on correcting Type-2 HARQ-ACK codebook determination is agreed as alignment CR.

**Agreement**

* The TP in draft CR [R1-2406341](file:///D%3A/RAN1/RAN1%23118/tdocs/R1-2406339.zip) for TS38.213 on correcting Type-2 HARQ-ACK codebook determination is agreed as alignment CR.

**Agreement**

* Adopt the following TP for Section 10.1, TS38.213 on PDCCH overbooking is agreed in principle for alignment.

10.1 UE procedure for determining physical downlink control channel assignment

< Unchanged parts are omitted >

For all search space sets that a UE monitors PDCCH on the primary cell within a slot $n$, or within a group of $X\_{s}$ slots for a corresponding combination $\left(X\_{s},Y\_{s}\right)$, or within a span in slot $n$, denote by $S\_{css}$ a set of CSS sets, except for CSS sets provided by *searchSpaceMCCH*, *searchSpaceMTCH* or by *SearchSpace* in *pdcch-ConfigMulticast* for DCI formats with CRC scrambled by G-RNTI or G-CS-RNTI, with cardinality of $I\_{css}$ and by $S\_{uss}$ a set of USS sets and CSS sets provided by *searchSpaceMCCH*, *searchSpaceMTCH* or by *SearchSpace* in *pdcch-ConfigMulticast* for DCI formats with CRC scrambled by G-RNTI or G-CS-RNTI with cardinality of $J\_{uss}$ ~~for scheduling on the primary cell~~ with PDCCH candidates and non-overlapping CCEs counted on the primary cell. The location of search space sets $s\_{j}$, $0\leq j<J\_{uss}$, in $S\_{uss}$ is according to an ascending order of the search space set index.

< Unchanged parts are omitted >

**Agreement**

Adopt the following TP for Section 9.1.5, TS38.213 is agreed in principle for alignment.

< Unchanged parts are omitted >

9.1.5 HARQ-ACK codebook retransmission

With reference to slots of PUCCH transmissions on the primary cell and for Type-1 or Type-2 HARQ-ACK codebooks, a UE that transmitted or would transmit a PUCCH or a PUSCH with a first HARQ-ACK codebook in slot $m$ can be indicated by a DCI format with CRC scrambled by a C-RNTI or a MCS-C-RNTI that does not schedule a PDSCH reception [4, TS 38.212] on one or more serving cells and is received in a PDCCH ending in slot $n$, to transmit a PUCCH with the first HARQ-ACK codebook in slot $n+k$, where slot $n+k$ is after slot $m$. The UE determines $k$ and a resource for the PUCCH transmission as described in clauses 9.2.3 and 9.2.5. If the UE is provided a periodic cell switching pattern for PUCCH transmissions by *pucch-sSCellPattern*, the UE further determines a corresponding cell based on the periodic cell switching pattern as described in clause 9.A.

If the HARQ-ACK retransmission indicator field value in a DCI format is '1', the UE determines slot $m$ as $m=n-l$ where $l$ is determined by a one-to-one mapping in ascending order among the values from -7 to 24 and the values of

- the MCS field for transport block 1 if the DCI format is DCI format 1\_1

- the MCS field if the DCI format is DCI format 1\_2

- the MCS field for transport block 1 for a serving cell if the DCI format is DCI format 1\_3, where the serving cell is the one with smallest index that has

- *resourceAllocation* = *resourceAllocationType0* and all bits of the corresponding block of the frequency domain resource assignment field equal to 0, or

- *resourceAllocation* = *resourceAllocationType1* and all bits of the corresponding block of the frequency domain resource assignment field equal to 1, or

- *resourceAllocation = dynamicSwitch* and all bits of the corresponding block of the frequency domain resource assignment field equal to 0 or 1

If the DCI format includes a priority indicator field having a value, a priority value of first HARQ-ACK information in the first HARQ-ACK codebook is same as the value of the priority indicator field; otherwise, the priority value of the first HARQ-ACK information is zero.

< Unchanged parts are omitted >

**Agreement**

* Adopt the following TP for Section 5.1.5, Rel-18 TS38.214 is agreed in principle for alignment.

