**3GPP TSG RAN WG1 #106bis-e R1-210xxxx**

**e-Meeting, October 11th – 19th, 2021**

**Agenda Item:** 8.2.5

**Source:** Moderator (LG Electronics)

**Title:** Summary #1 of PDSCH/PUSCH enhancements (Scheduling/HARQ)

**Document for:** Discussion and decision

# Introduction

This is the summary document for 8.2.5 on PDSCH/PUSCH enhancements (especially for scheduling and HARQ) for NR above 52.6 GHz, based on the contributions listed in reference section.

The following email thread is assigned for discussion of this topic:

[106bis-e-NR-52-71GHz-06] Email discussion/approval on scheduling particularly w.r.t. multi-PDSCH/PUSCH with a single DCI, HARQ, with checkpoints for agreements on October 14 and 19 – Seonwook (LGE)

# Multi-PDSCH/PUSCH scheduling

## Multi-PDSCH scheduling for 120 kHz

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| Company | Views |
| [1] Huawei | Proposal 6: Confirm the WA that multiple PDSCHs by single DL DCI applies to 120 kHz in addition to 480 and 960 kHz at least in FR2-2. The maximum number of PDSCH that can be scheduled with a single DCI is 8 for SCS of 120、480 and 960 kHz. |
| [13] Ericsson | Proposal 1: Confirm the working assumption that scheduling multiple PDSCHs by single DL DCI applies to 120 kHz in addition to 480 and 960 kHz at least in FR2, with removal of the FFS bullet of further limitations on maximum number of PDSCHs. |
| [23] LG Electronics | Proposal #1: Confirm the following working assumption from RAN1#106-e by removing the FFS point.   * Scheduling multiple PDSCHs by single DL DCI applies to 120 kHz in addition to 480 and 960 kHz at least in FR2-2.   + ~~FFS: Further limitations on maximum number of PDSCHs~~ |
| [26] Qualcomm | Proposal 7: Multi-PDSCH or multi-PUSCH scheduling with the same DCI should be applicable to 120kHz as well as 480 and 960kHz, though we don’t need to introduce multi-slot monitoring capability for 120kHz. |

### Summary on the applicability of 120 kHz SCS for multi-PDSCH scheduling:

Working assumption: (RAN1#106-e)

Scheduling multiple PDSCHs by single DL DCI applies to 120 kHz in addition to 480 and 960 kHz at least in FR2-2.

* FFS: Further limitations on maximum number of PDSCHs

Agreement: (RAN1#106-e)

* The maximum number of PDSCHs/PUSCHs that can be scheduled with a single DCI in Rel-17 is 8 for SCS of 120, 480 and 960 kHz.

[Moderator’s note] At least 3 companies suggest to confirm the above working assumption and to remove FFS based on the agreement made in RAN1#106-e. This issue is indicated as “HIGH” since it can affect the discussion on RRC parameter and UE feature.

### [HIGH] Proposal #2.1 (Support of 120 kHz for multi-PDSCH scheduling):

* Confirm the working assumption from RAN1#106-e with the following modification.

Working assumption: (RAN1#106-e)

Scheduling multiple PDSCHs by single DL DCI applies to 120 kHz in addition to 480 and 960 kHz at least in FR2-2.

* ~~FFS: Further limitations on maximum number of PDSCHs~~

Companies are encouraged to provide views on Proposal #2.1.

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| Company | Views |
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## Handling of collision with semi-static DL/UL/flexible symbols

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| Company | Views |
| [1] Huawei | Proposal 7: If the scheduled PDSCH/PUSCH could be identified invalid between gNB and UE, HARQ process number increment is skipped. For example:   * The scheduled PxSCH resource collides with pre-configured resource like SPS or CG   If the HARQ process number for a scheduled PDSCH/PUSCH collides with the HARQ process number of pre-configured resource like SPS or CG   * HARQ process number increment continues until no such collision happens   If the scheduled PDSCH/PUSCH could not be identified valid or invalid between gNB and UE, HARQ process number increment continues. For example:   * The scheduled PDSCH/PUSCH collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*) and UE is not configured SPS or CG for those flexible symbols.   NACK corresponding to the above cases of scheduled PDSCH should be reported by the UE.  Proposal 8: HARQ process ID indicated in the DCI is corresponding to the first scheduled PDSCH/PUSCH whether the scheduled PDSCH/PUSCH is valid or not. |
| [2] Futurewei | Proposal 9. For the case when scheduled multi-PDSCH/PUSCH collides with UL/DL resources dynamically indicated by DCI format 2\_0, it is recommended that HARQ process number increments for all PDSCH/PUSCHs including the ones that collides with UL/DL symbol(s), but a NACK is reported by the UE corresponding to the collided PDSCH. |
| [4] ZTE | Proposal 1: HARQ process number increment should not be skipped for the PDSCH/PUSCH which collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*) even if the UE is configured to monitor DCI format 2\_0. |
| [7] OPPO | Proposal 4: Clarify whether Rel-15 SFI cancel rule should be followed for multi-PDSCH scheduling.  Proposal 5: HARQ process number increment should be kept for a dynamically dropped PDSCH if Type-1 HARQ-ACK codebook is configured. |
| [8] NEC | Proposal 2: If a UE is scheduled by a DCI format to receive/transmit multiple PDSCHs/PUSCHs over consecutive or non-consecutive slots, and a slot or some slots from the multiple slots are collided with flexible symbols indicated by SFI-index field in DCI format 2\_0, the UE does not receive/transmit the PDSCH/PUSCH in the collision slot(s). |
| [10] CATT | Proposal 6：. When the time domain of the PDSCH scheduled is overlapping with flexible symbols that are defined by high layer message (such as *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*), the HARQ process ID is increased and HARQ-ACK is feedback. |
| [12] Xiaomi | Proposal 5: For multi-slot PDSCH scheduling, the HARQ ID for the PDSCH(s) exceeding the COT is/are still reserved. |
| [13] Ericsson | Proposal 5: If the UE is configured to monitor for DCI format 2\_0 and one of multiple PDSCH/PUSCH(s) scheduled by a single DCI collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*), the HARQ process number increment is not skipped for that PDSCH/PUSCH. |
| [14] Nokia | Proposal 3: Follow Rel-15/16 rules when determining the invalid slot(s) for PDSCH/PUSCH dropping and the corresponding HARQ process number skipping. |
| [16] Samsung | Proposal 9: HARQ process number field in a DCI scheduling multiple PDSCHs/PUSCHs applies to the first valid scheduled PDSCH/PUSCH. |
| [18] Intel | Proposal 4   * If a scheduled PUSCH is dropped due to collision with flexible symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* with SSB transmission, HARQ process number increment is skipped for the PUSCH. * If a scheduled PDSCH/PUSCH is dropped due to collision with UL/DL as indicated by dynamic SFI, UL CI or higher priority indication, HARQ process number increment is continued for the PDSCH/PUSCH. |
| [23] LG Electronics | Proposal #2: If a UE is configured to monitor DCI format 2\_0 and a PDSCH/PUSCH (among multiple PDSCHs/PUSCHs that are scheduled by a single DCI) is collided with flexible symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, HARQ process number increment is applied for the PDSCH/PUSCH.  Proposal #3: If a PDSCH among multiple PDSCHs that are scheduled by a single DCI is collided with uplink symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, NDI/RV fields corresponding to the PDSCH are absent in the DCI.  Proposal #4: If a PUSCH among multiple PUSCHs that are scheduled by a single DCI is collided with downlink symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, NDI/RV fields corresponding to the PUSCH are absent in the DCI.  Proposal #5: Discuss in which PUSCH aperiodic CSI report is included if M-th or (M-1)-th scheduled PUSCH is cancelled due to the collision with semi-static DL symbols. |
| [24] Apple | Proposal 12: For the case where a scheduled PDSCH/PUSCH collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*) if the UE is configured to monitor DCI format 2\_0, increment the HPN in case there is an error in decoding the DCI format. |
| [26] Qualcomm | Proposal 6: The UE always considers the flexible symbols available for PDSCH/PUSCH transmissions scheduled by DCI format 1\_1 or 0\_1. |
| [28] WILUS | Proposal 2: We propose that HARQ process number increment should not be skipped for the scheduled PDSCH(s)/PUSCH(s) which collides with a flexible symbol if the UE is configured to monitor DCI format 2\_0. |

### Issue 2.2-1) How to handle collision between PDSCHs or PUSCHs and semi-static flexible symbols:

Agreement: (RAN1#106-e)

If a scheduled PDSCH/PUSCH is dropped due to collision with UL/DL symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, HARQ process number increment is skipped for the PDSCH/PUSCH and applied only for valid PDSCH(s)/PUSCH(s).

* FFS: HARQ process number determination for the case where a scheduled PDSCH/PUSCH collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*) if the UE is configured to monitor DCI format 2\_0.

Company views on how to handle collision between PDSCHs (or PUSCHs) and semi-static flexible symbols:

* Follow Rel-15/16 SFI rule, i.e., UE assumes semi-static flexible symbols are always available for scheduled PXSCH.
  + Supported by OPPO?, Ericsson, Nokia, Qualcomm
  + Exceptions
    - Huawei: HARQ process number increment is skipped for the PDSCH/PUSCH collided with pre-configured resource like SPS or CG
    - NEC: If a PDSCH/PUSCH is collided with flexible symbols indicated by SFI-index field in DCI format 2\_0, the UE does not receive/transmit the PDSCH/PUSCH in the collision slot(s).
    - Intel: If a PUSCH is collided with semi-static flexible symbols and with SSB transmission, the UE does not receive/transmit the PUSCH.
  + Consequence: HARQ process number increment is not skipped for the PDSCH/PUSCH collided with semi-static flexible symbols
    - Supported by Futurewei, ZTE, CATT, Ericsson, Nokia, LG Electronics, Apple, Qualcomm, WILUS

[Moderator’s note to Issue 2.2-1] It seems straight-forward to follow Rel-16 SFI rule for multiple PDSCHs/PUSCHs scheduled by a single DCI, which implies that UE assumes semi-static flexible symbols are always available for scheduled PDSCHs/PUSCHs. As a result, HARQ process number increment is not skipped for the PDSCH/PUSCH collided with semi-static flexible symbols. On the other hand, several companies suggest some exceptional cases where HARQ process number can be skipped even for the collision with semi-static flexible symbols (e.g., SPS/CG, indicated as flexible by DCI 2\_0, SSB transmission, etc). Those exceptional cases can be discussed based on further comments from suggesting companies.

### [MID] Proposal #2.2-1 (HARQ process numbering):

* For multiple PDSCHs (or PUSCHs) scheduled by a single DCI,
  + UE follows Rel-15/16 behavior that is described in TS 38.213 Clauses 11 and 11.1 for a PDSCH (or PUSCH) indicated by DCI
  + If one of multiple PDSCHs (or PUSCHs) scheduled by the DCI collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*), the HARQ process number increment is not skipped for that PDSCH (or PUSCH).

Companies are encouraged to provide views on Proposal #2.2-1.

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| Company | Views |
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### Issue 2.2-2) How to apply the indicated HARQ process number:

Agreement: (RAN1#104bis-e)

For a DCI that can schedule multiple PDSCHs,

* HARQ process number: This applies to the first scheduled PDSCH and is incremented by 1 for subsequent PDSCHs (with modulo operation, if needed)

Agreement: (RAN1#106-e)

If a scheduled PDSCH/PUSCH is dropped due to collision with UL/DL symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, HARQ process number increment is skipped for the PDSCH/PUSCH and applied only for valid PDSCH(s)/PUSCH(s).

* FFS: HARQ process number determination for the case where a scheduled PDSCH/PUSCH collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*) if the UE is configured to monitor DCI format 2\_0.

Company views on how to apply the indicated HARQ process number:

* Option 1: HARQ process number indicated in the DCI corresponds to the first scheduled PDSCH (or PUSCH) regardless of whether the scheduled PDSCH (or PUSCH) is valid or not.
  + Supported by Huawei
* Option 2: HARQ process number indicated in the DCI corresponds to the first valid scheduled PDSCH (or PUSCH).
  + Supported by Samsung

[Moderator’s note to Issue 2.2-2] To clarify in which PDSCH (or PUSCH) the indicated HARQ process number is applied, two options are identified. Given a small number of inputs, it is encouraged for companies to provide views on the above options, if any.

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## TDMed PDSCHs/PUSCHs in a slot

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| Company | Views |
| [1] Huawei | Proposal 20: For single TRP operation, for 480/960 kHz, UE is not expect to be scheduled with more than one PDSCH/PUSCH in a slot, by a single DCI or multiple DCIs. |
| [2] Futurewei | Proposal 8. For single TRP operation, consider supporting multiple PxSCHs in a slot for 480/960 kHz SCS only if the feature is better motivated for use cases other than URLLC. Multiple PxSCHs in a slot for the multi-TRP case can be allowed. |
| [5] vivo | Proposal 10: Support more than one PDSCH/PUSCH scheduled within a slot by a single or multiple DCIs for 480/960 kHz SCS and single TRP operation. |
| [6] Fujitsu | Proposal 1: For 480/960kHz, support more than one PDSCH/PUSCH in a slot by a single or multiple DCIs. |
| [7] OPPO | Proposal 1: UE is not expected to be scheduled with more than one PDSCHs in a slot by a single DCI or multiple DCIs for 480/960 kHz SCS. |
| [10] CATT | Proposal 4: UE is not expected to configure same k0 for different PDSCHs scheduling, and this is to avoid the situation that more than one PDSCHs are scheduled in a slot by one DCI. |
| [12] Xiaomi | Proposal 3: For single TRP operation, for 480/960 kHz SCS,   * Subject to UE capability, a UE can be scheduled with more than one PDSCH in a slot, by a single DCI or multiple DCIs. * Subject to UE capability, a UE can be scheduled with more than one PUSCH in a slot, by a single DCI or multiple DCIs. |
| [13] Ericsson | Proposal 6: In single TRP operation, for 480 and 960 kHz SCS, a UE does not expect to be scheduled with multiple PDSCHs/PUSCHs in a single slot, regardless multi-PDSCH scheduling is configured or not.  Proposal 7: In multiple TRP operation, for 480 and 960 kHz SCS, a UE does not expect to be scheduled with multiple PDSCHs in a single slot from the same TRP, regardless multi-PDSCH scheduling is configured or not.  Note: this does not preclude a UE being scheduled with two PDSCHs in the same slot from two different TRPs for the multi-DCI based NC-JT scenario. |
| [15] Panasonic | Proposal 2: For single TRP operation, for 480/960 kHz SCS,   * A UE does not expect to be scheduled with more than one PDSCH in a slot, by a single DCI, * A UE does not expect to be scheduled with more than one PUSCH in a slot, by a single DCI. |
| [16] Samsung | Proposal 7: For single TRP operation, for 480/960 kHz SCS, a UE does not expect to be scheduled with more than one PDSCH in a slot, by a single DCI or multiple DCIs. |
| [17] MediaTek | Proposal 8: For 480kHz and 960kHz, support at most one scheduled PDSCH within a slot |
| [18] Intel | Proposal 1   * For NR 52.6-71 GHz, UE can be scheduled with more than one PDSCHs/PUSCHs in a slot for multi-PDSCH/PUSCH scheduling for 120/480/960 kHz SCS.   + More than one SLIVs per slot in a row in TDRA table for multi-PDSCH/PUSCH scheduling are supported. |
| [19] NTT DOCOMO | Proposal 1:  For multi-PUSCH scheduled by single DCI,   * Support single PUSCH repetition scheduling by a DCI format configured with TDRA table which includes more than one SLIVs in at least one row. * CBG based scheduling is not supported when multiple PUSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support frequency hopping for multi-PUSCH scheduling. Newly introduced frequency hopping scheme for multi-PUSCH scheduling can be considered. * Support scheduling more than one PUSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability.   For multi-PDSCH scheduled by single DCI,   * CBG based scheduling is not supported when multiple PDSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support scheduling more than one PDSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability. * For two-TB scheduling, two solutions can be considered to address DCI payload concern:   + Solution 1: Separate parameters to enable 2-TB scheduling for single PDSCH case and multi-PDSCH case.   + Solution 2: 2-TB scheduling can be supported only when the number of scheduled PDSCHs is no more than X (e.g. X=2/4). |
| [22] InterDigital | Proposal 5: Due to short slot duration, it is sufficient to support a single PDSCH per slot, at least for 480, 960 kHz SCS.  Proposal 6: The discussion on whether to allow TDMed PDSCHs/PUSCHs in a slot for multi-TRP operation should be discussed only after discussing the use cases of multi-PDSCH scheduling in multi-TRP operation. |
| [23] LG Electronics | Proposal #9: For single TRP operation, for 480 kHz SCS, a UE can be scheduled up to 2 PDSCHs/PUSCHs in a slot, by a single DCI or multiple DCIs.  Proposal #10: For single TRP operation, for 960 kHz SCS, a UE does not expect to be scheduled with more than one PDSCH in a slot, by a single DCI or multiple DCIs. |
| [24] Apple | Proposal 15: In Rel-17 for NR 52.6-71 GHz, UE does not expect to be scheduled with more than one PDSCHs/PUSCHs in a slot |
| [25] Convida | Proposal 2. To simplify type-1 codebook HARQ-ACK generation in Rel-17, receiving more than one PDSCH for 480/960 KHz in a slot is not considered. |
| [26] Qualcomm | Proposal 18: For single TRP operation, do not allow more than one PDSCH/PUSCH per slot for SCS 480kHz and 960kHz. |
| [27] ITRI | Proposal 1: Multiple PDSCHs scheduled in a slot should be supported for 480/960 kHz SCS considering UE capability. |

### Summary on whether or not to allow TDMed PDSCHs/PUSCHs in a slot:

Agreement: (RAN1#106-e)

* For single TRP operation, for 480/960 kHz SCS,
  + FFS: A UE does not expect to be scheduled with more than one PDSCH in a slot, by a single DCI or multiple DCIs.
  + FFS: A UE does not expect to be scheduled with more than one PUSCH in a slot, by a single DCI or multiple DCIs.
* For single TRP operation, for 120 kHz SCS (same as current specification for FR2-1 for PUSCH),
  + Subject to UE capability, a UE can be scheduled with more than one PDSCH in a slot, by a single DCI or multiple DCIs.
  + Subject to UE capability, a UE can be scheduled with more than one PUSCH in a slot, by a single DCI or multiple DCIs.
* FFS for multi-TRP operation

Company views on whether or not to allow TDMed PDSCHs/PUSCHs in a 480/960 kHz slot, for single TRP:

* Allow TDMed PDSCHs/PUSCHs in a slot
  + Supported by vivo, Fujitsu, Xiaomi, Intel, NTT DOCOMO, ITRI
  + Objected by Huawei, OPPO, CATT, Ericsson, Panasonic, Samsung, MediaTek, InterDigital, Apple, Convida, Qualcomm
  + Futurewei: Support only if the feature is better motivated for use cases other than URLLC
  + LG Electronics: Up to 2 PDSCHs/PUSCHs in a 480 kHz slot, but at most 1 PDSCH/PUSCH in a 960 kHz slot

Company views on whether or not to allow TDMed PDSCHs/PUSCHs in a 480/960 kHz slot, for multi-TRP:

* Allow at most one PDSCH/PUSCH in a slot, per TRP
  + Supported by Futurewei?, Ericsson

[Moderator’s note] 11 companies suggest not to allow TDMed PDSCHs/PUSCHs in a slot but have different views on what conditions to consider. On the other hand, 6 companies suggest to allow TDMed PDSCHs/PUSCHs in a slot, as in Rel-15/16 NR. Considering the majority view, we can go with disallowing TDMed PDSCHs/PUSCHs in a slot, but if it cannot be converged, we may consider the middle ground solution such as allowing up to 2 PDSCHs/PUSCHs in a 480 kHz slot but at most 1 PDSCH/PUSCH in a 960 kHz slot (in order to support the same level of the TDM capability with 120 kHz). For multi-TRP case, we can discuss once single TRP case is settled down.

### [MID] Proposal #2.3 (TDMed PDSCHs/PUSCHs in a slot):

* For single TRP operation, for 480/960 kHz SCS,
  + A UE does not expect to be scheduled with more than one PDSCH in a slot, by a single DCI or multiple DCIs.
  + A UE does not expect to be scheduled with more than one PUSCH in a slot, by a single DCI or multiple DCIs.