5.1.5 Antenna ports quasi co-location

**<Unchanged parts are omitted>**

When a UE configured with *dl-OrJointTCI-StateList* would transmit a PUCCH with positive HARQ-ACK or a PUSCH with positive HARQ-ACK corresponding to the DCI carrying the TCI State indication and without DL assignment, or corresponding to ~~the~~ one or more PDSCHs scheduled by the DCI carrying the TCI State indication, and if the indicated TCI State(s) is/are different from the previously indicated one*(s)*, the indicated *TCI-State(s)* and/or *TCI-UL-State(s)* should be applied starting from the first slot that is at least $ beamAppTime$ symbols after the last symbol of the PUCCH or the PUSCH, and if the UE receives more than one indicated TCI state for a CC/BWP to be applied starting from the first slot that is at least $ beamAppTime$ symbols after the last symbol of the PUCCH or the PUSCH, the indicated TCI state carried in the latest DCI, for the corresponding *coresetPoolIndex* value when applicable, in time corresponding to positive HARQ-ACK value is applied. The first slot and the $ beamAppTime$ symbols are both determined on the active BWP with the smallest SCS among the BWP(s) from the CCs applying the indicated *TCI-State(s)* or *TCI-UL-State(s)* that are active at the end of the PUCCH or the PUSCH carrying the positive HARQ-ACK.

**<Unchanged parts are omitted>**

**Agreement**

Draft CR in Section 11 of R1-2407227 is endorsed in principle.

**Agreement**

Final CR R1-247545 is endorsed.

## Agreements made in RAN1#118bis

For Rel-18 CR

Agreement

* Adopt the following TP for Section 6.1.2.2, TS38.214 in principle for alignment CR.

6.1.2.2 Resource allocation in frequency domain

-------------------------------------Begin of TP----------------------------------------------

The UE shall determine the resource block assignment in frequency domain using the resource allocation field in the detected PDCCH DCI except for a PUSCH transmission scheduled by a RAR UL grant or fallbackRAR UL grant, in which case the frequency domain resource allocation is determined according to clause 8.3 of [6, 38.213] or a MsgA PUSCH transmission with frequency domain resource allocation determined according to clause 8.1A of [6, 38.213]. Three uplink resource allocation schemes type 0, type 1 and type 2 are supported. Uplink resource allocation scheme type 0 is supported for PUSCH only when transform precoding is disabled. Uplink resource allocation scheme type 1 and type 2 are supported for PUSCH for both cases when transform precoding is enabled or disabled.

If the scheduling DCI is configured to indicate the uplink resource allocation type as part of the '*Frequency domain resource'* assignment field by setting a higher layer parameter r*esourceAllocation* in *pusch-Config* to 'dynamicSwitch', for DCI format 0\_1 or setting a higher layer parameter *resourceAllocationDCI-0-2* in *pusch-Config* to 'dynamicSwitch' for DCI format 0\_2 or setting a higher layer parameter *resourceAllocationDCI-0-3* in *pusch-ConfigDCI-0-3* to 'dynamicSwitch' for DCI format 0\_3, the UE shall use uplink resource allocation type 0 or type 1 as defined by this DCI field. Otherwise the UE shall use the uplink frequency resource allocation type as defined by the higher layer parameter *resourceAllocation* for DCI format 0\_1 or the higher layer parameter *resourceAllocationDCI-0-2* for DCI format 0\_2 or by the higher layer parameter *resourceAllocationDCI-0-3* for DCI format 0\_3. The UE shall assume that when the scheduling PDCCH is received with DCI format 0\_1/0\_3 and *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated* is configured, uplink type 2 resource allocation is used.

-------------------------------------End of TP----------------------------------------------

Agreement

* Adopt the TP in R1-2408629 for Section 7.3.1.1.4, TS38.212 in principle for alignment CR with additional change of the changed text “mapped” to “associated”.

Agreement

Adopt the following TP for Section 12, TS38.213 in principle for alignment CR.

12 Bandwidth part operation

< Unchanged parts are omitted >

The UE does not expect to be scheduled by a DCI format 0\_3/1\_3 to transmit/receive a PUSCH/PDSCH on an activated SCell, if:

- the DCI format 0\_3/1\_3 indicates an active DL BWP provided by *dormantBWP-Id* for the activated SCell, and

- *resourceAllocation* = *resourceAllocationType0* and not all bits of a block of the frequency domain resource assignment field associated with the activated SCell in the DCI format 0\_3/1\_3 are equal to 0, or

- *resourceAllocation* = *resourceAllocationType1* and not all bits of a block of the frequency domain resource assignment field associated with the activated SCell in the DCI format 0\_3/1\_3 are equal to 1, or

- *resourceAllocation = dynamicSwitch* and not all bits of a block of the frequency domain resource assignment field associated with the activated SCell in the DCI format 0\_3/1\_3 are equal to either 0 or 1, or

- *useInterlacePUCCH-PUSCH* is provided and not all bits of a block of the frequency domain resource assignment field associated with the serving cell in the DCI format 0\_3 are equal to 1 for $μ=0$ or not all bits of the block are equal to 0 for $μ=1$.

< Unchanged parts are omitted >

Agreement

Draft CR R1-2408973 to TS38.214 is endorsed in principle for alignment CR.

Agreement

Adopt the following TP for Section 5.1.5, TS38.214 in principle for alignment CR.

5.1.5 Antenna ports quasi co-location

< Unchanged parts are omitted >

When a UE supports two TCI states in a codepoint of the DCI field '*Transmission Configuration Indication'* the UE may receive an activation command, as described in clause 6.1.3.24 of [10, TS 38.321], the activation command is used to map up to 8 combinations of one or two TCI states to the codepoints of the DCI field *'Transmission Configuration Indication'*. The UE is not expected to receive more than 8 TCI states in the activation command.

If the UE is provided a set of serving cells by *mc-DCI-SetOfCellsToAddModList-r18*, the UE does not expect to receive an activation command mapping two *TCI-States* and/or two *TCI-UL-States* to only one TCI codepoint, or to be provided *PDCCH-Config* that is associated with two different values of *coresetPoolIndex* for scheduling on a serving cell from the set of serving cells.

When the DCI field *'Transmission Configuration Indication'* is present in DCI format 1\_2 and when the number of codepoints S in the DCI field *'Transmission Configuration Indication'* of DCI format 1\_2 is smaller than the number of TCI codepoints that are activated by the activation command, as described in clause 6.1.3.14, 6.1.3.24 and 6.1.3.47 of [10, TS38.321], only the first S activated codepoints are applied for DCI format 1\_2.

< Unchanged parts are omitted >

For Rel-19 MCE:

Agreement

* For multiple PUSCHs/PDSCHs scheduled on a cell by a DCI format 0\_3/1\_3,
* Common FDRA is applied to the PUSCHs/PDSCHs on the cell as Rel-16/17 multi-PUSCH/PDSCH scheduling.
* Common MCS is applied to the PUSCHs/PDSCHs on the cell as Rel-16/17 multi-PUSCH/PDSCH scheduling.
* HARQ process number indicated for the cell is applied to the first scheduled PUSCH/PDSCH and then incremented by 1 for subsequent PUSCHs/PDSCHs on the cell (with modulo operation if needed) as Rel-16/17 multi-PUSCH/PDSCH scheduling.

Agreement

* In DCI format 0\_3/1\_3, for each block of NDI field, consider the following options:
	+ Option 1: the number of bits is equal to the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.
	+ Option 2: the number of bits is equal to the actual number of scheduled PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3.
	+ Option 3: if the number of scheduled PUSCH/PDSCH is 1, then one bit NDI is applied; otherwise, option 1 is applied.

Agreement

* In DCI format 0\_3/1\_3, for each block of RV field, consider the following options:
	+ Option 1: the number of bits is determined based on the maximum number of schedulable PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.
	+ Option 2: the number of bits is determined based on the actual number of scheduled PUSCHs/PDSCHs on the corresponding cell by the DCI format 0\_3/1\_3 and number of bits for RV configured for the corresponding cell.
	+ Option 3: if the number of scheduled PUSCH/PDSCH is 1, then option 2 is applied; otherwise, option 1 is applied.

Agreement

* A single TDRA field in DCI format 0\_3/1\_3 indicates one row from a joint TDRA table.
* Each row in the table contains only one TDRA index for each BWP of each cell within the set of cells. Each TDRA index points to one or multiple time domain resource allocations in the TDRA table applicable for multi-PUSCH/PDSCH scheduling by DCI format 0\_3/1\_3 for the corresponding cell.

Agreement

* Time domain HARQ-ACK bundling is supported.

Agreement

* Consider at least the case that up to two different SCS can be scheduled by a DCI format 0\_3/1\_3 in Rel-19.
* Consider at least the following cases for scheduled cells in Rel-19:
* Case 1: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed FDD cell(s) with SCS1 and FR1 licensed TDD cell(s) with SCS2.
	+ SCS1 can be same or different to SCS2.
* Case 2: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed FDD cell(s) with SCS1 and FR2-1 cell(s) with SCS2.
	+ SCS1 can be same or different to SCS2.
* Case 3: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed TDD cell(s) with SCS1 and FR2-1 cell(s) with SCS2.
	+ SCS1 can be same or different to SCS2.
* Case 4: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed FDD cell(s) with different SCS.
* Case 5: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR1 licensed TDD cell(s) with different SCS.
* Case 6: A DCI format 0\_3/1\_3 scheduling PUSCHs/PDSCHs on FR2-1 cell(s) with different SCS.