Companies are encouraged to provide views on Proposal #2.3. If this is not acceptable, **please provide your views on allowing up to 2 PDSCHs/PUSCHs in a 480 kHz slot, but at most 1 PDSCH/PUSCH in a 960 kHz slot, as a compromise.**

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## 2-TB transmission

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| Company | Views |
| [1] Huawei | Proposal 9: Support scheduling 2nd TB for multi-slot PDSCH/PUSCH scheduling. MCS for the 2nd TB is applied commonly to all the scheduled PDSCHs/PUSCHs, even if the number of layers is less than 5. NDI and RV are indicated individually for each scheduled PDSCH/PUSCH. |
| [3] Spreadtrum | Proposal 4: Confirm the working assumption to support to indicate the MCS/NDI/RV for the 2nd TB for multi-PDSCH scheduling. |
| [4] ZTE | Proposal 2: To minimize the increase in the number of bits in the DCI, signaling of MCS/NDI/RV for the second TB can reuse the signaling of MCS/NDI/RV for the first TB in a DCI that can schedule multiple PDSCHs when two codeword transmission is enabled. |
| [7] OPPO | Proposal 3: If two TBs is supported when more than one PDSCHs are scheduled, no enhancement is needed on signaling overhead. |
| [13] Ericsson | Proposal 14: For a DCI that can schedule multiple PDSCHs, if the MCS/NDI/RV fields for the second TB is present in the DCI, they are signalled in the same way as for the corresponding fields for the first TB.  Proposal 15: Reuse the legacy RRC configuration parameter (*maxNrofCodeWordsScheduledByDCI*) to enable/disable 2-TB transmission for multi-PDSCH scheduling in Rel-17. |
| [14] Nokia | Proposal 4: For a DCI that can schedule multiple PDSCH, MCS/NDI/RV fields for the 2nd TB are present only if the RRC parameter indicates that two CW transmission is enabled   * The same RRC parameter adjusts MCS/NDI/RV fields for both single and multiple PDSCH scheduling * The signalling details are up-to RAN2 to decide. |
| [16] Samsung | Proposal 6: If two codeword transmission is supported for FR2-2, the maximum number of SLIVs in a TDRA table in a DCI format scheduling multi-PDSCH is limited to 2.  Proposal 13: For multi-PDSCH scheduling, the bit field common for DL and UL grant use the same design as multi-PUSCH scheduling, and at least following DL-specific bit field should be specified,   * Single MCS for 2nd TBs for all PDSCHs and separate 1-bit NDI/1-bit RV for 2nd TB for each PDSCH if the working assumption on two codeword transmission for FR2-2 is confirmed * CBG-based transmission is not applicable to single and multi-PDSCH scheduling * HARQ-ACK relevant bit field is applicable to all PDSCHs and single PUCCH |
| [18] Intel | Proposal 3  For multi-PDSCH scheduling   * For 2nd TB, separate MCS, NDI and RV are signaled from 1st TB. * For 2nd TB, similar mechanisms for signaling of MCS, NDI and RV for 1st TB are reused. |
| [19] NTT DOCOMO | Proposal 1:  For multi-PUSCH scheduled by single DCI,   * Support single PUSCH repetition scheduling by a DCI format configured with TDRA table which includes more than one SLIVs in at least one row. * CBG based scheduling is not supported when multiple PUSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support frequency hopping for multi-PUSCH scheduling. Newly introduced frequency hopping scheme for multi-PUSCH scheduling can be considered. * Support scheduling more than one PUSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability.   For multi-PDSCH scheduled by single DCI,   * CBG based scheduling is not supported when multiple PDSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support scheduling more than one PDSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability. * For two-TB scheduling, two solutions can be considered to address DCI payload concern:   + Solution 1: Separate parameters to enable 2-TB scheduling for single PDSCH case and multi-PDSCH case.   + Solution 2: 2-TB scheduling can be supported only when the number of scheduled PDSCHs is no more than X (e.g. X=2/4). |
| [22] InterDigital | Observation 7: Reuse as many parameters indicated across multiple PDSCHs to minimize the increase in the number of bits in the DCI needed for supporting 2nd CW when multiple PDSCHs are scheduled by a single DCI.  Proposal 16: For the second CW in a DCI that can schedule multiple PDSCHs when two CW transmission is enabled, follow a similar mechanism used for indicating MCS/NDI and RV.   * MCS for the 2nd CW: This appears only once in the DCI and applies commonly to the second CW of each PDSCH * NDI for the 2nd CW: This is signaled per PDSCH and applies to the second CW of each PDSCH * RV for the 2nd CW: This is signaled per PDSCH, with 2 bits if only a single PDSCH is scheduled or 1 bit for each PDSCH otherwise and applies to the second CW of each PDSCH   Proposal 17: Use the same RRC parameter for both single-PDSCH case and multi-PUSCH case to enable/disable 2nd CW. |
| [23] LG Electronics | Proposal #11: For multi-PDSCH scheduling with a single DCI,   * MCS for the 2nd TB: This appears only once in the DCI and applies commonly to the second TB of each PDSCH. * NDI: For 2-TB case, this can be signalled per TB. Alternatively, NDI per TB for up to N-scheduled PDSCHs and TB-common NDI for more than N-scheduled PDSCHs (e.g., N=1) can be considered to minimize DCI overhead. * RV: For 2-TB case, 2 bit RV per PDSCH (i.e, TB-common RV) for up to N-scheduled PDSCHs and TB-common 1 bit RV for more than N-scheduled PDSCHs (N=1) can be considered to keep the number of bits allocated for RV the same as for single TB case. |
| [24] Apple | Proposal 14: For multi-PDSCH scheduling with a single DCI the following fields are signaled:   * Per DCI: FDRA, 2nd MCS, HARQ\_process\_number (with adjustment based on CG HPN), and VRB-to-PRB mapping, PRB bundling size and ZP CSI-RS trigger * Per PUSCH: TDRA-K0, 2nd NDI, 2nd RV, rate matching indicator, * FFS: C-DAI, Downlink T-DAI, and PRI. |
| [26] Qualcomm | Proposal 14: To indicate that the second TB is disabled for a certain DCI that schedules multiple PDSCHs, use a combination of MCS and rvid such that rvid bit of PDCSH i-1 is the complement of the one of PDSCH i for i=1 : number of maximum PDSCHs -1. |

### Summary on 2-TB transmission:

Working assumption: (RAN1#106-e)

For NR FR2-2, two codeword transmission is supported, subject to UE capability.

* RRC parameter configures whether two codeword transmission is enabled or disabled.
  + FFS: Details on signaling of MCS/NDI/RV for the second TB in a DCI that can schedule multiple PDSCHs when two codeword transmission is enabled
  + FFS: Whether unified or separate parameter to enable/disable 2-TB for single and for multiple PDSCH scheduling
  + Strive to minimize the increase in the number of bits in the DCI needed to support this feature

Company views on detailed design for multi-PDSCH scheduling DCI when 2-TB transmission is enabled:

* Confirm the working assumption
  + Supported by Spreadtrum
* Reuse the rule for signalling MCS/NDI/RV, as defined for single TB scheduling
  + Supported by Huawei, OPPO, Ericsson, Nokia, Samsung, Intel, InterDigital
  + ZTE: Signaling of MCS/NDI/RV for the 2nd TB can reuse the signaling of MCS/NDI/RV for the 1st TB
  + LG Electronics: TB-common NDI or RV
* Huawei: 2-TB can be enabled even if the number of layers is less than 5.
* Samsung: Maximum number of SLIVs in a TDRA table in the DCI is limited to 2.
* NTT DOCOMO: Separate parameters to enable 2-TB scheduling for single PDSCH case and multi-PDSCH case, alternatively, 2-TB scheduling can be supported only when the number of scheduled PDSCHs is no more than X (e.g. X=2/4).

[Moderator’s note] Based on company views, majority companies suggest to reuse the signaling of MCS/NDI/RV as defined for the case of single TB. Therefore, the following proposal #2.4 can be made. Further restrictions as suggested from Samsung and NTT DOCOMO can be discussed based on additional comments from them. This issue is indicated as “HIGH” since it is vital to confirm the previous working assumption.

### [HIGH] Proposal #2.4 (2-TB TX):

* For a DCI that can schedule multiple PDSCHs, and if RRC parameter configures that two codeword transmission is enabled,
  + MCS: Two MCS values are signalled. One value is applied commonly to the first codeword of each PDSCH and the other is applied commonly to the second codeword of each PDSCH.
  + NDI: This is signaled per codeword and applies to each codeword of scheduled PDSCH(s).
  + RV: This is signaled per codeword, with 2 bits for each codeword if only a single PDSCH is scheduled or 1 bit for each codeword of scheduled PDSCHs otherwise

Companies are encouraged to provide views on Proposal #2.4.

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## SPS/CG-related issues

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| Company | Views |
| [1] Huawei | Proposal 7: If the scheduled PDSCH/PUSCH could be identified invalid between gNB and UE, HARQ process number increment is skipped. For example:   * The scheduled PxSCH resource collides with pre-configured resource like SPS or CG   If the HARQ process number for a scheduled PDSCH/PUSCH collides with the HARQ process number of pre-configured resource like SPS or CG   * HARQ process number increment continues until no such collision happens   If the scheduled PDSCH/PUSCH could not be identified valid or invalid between gNB and UE, HARQ process number increment continues. For example:   * The scheduled PDSCH/PUSCH collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommo*n or *tdd-UL-DL-ConfigurationDedicated*) and UE is not configured SPS or CG for those flexible symbols.   NACK corresponding to the above cases of scheduled PDSCH should be reported by the UE. |
| [6] Fujitsu | Proposal 4: For SPS activation/retransmission via DCI format 1\_1, the following 2 options can be considered, and Option 1 is slightly preferred for more flexibility.   * Option 1: If the DCI can schedule multiple PDSCHs, the SPS activation/retransmission is triggered/scheduled by the last SLIV of the row of TDRA table indicated by the DCI. * Option 2: If the DCI can schedule multiple PDSCHs, the DCI shall indicate a row of TDRA table with a single SLIV for SPS activation/retransmission. |
| [10] CATT | Proposal 7: For special HARQ process ID that is assigned to SPS PDSCH by RRC, UE shall skip these occupied SPS HARQ process ID when the dynamic scheduling overlaps with these ID.  Proposal 11: when the DCI format 1\_1 SPS PDSCH release or SCell dormancy indication without scheduled PDSCH, the count C-DAI/T-DAI as single PDSCH scheduling and only feedback 1 bit HARQ-ACK, the UE compute PUCCH slot carrying the HARQ-ACK based on slot position of first scheduled PDSCH. |
| [11] CATT | Observation 1: To activate a SPS PDSCH configuration by multiple PDSCHs scheduling, one TDRA (Time Domain Resource Assignments) including SLIV and K0 is needed to be selected.  Proposal 1: When one SPS configuration is activated by a DCI which schedules multiple PDSCHs:   * The first valid PDSCH scheduled is used for the SPS PDSCH * K1 is counted from the first PDSCH slot   Proposal 2: When one SPS configuration is released by a DCI which schedules multiple PDSCHs:   * The first valid PDSCH scheduled is used for the SPS PDSCH * K1 is counted from the first PDSCH slot   Proposal 3: More than one SPS configurations can be defined in a list by RRC. And more than one SPS configurations in one list can be activated or released by a DCI that schedules multiple PDSCHs.  Proposal 4: For some special HARQ process ID（e.g. ID assigned to SPS PDSCH by RRC）, UE shall skip occupied HARQ process ID of SPS when the dynamic scheduling overlaps with these process ID. |
| [16] Samsung | Observation 5: SPS PDSCH reception has large scheduling restriction on multi-PDSCH scheduling.  Proposal 11: UE is not expected to receive a SPS PDSCH if the SPS PDSCH is configured to be received between a PDCCH with a DCI scheduling multiple PDSCHs and the last PDSCH scheduled by the DCI.  Proposal 12: If a CG PUSCH is configured to be transmitted between the first scheduled PUSCH and the last scheduled PUSCH by a single DCI scheduling multiple PUSCHs, HARQ process number increment is skipped for the HARQ ID used for the CG PUSCH when determining the HARQ ID of the multiple scheduled PUSCHs.  Proposal 14: For a DCI capable of scheduling multi-PDSCH/PUSCHs, gNB can only indicate a row with single SLIV for SPS PDSCH/CG PUSCH activation. |
| [18] Intel | Proposal 5   * A HARQ process number configured for SPS PDSCH/CG PUSCH can be allocated to a PDSCH/PUSCH of multi-PDSCH/PUSCH scheduling, as long as the timeline is met. |
| [23] LG Electronics | Proposal #8: Discuss whether/how to handle the case where a DCI that can schedule multiple PDSCHs (or PUSCHs) (de)activates SPS PDSCH (or CG PUSCH) and indicates a row index of the TDRA table associated with multiple SLIVs. |
| [24] Apple | Proposal 10: For Rel-17 multi-PUSCH transmission   * The maximum number of PUSCHs that can be scheduled for 120 kHz and 480 kHz SCS can be further restricted based on UE capabilities. * For 480 kHz and 960 kHz SCS, no support for CBGTI field configuration in the DCI that can schedule multiple PUSCHs * The FDRA size should be optimized to reduce the FDRA overhead. * Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz * Define UE behaviour in a scenario where a CG resource lies between the resources of the first and last PUSCH transmission   + Modify the HPN of the DG PUSCH transmissions to account for the HPN of the CG PUSCH in the case that it is transmitted   Proposal 11: For multi-PUSCH scheduling with a single DCI the following fields are signaled:   * Per DCI: FDRA, HARQ\_process\_number (with adjustment based on CG HPN) |

### Issue 2.5-1) How to handle HARQ process number when it collides with that assigned for SPS or CG:

Company views on how to handle HARQ process number when it collides with that assigned for SPS or CG:

* Option 1-1: Skip HARQ process number(s) pre-configured for SPS or CG when HARQ process numbers for PDSCHs (or PUSCHs) scheduled by a single DCI collide with HARQ process number(s) configured for SPS PDSCH (or CG PUSCH).
  + Supported by Huawei, CATT
* Option 1-2: Skip HARQ process number(s) pre-configured for SPS or CG when any of scheduled PDSCHs (or PUSCHs) is overlapped with an SPS PDSCH (or CG PUSCH), and when HARQ process numbers for PDSCHs (or PUSCHs) scheduled by a single DCI collide with HARQ process number(s) configured for the SPS PDSCH (or CG PUSCH).
  + Supported by Samsung, Apple?
* Option 2: HARQ process number configured for SPS PDSCH (or CG PUSCH) can be allocated to a PDSCH (or PUSCH) of multi-PDSCH (or multi-PUSCH) scheduling, as long as the timeline (PUSCH cancellation time) is met.
  + Supported by Intel

[Moderator’s note to Issue 2.5-1] Given a small number of inputs, it is encouraged for companies to provide views on the above options, if any.

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### Issue 2.5-2) (De)activation of SPS (or CG) by using multi-PDSCH (or multi-PUCH) scheduling DCI:

Company views on the issue for (de)activation of SPS (or CG) by using multi-PDSCH (or multi-PUCH) scheduling DCI:

* Option 1: Allow only single SLIV-based (de)activation
  + Supported by Fujitsu, Samsung
* Option 2: Based on the last (valid) SLIV
  + Supported by Fujitsu
* Option 3: Based on the first (valid) SLIV
  + Supported by CATT

[Moderator’s note to Issue 2.5-2] Given a small number of inputs, it is encouraged for companies to provide views on the above options, if any.

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## Out-of-order handling

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| Company | Views |
| [8] NEC | Figure 2.    Figure 3.  Proposal 1: For a UE can be scheduled with more than one PDSCH/PUSCH in a slot by multiple DCIs, the in-order scheduling need to be clarified. |
| [10] CATT | Figure 3: the scenarios on out of order scheduling for multiple PDSCHs  Proposal 9: For scheduling multiple PDSCHs, out of order scheduling is not supported. |
| [16] Samsung | Observation 5: SPS PDSCH reception has large scheduling restriction on multi-PDSCH scheduling.  Proposal 11: UE is not expected to receive a SPS PDSCH if the SPS PDSCH is configured to be received between a PDCCH with a DCI scheduling multiple PDSCHs and the last PDSCH scheduled by the DCI. |
| [17] MediaTek | Proposal 9: For multi-PDSCH/PUSCH scheduling, UE doesn’t expect any of the scheduled PDSCHs and the scheduling DCI lead to out-of-order scheduling.  Proposal 10: For multi-PDSCH scheduling, UE doesn’t expect any of the scheduled PDSCHs and the resource for the HARQ-ACK transmission lead to out-of-order scheduling. |
| [18] Intel | Figure 2. Relative timing between two PDCCHs and the scheduled PDSCHs  Proposal 8  For the relative timing among two PDCCHs and the scheduled PDSCHs/PUSCHs, referring to Figure 2,   * Case A/C are valid; * Case B/D/E are invalid. |

### Issue 2.6-1) DCI-to-data out-of-order issue:

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| TS 38.214  For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start receiving a first PDSCH starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to receive a PDSCH starting earlier than the end of the first PDSCH with a PDCCH that ends later than symbol *i*.  …  For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH that ends later than symbol *i*. |

Company views on DCI-to-data out-of-order issue:

* For multi-PDSCH/PUSCH scheduling, UE doesn’t expect any of the scheduled PDSCHs and the scheduling DCI lead to out-of-order scheduling.
  + Supported by NEC?, CATT, MediaTek, Intel

[Moderator’s note to Issue 2.6-1] Given a small number of inputs, it is encouraged for companies to provide views on the above proposal, if any.

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### Issue 2.6-2) PDSCH-to-HARQ-ACK out-of-order issue:

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| TS 38.214  In a given scheduled cell, the UE is not expected to receive a first PDSCH in slot *i*, with the corresponding HARQ-ACK assigned to be transmitted in slot *j*, and a second PDSCH starting later than the first PDSCH with its corresponding HARQ-ACK assigned to be transmitted in a slot before slot *j*. |

Company views on DCI-to-data out-of-order issue:

* UE is not expected to receive a SPS PDSCH if the SPS PDSCH is configured to be received between a PDCCH with a DCI scheduling multiple PDSCHs and the last PDSCH scheduled by the DCI.
  + Supported by Samsung
* For multi-PDSCH scheduling, UE doesn’t expect any of the scheduled PDSCHs and the resource for the HARQ-ACK transmission lead to out-of-order scheduling.
  + Supported by MediaTek

[Moderator’s note to Issue 2.6-2] Given a small number of inputs, it is encouraged for companies to provide views on the above proposals, if any.

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## CBG-based (re)transmission

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| Company | Views |
| [1] Huawei | Proposal 10: CBGTI is not present if multi-PDSCHs is scheduled among a TDRA table including at least one row with multiple SLIVs. |
| [3] Spreadtrum | Proposal 2: CBG (re)transmission should not be supported when more than one PDSCHs/PUSCHs are scheduled. |
| [5] vivo | Proposal 12: For CBG based scheduling, the same behaviour for multi-PUSCH scheduling with 120 kHz SCS is applied to 480/960 kHz SCS as well, i.e., CBG based scheduling is supported only when a DCI schedules a single PUSCH. |
| [7] OPPO | Proposal 2: CBG-based (re)transmission can be configured when one PUSCH/PDSCH is scheduled for 120/480/960 kHz SCS. |
| [13] Ericsson | Proposal 11: The discussion on whether to support CBG-based transmission for multi-PDSCH scheduling should be postponed until the on-going discussion on sub-codebook design for dynamic HARQ-ACK codebook enhancement is concluded.  Proposal 12: For 480/960 kHz SCS, for a DCI that can schedule single and/or multiple PUSCHs, configuration of CBG-based (re)-transmission is not supported, and thus the CBGTI and CBGFI fields are not present. |
| [15] Panasonic | Proposal 3: For SCSs of 480 kHz and 960 kHz, for a DCI that can schedule multiple PUSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs,   * If CBG-based (re)transmission is configured, CBGTI field is not present when more than one PUSCHs are scheduled, but is present when a single PUSCH is scheduled, as in Rel-16.   Proposal 4: For SCSs of 120 kHz, 480 kHz, and 960 kHz, for a DCI that can schedule multiple PDSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs,   * If CBG-based (re)transmission is configured, CBGTI/CBGFI fields are not present when more than one PDSCHs are scheduled, but are present when a single PUSCH is scheduled, as in Rel-16. |
| [16] Samsung | Proposal 8: For multi-PUSCH scheduling DCI:   * CBG:   + Not support CBG-based transmission for single and multi-PUSCH scheduling for 480/960 KHz.   + Not support CBG-based transmission for multi-PUSCH scheduling for 120KHz, but applicable for single-PUSCH scheduling for 120KHz. * Frequency hopping: Support intra-PUSCH hopping * FDRA: Support increased RBG size using the same mechanism introduced in Rel-16 URLLC   Proposal 13: For multi-PDSCH scheduling, the bit field common for DL and UL grant use the same design as multi-PUSCH scheduling, and at least following DL-specific bit field should be specified,   * Single MCS for 2nd TBs for all PDSCHs and separate 1-bit NDI/1-bit RV for 2nd TB for each PDSCH if the working assumption on two codeword transmission for FR2-2 is confirmed * CBG-based transmission is not applicable to single and multi-PDSCH scheduling * HARQ-ACK relevant bit field is applicable to all PDSCHs and single PUCCH |
| [17] MediaTek | Proposal 5: CBG (re)transmission feature for 480kHz and 960kHz is not supported in FR2-2.  Proposal 11: To improve gNB scheduling flexibility, reinterpret CGBTI field to indicate which scheduled PDSCHs corresponding to a DCI are transmitted/retransmitted. |
| [18] Intel | Proposal 2   * For multi-PDSCH/PUSCH scheduling, CBG based transmission is supported for 120/480/960kHz subcarrier spacing when a single PDSCH/PUSCH is scheduled. |
| [19] NTT DOCOMO | Proposal 1:  For multi-PUSCH scheduled by single DCI,   * Support single PUSCH repetition scheduling by a DCI format configured with TDRA table which includes more than one SLIVs in at least one row. * CBG based scheduling is not supported when multiple PUSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support frequency hopping for multi-PUSCH scheduling. Newly introduced frequency hopping scheme for multi-PUSCH scheduling can be considered. * Support scheduling more than one PUSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability.   For multi-PDSCH scheduled by single DCI,   * CBG based scheduling is not supported when multiple PDSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support scheduling more than one PDSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability. * For two-TB scheduling, two solutions can be considered to address DCI payload concern:   + Solution 1: Separate parameters to enable 2-TB scheduling for single PDSCH case and multi-PDSCH case.   + Solution 2: 2-TB scheduling can be supported only when the number of scheduled PDSCHs is no more than X (e.g. X=2/4). |
| [21] Lenovo | Proposal 4: For NR operation between 52.6 GHz and 71 GHz, when multiple PDSCHs/PUSCHs can be scheduled by a single DCI, Rel-16 behavior defined for multiple PUSCH scheduling should be adopted for 480kHz and 960kHz as well for both PDSCH and PUSCH i.e., if CBG-based (re)transmission is configured, CBGTI field (and CBGFI in case of PDSCH) is not present when more than one PDSCHs/PUSCHs are scheduled, but is present when a single PDSCH/PUSCH is scheduled |
| [22] InterDigital | Proposal 8: For 480/960 kHz SCS, apply the same behavior of 120 kHz SCS for CBGTI field configuration in the DCI that can schedule multiple PUSCHs, i.e., if CBG-based (re)transmission is configured, CBGTI field is not present when more than one PUSCHs are scheduled, but is present when a single PUSCH is scheduled, as in Rel-16.  Proposal 9: The same behavior of multi PUSCH could be applied for CBGTI/CBGFI fields when a DCI schedule multiple PDSCHs, i.e., CBGTI/CBGFI fields are not present if multiple PDSCHs are scheduled, but present if only one PDSCH is scheduled. |
| [23] LG Electronics | Proposal #6: Support CBG-based (re)transmission for 480/960 kHz SCS, subject to optional UE capability.  Proposal #7: For multi-PDSCH (or multi-PUSCH) scheduling DCI, if CBG-based (re)transmission is configured, CBG-related field(s) is not present when more than one PDSCH (or PUSCH) are scheduled, but is present when a single PDSCH (or PUSCH) is scheduled, for all SCSs. |
| [24] Apple | Proposal 10: For Rel-17 multi-PUSCH transmission   * The maximum number of PUSCHs that can be scheduled for 120 kHz and 480 kHz SCS can be further restricted based on UE capabilities. * For 480 kHz and 960 kHz SCS, no support for CBGTI field configuration in the DCI that can schedule multiple PUSCHs * The FDRA size should be optimized to reduce the FDRA overhead. * Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz * • Define UE behaviour in a scenario where a CG resource lies between the resources of the first and last PUSCH transmission   + Modify the HPN of the DG PUSCH transmissions to account for the HPN of the CG PUSCH in the case that it is transmitted   Proposal 13: For Rel-17 multi-PDSCH transmission   * The maximum number of PDSCHs that can be scheduled for 120 kHz and 480 kHz SCS can be further restricted based on UE capabilities. * For a DCI that can schedule multiple PDSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs, do not support/configure CBGTI/CBGFI fields * The FDRA size should be optimized to reduce the FDRA overhead. * Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz * New signaling is be needed for the PRI and DAI to support HARQ compared with multi-PUSCH transmission. |

### Summary on CBG-based (re)transmission:

Agreement: (RAN1#105-e)

* At least for 120 kHz SCS, for a DCI that can schedule multiple PUSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs,
  + If CBG-based (re)transmission is configured, CBGTI field is not present when more than one PUSCHs are scheduled, but is present when a single PUSCH is scheduled, as in Rel-16.
* FFS:
  + For 480/960 kHz SCS, whether to apply the same behavior with 120 kHz SCS or not to support CBGTI field configuration in the DCI that can schedule multiple PUSCHs
  + For a DCI that can schedule multiple PDSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs, whether/how to configure CBGTI/CBGFI fields

Company views on CBGTI/CBGFI field in multi-PDSCH/PUSCH scheduling DCI:

* Same behaviour for all SCSs as in Rel-16
  + Supported by Huawei?, vivo, OPPO, Panasonic, Intel, NTT DOCOMO, Lenovo, InterDigital, LG Electronics
* Do not support CBGTI/CBGFI field configuration for multi-PDSCH/PUSCH scheduling DCI for 480/960 kHz
  + Supported by Spreadtrum, Ericsson, Samsung, MediaTek, Apple

[Moderator’s note] Since this is tightly correlated with the discussion in Section 3.4, it is proposed to postpone this discussion until the discussion in Section 3.4 is concluded.

Please feel free to express views on Moderator’s note, if any.

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## Frequency hopping

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| Company | Views |
| [3] Spreadtrum | Proposal 1: Frequency hopping should be supported for scheduled PUSCH. |
| [5] vivo | Proposal 13: For frequency hopping for multi-PUSCH scheduling, only intra-slot frequency hopping is applicable, and is applied to each scheduled PUSCH when configured and enabled, while inter-slot frequency hopping is inapplicable. |
| [12] Xiaomi | Proposal 9: Support to study intra-TTI frequency hopping and its enabling mechanism for multi-TTI scheduling. |
| [13] Ericsson | Observation 2: For multi-PUSCH scheduling in Rel-17, frequency hopping is beneficial to achieve frequency diversity for some use cases, even in unlicensed spectrum, and hence should not be precluded.  Proposal 13: After the aforementioned ambiguity is resolved in the Rel-16 maintenance WI, frequency hopping schemes for multi-PUSCH scheduling in Rel-16 should be carried over to multi-PUSCH scheduling in Rel-17. |
| [14] Nokia | Proposal 5: For other multi-PxSCH enhancements:   * No FDRA enhancements for multi-PxSCH * Intra-slot frequency hopping (if configured) applies to both single PUSCH and multiple PUSCH transmission. |
| [16] Samsung | Proposal 8: For multi-PUSCH scheduling DCI:   * CBG:   + Not support CBG-based transmission for single and multi-PUSCH scheduling for 480/960 KHz.   + Not support CBG-based transmission for multi-PUSCH scheduling for 120KHz, but applicable for single-PUSCH scheduling for 120KHz. * Frequency hopping: Support intra-PUSCH hopping * FDRA: Support increased RBG size using the same mechanism introduced in Rel-16 URLLC |
| [18] Intel | Proposal 6  For multi-PUSCH scheduling,   * Support intra-slot frequency hopping for scheduled PUSCHs. * Do not support enhancement on FDRA. |
| [19] NTT DOCOMO | Proposal 1:  For multi-PUSCH scheduled by single DCI,   * Support single PUSCH repetition scheduling by a DCI format configured with TDRA table which includes more than one SLIVs in at least one row. * CBG based scheduling is not supported when multiple PUSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support frequency hopping for multi-PUSCH scheduling. Newly introduced frequency hopping scheme for multi-PUSCH scheduling can be considered. * Support scheduling more than one PUSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability.   For multi-PDSCH scheduled by single DCI,   * CBG based scheduling is not supported when multiple PDSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support scheduling more than one PDSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability. * For two-TB scheduling, two solutions can be considered to address DCI payload concern:   + Solution 1: Separate parameters to enable 2-TB scheduling for single PDSCH case and multi-PDSCH case.   + Solution 2: 2-TB scheduling can be supported only when the number of scheduled PDSCHs is no more than X (e.g. X=2/4). |
| [22] InterDigital | Proposal 19: When multiple PUSCHs are scheduled using the same DCI, support only intra-slot frequency hopping |
| [24] Apple | Proposal 10: For Rel-17 multi-PUSCH transmission   * The maximum number of PUSCHs that can be scheduled for 120 kHz and 480 kHz SCS can be further restricted based on UE capabilities. * For 480 kHz and 960 kHz SCS, no support for CBGTI field configuration in the DCI that can schedule multiple PUSCHs * The FDRA size should be optimized to reduce the FDRA overhead. * Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz * • Define UE behaviour in a scenario where a CG resource lies between the resources of the first and last PUSCH transmission   + Modify the HPN of the DG PUSCH transmissions to account for the HPN of the CG PUSCH in the case that it is transmitted |
| [26] Qualcomm | Proposal 15: Consider the impact of RF retuning delay on the frequency hopping when operating over larger SCS   * Frequency hopping discussion can be deprioritized |

[Moderator’s note] Considering that the clarification on frequency hopping for multi-PUSCH scheduling in Rel-16 is being discussed in Rel-16 NR-U maintenance, it is proposed to discuss this issue once a conclusion will be drawn from Rel-16 discussion and to deprioritize this issue in this meeting.

Please feel free to express views on Moderator’s note, if any.

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## FDRA enhancement

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| Company | Views |
| [3] Spreadtrum | Proposal 3: Apply same method rule compared to Rel-16 NR-U for FDRA. |
| [5] vivo | Proposal 11: Legacy frequency domain scheduling in NR Rel-15/16 is reused for multi-PUSCH/PDSCH scheduling. |
| [12] Xiaomi | Observation 1: The current DCI 0-2/1-2 can be reused to allow frequency domain resource by multi-PRB granularity. |
| [13] Ericsson | Proposal 9: Introduce new RBG configuration for PDSCH/PUSCH frequency resource allocation Type 0 to reduce FDRA granularity and DCI size.  Proposal 10: Support configurable Resource Allocation Granularity (P) up to 32 for DCI Format 0\_1 and 1\_1 with PUSCH/PDSCH frequency resource allocation Type 1 to reduce FDRA granularity and DCI size. |
| [14] Nokia | Proposal 5: For other multi-PxSCH enhancements:   * No FDRA enhancements for multi-PxSCH * Intra-slot frequency hopping (if configured) applies to both single PUSCH and multiple PUSCH transmission. |
| [15] Panasonic | Proposal 5: No need to have the optimization of FDRA size. |
| [16] Samsung | Proposal 8: For multi-PUSCH scheduling DCI:   * CBG:   + Not support CBG-based transmission for single and multi-PUSCH scheduling for 480/960 KHz.   + Not support CBG-based transmission for multi-PUSCH scheduling for 120KHz, but applicable for single-PUSCH scheduling for 120KHz. * Frequency hopping: Support intra-PUSCH hopping * FDRA: Support increased RBG size using the same mechanism introduced in Rel-16 URLLC |
| [18] Intel | Proposal 6  For multi-PUSCH scheduling,   * Support intra-slot frequency hopping for scheduled PUSCHs. * Do not support enhancement on FDRA. |
| [19] NTT DOCOMO | Proposal 1:  For multi-PUSCH scheduled by single DCI,   * Support single PUSCH repetition scheduling by a DCI format configured with TDRA table which includes more than one SLIVs in at least one row. * CBG based scheduling is not supported when multiple PUSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support frequency hopping for multi-PUSCH scheduling. Newly introduced frequency hopping scheme for multi-PUSCH scheduling can be considered. * Support scheduling more than one PUSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability.   For multi-PDSCH scheduled by single DCI,   * CBG based scheduling is not supported when multiple PDSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support scheduling more than one PDSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability. * For two-TB scheduling, two solutions can be considered to address DCI payload concern:   + Solution 1: Separate parameters to enable 2-TB scheduling for single PDSCH case and multi-PDSCH case.   + Solution 2: 2-TB scheduling can be supported only when the number of scheduled PDSCHs is no more than X (e.g. X=2/4). |
| [22] InterDigital | Observation 8: It is observed that required payloads of DCI for frequency domain resource allocation do not increase as maximum number of RBs does not increase.  Observation 9: Larger RB size reduces frequency domain resource allocation flexibility, and this may be a crucial disadvantage as higher SCSs occupies larger bandwidths than lower SCSs with the same RBG size.  Proposal 20: The benefits from frequency domain resource allocation enhancements should be carefully evaluated. |
| [24] Apple | Proposal 10: For Rel-17 multi-PUSCH transmission   * The maximum number of PUSCHs that can be scheduled for 120 kHz and 480 kHz SCS can be further restricted based on UE capabilities. * For 480 kHz and 960 kHz SCS, no support for CBGTI field configuration in the DCI that can schedule multiple PUSCHs * The FDRA size should be optimized to reduce the FDRA overhead. * Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz * • Define UE behaviour in a scenario where a CG resource lies between the resources of the first and last PUSCH transmission   + Modify the HPN of the DG PUSCH transmissions to account for the HPN of the CG PUSCH in the case that it is transmitted   Proposal 13: For Rel-17 multi-PDSCH transmission   * The maximum number of PDSCHs that can be scheduled for 120 kHz and 480 kHz SCS can be further restricted based on UE capabilities. * For a DCI that can schedule multiple PDSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs, do not support/configure CBGTI/CBGFI fields * The FDRA size should be optimized to reduce the FDRA overhead. * Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz * New signaling is be needed for the PRI and DAI to support HARQ compared with multi-PUSCH transmission. |

### Summary on FDRA enhancement:

Company views on FDRA enhancement:

* Same as in Rel-16 (i.e., no enhancement): Spreadtrum, vivo, Xiaomi, Nokia, Panasonic, Intel
* FDRA field enhancement to reduce DCI overhead
  + Supported by Ericsson, Samsung, NTT DOCOMO, Apple

[Moderator’s note] 4 companies suggest to enhance FDRA field to reduce DCI overhead while 6 companies are against FDRA enhancement. Therefore, it is proposed to deprioritize this issue in this meeting.

Please feel free to express views on Moderator’s note, if any.

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| Company | Views |
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## TDRA enhancement

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| Company | Views |
| [1] Huawei | Proposal 11: RAN1 could send an LS to RAN2 about the overhead issue of RRC signaling introduced by separate k0 (k2) in the TDRA table. |
| [13] Ericsson | Proposal 8: If the UE is configured with a TDRA table in which one or more rows contains multiple SLIVs, the UE is not expected to be configured with legacy single TRP PDSCH/PUSCH repetition. Legacy single-TRP repetition refers to either Rel-15 repetition through configuration of *pdsch-AggregationFactor* / *pusch-AggregationFactor*, or Rel-16 repetition through configuration of *repetitionNumber* / *numberOfRepetitions* within the TDRA table. |
| [19] NTT DOCOMO | Proposal 1:  For multi-PUSCH scheduled by single DCI,   * Support single PUSCH repetition scheduling by a DCI format configured with TDRA table which includes more than one SLIVs in at least one row. * CBG based scheduling is not supported when multiple PUSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support frequency hopping for multi-PUSCH scheduling. Newly introduced frequency hopping scheme for multi-PUSCH scheduling can be considered. * Support scheduling more than one PUSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability.   For multi-PDSCH scheduled by single DCI,   * CBG based scheduling is not supported when multiple PDSCHs are scheduled by one DCI. * Support FDRA enhancement to reduce DCI overhead. * Support scheduling more than one PDSCHs in one slot for 480/960 kHz SCS, which can be subject to UE capability. * For two-TB scheduling, two solutions can be considered to address DCI payload concern:   + Solution 1: Separate parameters to enable 2-TB scheduling for single PDSCH case and multi-PDSCH case.   + Solution 2: 2-TB scheduling can be supported only when the number of scheduled PDSCHs is no more than X (e.g. X=2/4). |
| [26] Qualcomm | Proposal 20: Support the ability to schedule a single TB to be repeated over multiple allocations and multiple TBs, with no repetitions, using the same DCI format.   * FFS: signaling details and TB size calculations. |

### Summary on TDRA enhancement:

Company views on TDRA-related issues for multi-PDSCH/PUSCH scheduling:

* A DCI format that is configured with a TDRA table containing at least one row with multiple SLIVs, can schedule PDSCH/PUSCH repetition schemes (which are supported from Rel-15 or Rel-16) by using different rows in the TDRA table
  + Supported by NTT DOCOMO, Qualcomm
  + Objected by Ericsson

[Moderator’s note] Given a small number of inputs, it is encouraged for companies to provide views on the above proposal, if any.

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## Maximum gap between PDSCHs/PUSCHs

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| Company | Views |
| [2] Futurewei | Proposal 7. Since 8 has been adopted as the maximum configurable number for multi-PxSCH under 120kHz SCS, it is suggested to continue the discussion of the maximal allowable slot gaps between adjacent PxSCHs taking coherence time as one factor for the non-consecutive multi-PxSCH.  Observation 3. If the maximal allowed gaps is large, the LBT is necessary for the unlicensed band and in the case of LBT failure the sequence of multi-PDSCH can be interrupted. |
| [13] Ericsson | Proposal 4: Do not introduce constraints on maximum value of the gap between two consecutively scheduled PDSCHs/PUSCHs or maximum value of the gap between the first and the last scheduled PDSCH/PUSCH other than that inherently provided by the range of K0/K2 value. |
| [14] Nokia | Proposal 2: The maximum gap between scheduled PDSCHs/PUSCH does not require additional impact on specification |
| [15] Panasonic | Proposal 1: For TDRA in a DCI that can schedule multiple PDSCHs (or PUSCHs),   * The maximum value of the gap between two consecutively scheduled PDSCHs or between two consecutively scheduled PUSCHs is 2 slots, * The maximum number of gaps is 2. |
| [17] MediaTek | Proposal 7: For multi-PDSCH scheduling, if M PDSCHs are scheduled by a DCI, the M PDSCHs should be contained within at most M consecutive slots |
| [21] Lenovo | Proposal 2: For NR operation between 52.6 GHz and 71 GHz, when multiple PDSCHs/PUSCHs can be scheduled by a single DCI, then only the maximum allowed gap between first and last PDSCH/PUSCH is defined, or alternatively, maximum duration to contain all the scheduled PDSCHs/PUSCHs can be defined (in case of non-contiguous allocation)   * Maximum allowed gap between two adjacent PDSCHs/PUSCHs need not be defined as network implementation can handle it under the constraint that all the scheduled PDSCHs/PUSCHs are contained within the maximum allowed gap between first and last PDSCH/PUSCH   Proposal 3: For NR operation between 52.6 GHz and 71 GHz, when multiple PDSCHs/PUSCHs can be scheduled by a single DCI, one value to define the maximum allowed gap between first and last PDSCH/PUSCH for each of the SCS value can be defined |
| [22] InterDigital | Proposal 18: As all scheduled PDSCHs/PUSCHs should be transmitted within the channel coherent time, the maximum value of the gap between the first scheduled PDSCH and the last scheduled PDSCH or between the first scheduled PUSCH and the last scheduled PUSCH should be carefully selected. |
| [23] LG Electronics | Observation #1: Adjustment of the gap between PDSCHs (or PUSCHs) for multi-PDSCH (or multi-PUSCH) scheduling DCI can be left up to network implementation. |
| [24] Apple | Proposal 16: The maximum gap between any two consecutive PxSCH transmission should factor in the parameters for multi-slot PDCCH monitoring (e.g. 4 slots for 480 kHz and 8 slots for 960 kHz)  Proposal 17: The maximum gap between the first and last PxSCH transmissions should be selected to (a) limit the memory needed for buffering and (b) account for the use of a single MCS in the DCI.  Proposal 18: UE behavior such as transmission cancellation should be addressed. |
| [26] Qualcomm | Proposal 16: Define the maximum slot gap between any two SLIVs, it can be either SCS dependent or fixed values for all SCSs.  Proposal 17: Define a maximum allowed span per single DCI as X slots, where X >= 8. |

### Summary on the maximum gap between scheduled PDSCHs/PUSCHs:

Agreement: (RAN1#105-e)

For TDRA in a DCI that can schedule multiple PDSCHs (or PUSCHs),

* A row of the TDRA table can indicate PDSCHs (or PUSCHs) that are in consecutive or non-consecutive slots.
  + FFS: The maximum value of the gap between two consecutively scheduled PDSCHs or between two consecutively scheduled PUSCHs
  + FFS: The maximum value of the gap between the first scheduled PDSCH and the last scheduled PDSCH or between the first scheduled PUSCH and the last scheduled PUSCH
  + FFS: Details to introduce the gap between PDSCHs or between PUSCHs

Company views on the maximum gap between scheduled PDSCHs/PUSCHs:

* Between two consecutively scheduled PDSCHs or between two consecutively scheduled PUSCHs
  + No additional impact on specification: Ericsson, Nokia, LG Electronics
  + To be specified: Futurewei, Panasonic, Lenovo, InterDigital, Apple, Qualcomm
* Between the first scheduled PDSCH and the last scheduled PDSCH or between the first scheduled PUSCH and the last scheduled PUSCH
  + No additional impact on specification: Ericsson, Nokia, LG Electronics
  + To be specified: Panasonic, MediaTek, Lenovo, InterDigital, Apple, Qualcomm

[Moderator’s note] In general, company views are divided into two categories where one is to suggest specifying a certain value to restrict the maximum gap between PDSCHs or PUSCHs and the other is not to further specify the maximum gap between PDSCHs or PUSCHs. In addition, even for proponents suggesting to specify the maximum gap between shared channels, the exact values for the gap are not aligned. Therefore, it is proposed to deprioritize this issue in this meeting.

Please feel free to express views on Moderator’s note, if any.

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## Others

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| Company | Views |
| [1] Huawei | Observation 1: The interleaved VRB-to-PRB mapping for 120 kHz SCS can be reused for 480 kHz and 960 kHz SCS.  Observation 2: PRB bundling mechanism defined in Rel-15 can be reused as a baseline for multi-PDSCH scheduling in this new frequency range.  Observation 3: The existing configuration and indication related to RateMatchPattern can be reused.  Observation 4: Triggering scheme defined in Rel-15/16 can be reused directly for aperiodic ZP CSI-RS.  Proposal 12: Support periodic/semi-persistent ZP CSI-RS for 480 and 960 kHz SCS with periodicity up to 80 ms. |
| [12] Xiaomi | Proposal 7: Support to indicate more than one channel access types in a single DCI. |
| [16] Samsung | Proposal 13: For multi-PDSCH scheduling, the bit field common for DL and UL grant use the same design as multi-PUSCH scheduling, and at least following DL-specific bit field should be specified,   * Single MCS for 2nd TBs for all PDSCHs and separate 1-bit NDI/1-bit RV for 2nd TB for each PDSCH if the working assumption on two codeword transmission for FR2-2 is confirmed * CBG-based transmission is not applicable to single and multi-PDSCH scheduling * HARQ-ACK relevant bit field is applicable to all PDSCHs and single PUCCH |
| [18] Intel | Proposal 7  For multi-PDSCH scheduling   * Carrier indicator, BWP indicator, frequency domain resource allocation and DMRS configuration including antenna port, DMRS sequence initialization, etc., can be applied for all the scheduled PDSCHs. |
| [19] NTT DOCOMO | Observation 1: The maximum gain of JCE over multi-PDSCH scheduling is about 0.41dB and 0.63dB in SCS of 480kHz and 960kHz, respectively.    Proposal 5: No need to support JCE for multi-PDSCH scheduling due to no significant gain. |

### Summary on other aspects for multi-PDSCH/PUSCH scheduling:

The following issues are brought up by several companies:

* Huawei: Introduction of new periodicity (e.g., 80 ms) for P/SP-CSI-RS with 480/960 kHz SCS
* Xiaomi: Support of more than one channel access type indication fields in a single DCI
* Samsung: HARQ-ACK relevant bit field is applicable to all PDSCHs and single PUCCH
* Intel: Carrier indicator, BWP indicator, frequency domain resource allocation and DMRS configuration including antenna port, DMRS sequence initialization, etc., can be applied for all the scheduled PDSCHs.
* NTT DOCOMO: No need to support JCE for multi-PDSCH scheduling due to no significant gain.

[Moderator’s note] Given a small number of inputs for those issues, it is proposed to deprioritize them in this meeting but please feel free to express views on above issues, if any.

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# HARQ

## Impact of invalid PDSCH on HARQ-ACK feedback

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| Company | Views |
| [1] Huawei | Proposal 7: If the scheduled PDSCH/PUSCH could be identified invalid between gNB and UE, HARQ process number increment is skipped. For example:   * The scheduled PxSCH resource collides with pre-configured resource like SPS or CG   If the HARQ process number for a scheduled PDSCH/PUSCH collides with the HARQ process number of pre-configured resource like SPS or CG   * HARQ process number increment continues until no such collision happens   If the scheduled PDSCH/PUSCH could not be identified valid or invalid between gNB and UE, HARQ process number increment continues. For example:   * The scheduled PDSCH/PUSCH collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommo*n or *tdd-UL-DL-ConfigurationDedicated*) and UE is not configured SPS or CG for those flexible symbols.   NACK corresponding to the above cases of scheduled PDSCH should be reported by the UE. |
| [8] NEC | Proposal 4: For Alt 1 of type-2 HARQ-ACK codebook determination:   * Three sub-codebooks should be generated if CBG based transmission is configured for a serving cell in the PUCCH cell group. * The HARQ-ACK of the SPS PDSCH release and SCell dormancy indication without scheduled PDSCH should belong to the first sub-codebook. * If time domain bundling is supported, similar grouping way as CBG can be reused, and spatial bundling and time bundling should not be simultaneously configured or applied. * If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, how to fill the NACK bits for the collision slot(s) needs to be determined. * If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, and only 1 actual scheduled PDSCH left in this DCI scheduling, this PDSCH will belong to sub-codebook 1. |
| [10] CATT | Proposal 5: When the scheduled PDSCH overlaps with uplink slot/symbols configured by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, UE doesn’t feedback any HARQ-ACK information for the PDSCH. |
| [16] Samsung | Proposal 10: Down-select from the following two options for the reference PDSCH of K1 field in a DCI scheduling multiple PDSCHs.   * Option 1) K1 applies to the last scheduled PDSCH of the multiple SLIVs indicated by the DCI. * Option 2) K1 applies to the last valid scheduled PDSCH.   Proposal 15: If a PUCCH overlaps with one of the multiple PUSCHs scheduled by a single DCI, UE checks DL collision for the overlapping PUSCH before UCI multiplexing. |
| [23] LG Electronics | Proposal #12: For type-1 HARQ-ACK codebook generation, do not consider the SLIV corresponding to a PDSCH skipped due to the collision with semi-static UL symbols for pruning procedure.  Proposal #13: For (enhanced) type-2 HARQ-ACK codebook generation, NACK information is padded for an invalid PDSCH due to collision with semi-static UL symbol(s).  Proposal #14: For a DCI scheduling multiple PDSCHs, the following two options can be considered to determine HARQ-ACK timing and needs to be down-selected.   * Option 1: K1 corresponds to the slot offset between the slot of the last scheduled PDSCH and the slot carrying HARQ-ACK feedback, regardless of whether the last PDSCH is skipped or not. * Option 2: K1 corresponds to the slot offset between the slot of the last valid PDSCH (which is not collided with semi-static UL symbols) and the slot carrying HARQ-ACK feedback. |

### Issue 3.1-1) How to handle HARQ-ACK bit corresponding to invalid PDSCH (i.e., a PDSCH skipped due to collision with semi-static UL symbols):

Company views on how to handle HARQ-ACK bit corresponding to invalid PDSCH:

* Common to Type-1 and Type-2 HARQ-ACK codebook generation
  + Huawei: NACK corresponding to the invalid PDSCH should be reported by the UE.
  + CATT: UE doesn’t feedback any HARQ-ACK information for the PDSCH.
* For Type-1 HARQ-ACK codebook generation
  + LG Electronics: Do not account for invalid PDSCHs for SLIV pruning procedure
* For Type-2 HARQ-ACK codebook generation
  + LG Electronics: NACK padding for invalid PDSCHs

[Moderator’s note to Issue 3.1-1] More company views are needed to draw a proposal so, companies are encouraged to provide more views on HARQ-ACK codebook issue due to collision with semi-static UL symbols.

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### Issue 3.1-2) K1 timing based on the last PDSCH:

Agreement: (RAN1#104-e)

* For a DCI scheduling multiple PDSCHs, HARQ-ACK information corresponding to PDSCHs scheduled by the DCI is multiplexed with a single PUCCH in a slot that is determined based on K1,
  + where K1 (indicated by the PDSCH-to-HARQ\_feedback timing indicator field in the DCI or provided by *dl-DataToUL-ACK* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the DCI) indicates the slot offset between the slot of the last PDSCH scheduled by the DCI and the slot carrying the HARQ-ACK information corresponding to the scheduled PDSCHs.
    - It is noted that granularity of K1 can be separately discussed.
* FFS: If needed, further discuss whether or not HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s)

Company views on K1 timing based on the last PDSCH:

* Samsung and LG Electronics identified two options:
  + Option 1: K1 indicates the slot offset between the slot of the last scheduled PDSCH and the slot carrying the HARQ-ACK information corresponding to the scheduled PDSCHs.
  + Option 2: K1 indicates the slot offset between the slot of the last valid scheduled PDSCH and the slot carrying the HARQ-ACK information corresponding to the scheduled PDSCHs.

[Moderator’s note to Issue 3.1-2] Given a small number of inputs, it is encouraged for companies to provide views on the above options, if any.

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## Time domain bundling

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| Company | Views |
| [1] Huawei | Proposal 21: For FR2-2, Time domain bundling of Type-1 HARQ-ACK codebook can be supported in granularity of DCI scheduling. The size and mapping of the HARQ-ACK codebook are determined by the number and position of the last non-overlapped SLIV by each row of TDRA table and K1 set. Pruning of last SLIV with UL symbols by semi-static TDD configuration is not applied. |
| [5] vivo | Proposal 14: Regarding time domain bundling for Type-1 codebook when multi-PDSCH scheduling is configured, consider the following two alternatives:   * Alt. 1: A set of occasions is determined based on the last (valid) SLIV in each row of the TDRA table, and time domain bundling is performed across all valid PDSCH(s) scheduled by a DCI by indicating a row in the TDRA table. * Alt. 2: A set of occasions is determined based on all (valid) SLIVs in each row of the TDRA table, in the same way as the case when time domain bundling is not configured, and time domain bundling is performed for each subset of occasions divided from the set of occasions.   Proposal 16: Regarding time domain bundling for Type-2 codebook when multi-PDSCH scheduling is configured, consider the following two alternatives:   * Alt. 1: Time domain bundling is performed across all valid PDSCH(s) scheduled by a DCI by indicating a row in the TDRA table. * Alt. 2: Time domain bundling is performed across a subset of valid PDSCHs, which is divided from the set of valid PDSCH(s) scheduled by a DCI by indicating a row in the TDRA table. |
| [6] Fujitsu | Proposal 2: For Type-1 HARQ-ACK codebook, support time domain bundling.   * For each , the corresponding candidate PDSCH reception occasion can be determined based on all the SLIVs of each row in the TDRA table. If at least one of SLIVs in a row in the TDRA table is not colliding with UL symbols configured by RRC signaling, it corresponds to one candidate PDSCH reception occasion. * For each determined candidate PDSCH reception occasion, HARQ-ACK information for all PDSCHs in slots that include SLIV(s) not colliding with UL symbols can be bundled as 1 bit. |
| [8] NEC | Proposal 4: For Alt 1 of type-2 HARQ-ACK codebook determination:   * Three sub-codebooks should be generated if CBG based transmission is configured for a serving cell in the PUCCH cell group. * The HARQ-ACK of the SPS PDSCH release and SCell dormancy indication without scheduled PDSCH should belong to the first sub-codebook. * If time domain bundling is supported, similar grouping way as CBG can be reused, and spatial bundling and time bundling should not be simultaneously configured or applied. * If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, how to fill the NACK bits for the collision slot(s) needs to be determined. * If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, and only 1 actual scheduled PDSCH left in this DCI scheduling, this PDSCH will belong to sub-codebook 1. |
| [10] CATT | Proposal 14: Time bundling of HARQ-ACK feedback is low priority. |
| [13] Ericsson | Proposal 20: Configurable time domain HARQ-ACK bundling for semi-static codebook, which generates a single HARQ-ACK feedback for multiple PDSCHs scheduled by the same DCI, can be considered.  Observation 4: Applying configurable time domain HARQ-ACK bundling to dynamic codebook can reduce the HARQ-ACK codebook size, thus achieving a configurable balance with retransmission efficiency depending on the deployment scenario.  Observation 5: In an extreme case, when NHBG is set to 1, all HARQ-ACK bits corresponding to the PDSCHs scheduled by the same DCI are bundled into a single bit. In this case same HARQ-ACK sub-codebook can be used for single and multiple PDSCH scheduling.  Proposal 23: Time domain HARQ-ACK bundling with configurable number of time bundling groups (including the extreme case of single bundling group) can be considered for dynamic codebook enhancement. |
| [14] Nokia | Proposal 9: Time domain bundling of HARQ-ACK feedback over PDSCHs scheduled by the same DCI is supported. In the case that all HARQ-ACK(s) are bundled into a single bit per DCI, single sub-codebook is used.  Proposal 10: For Type-1 codebook, configurable time domain bundling of HARQ-ACK feedback over M consecutive PDSCHs scheduled by the same DCI is supported.   * Modified TDRA table is used in the codebook determination * TDRA rows are modified by keeping the last SLIV(s) of the row corresponding to the number of bundled HARQ-ACK bit(s) and removing other SLIVs from that row. |
| [16] Samsung | Proposal 17: If HARQ-ACK bundling is supported, bundling is performed within valid PDSCHs scheduled by a single DCI. Down-select one of the following alternatives:   * Alt a: gNB configures a number of HARQ-ACK bundling groups (Nb) per DCI * Alt b: gNB configures a number of valid PDSCHs per HARQ-ACK bundling groups (Npb) * Alt c: gNB configures time duration of one HARQ-ACK bundling group (Tb). * Prioritize HARQ-ACK bundling for Type-2 HARQ-ACK codebook.   Proposal 22: Postpone the discussion on whether/how to support time domain bundling for type-1 HARQ-ACK codebook until RAN1 makes the decision for the HARQ-ACK bundling mechanism. |
| [17] MediaTek | Proposal 1: For Type-2 codebook construction based on the principle of DAI per DCI, support the following PDSCH grouping and HARQ-ACK bit reporting to manage the codebook size.   * When a UE is configured with multi-PDSCH scheduling in a cell c, the scheduled PDSCHs from one DCI are grouped into PDSCH groups based on Rel-15/16 CBG grouping principle   + , where N is the maximum number of PDSCH groups per DCI configured by network and C is the number of scheduled PDSCHs in the DCI.   + Let   + Each PDSCH group in the first PDSCH groups contains scheduled PDSCHs and each PDSCH group in the remaining PDSCH groups contains scheduled PDSCHs.   + UE reports one HARQ-ACK bit for each PDSCH group     - If all PDSCHs within a PDSCH group are decoded correctly, UE reports “ACK”     - Else, UE reports “NACK”   + If , UE will append “NACK” bits after the M HARQ-ACK bits from the TB groups to construct the codebook |
| [18] Intel | Proposal 10   * Time domain bundling is supported in HARQ-ACK transmission. * The PDSCHs associated with the HARQ-ACKs that are time bundled should be scheduled by the same DCI. * The maximum number of PDSCHs for which HARQ-ACKs are bundled can be configured by high layer.   Proposal 11   * For Type-1 HARQ-ACK codebook with time domain bundling   + For each row in TDRA table, N SLIVs are selected and associated with N bundled HARQ-ACK of the row.     - It is beneficial that the selected SLIVs of each row in TDRA table for each K1 value can be mapped to the same slot(s).   + A modified TDRA table can be obtained with each row only containing the N selected SLIVs.   + Rel-16 Type-1 HARQ-ACK codebook generation can be applied based on the modified TDRA table.   Proposal 12   * For Type-2 HARQ-ACK codebook with time domain bundling,   + If the maximum number of bundled HARQ-ACK per DCI is one or two, single HARQ-ACK codebook can be used. Otherwise, two sub-codebooks can be applied.   + When two sub-codebooks are used, if the actual number of bundled bits is 1 or 2 for a DCI, the first sub-codebook is used to carry the bundled HARQ-ACK for the DCI. Otherwise, the second sub-codebook is used.   Proposal 13   * Time domain bundling can be applied to Type-3 HARQ-ACK codebook.   + HARQ-ACK bits of adjacent HARQ process IDs that are scheduled by the same DCI can be bundled. |
| [19] NTT DOCOMO | Proposal 4: Support time domain HARQ-ACK bundling. |
| [23] LG Electronics | Proposal #15: If time domain bundling is to be supported for type-1 HARQ-ACK codebook construction,   * Only allow bundling operation for all PDSCHs corresponding to each DCI. * Each PDSCH reception occasion is determined based on the last SLIV among multiple SLIVs associated with a row index.   Proposal #17: If time domain bundling is to be supported for (enhanced) type-2 HARQ-ACK codebook construction,   * Only allow bundling operation for all PDSCHs corresponding to each DCI. * HARQ-ACK bits corresponding to single PDSCH reception and multi-PDSCH reception are merged into the same sub-codebook. |
| [24] Apple | Proposal 19: The output of the codebook procedure is grouped into bundles with a maximum # (M) of HARQ-ACK bits per HARQ-ACK bundle X. The bits in each bundle undergo an “AND” operation as output to the codebook.  Proposal 20: Introduce signaling mechanism to enable generating a HARQ-ACK bit per ‘M’ scheduled PDSCHs in a multi-PDSCH scheduling by performing HARQ-ACK bundling to compress the HARQ-ACK bits overhead. |
| [26] Qualcomm | Proposal 10: For type-2 codebook, in the case of time domain bundling of A/N bits corresponding to PDSCHs scheduled by the same DCI into one bit, a single codebook should be defined at least if CBG operation is not configured.  Proposal 11: Allowing different numbers of A/N bits per multi-PDSCH grant, such that for each A/N occasion all the corresponding multi-PDSCH grants will have the same A/N bits, however, from one A/N occasion to another we can allow different number A/N bits per grant   * If time domain bundling is enabled, then the bundling pattern can be changed from one A/N occasion to another.   + Time-domain bundling patterns to be defined via RRC configuration and the active pattern can be changed by MAC-CE or PDCCH. |
| [27] ITRI | Observation 1: There may have redundant HARQ-ACK bits of type-1 codebook considering multiple PDSCHs scheduled by a DCI, if Rel-16 procedure is applied.  Proposal 3: Time domain bundling could be considered to reduce the size of type-1 codebook. |

### Issue 3.2-1) Time domain bundling for type-1 HARQ-ACK codebook:

Company views on time domain bundling for type-1 HARQ-ACK codebook:

* Option 1: Time domain bundling is performed across all PDSCHs scheduled by a DCI and pruning procedure is based on the last SLIV
  + Supported by Huawei, vivo, Fujitsu, Ericsson, LG Electronics
* Option 2: Time domain bundling is performed across subset of PDSCHs scheduled by a DCI, FFS for pruning procedure
  + Supported by vivo, Nokia, Intel
  + vivo: A set of occasions is determined based on all (valid) SLIVs in each row of the TDRA table, in the same way as the case when time domain bundling is not configured, and time domain bundling is performed for each subset of occasions divided from the set of occasions.
  + Nokia: Modified TDRA table is used in the codebook determination and TDRA rows are modified by keeping the last SLIV(s) of the row corresponding to the number of bundled HARQ-ACK bit(s) and removing other SLIVs from that row.
  + Intel: For each row in TDRA table, N SLIVs are selected and associated with N bundled HARQ-ACK of the row. A modified TDRA table can be obtained with each row only containing the N selected SLIVs.

[Moderator’s note to Issue 3.2-1] Given a small number of inputs and split views, it is encouraged for companies to provide views on the above options, if any.

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| Company | Views |
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### Issue 3.2-2) Time domain bundling for type-2 HARQ-ACK codebook:

Company views on time domain bundling for type-2 HARQ-ACK codebook:

* Option 1: Time domain bundling is performed across all PDSCHs scheduled by a DCI and corresponding HARQ-ACK bit belongs to the first sub-codebook.
  + Supported by vivo, Ericsson, LG Electronics, Qualcomm
* Option 2: Time domain bundling is performed across subset of PDSCHs scheduled by a DCI, FFS for how to determine the subset of scheduled PDSCHs
  + Supported by vivo, Ericsson, Samsung?, MediaTek, Intel, Apple, Qualcomm
  + Ericsson, Samsung: Configure the number of bundling groups
  + Samsung, MediaTek, Intel, Apple, Qualcomm: Configure the number of PDSCHs per bundling group
    - Qualcomm: Time domain bundling pattern can be configured by higher layer parameter.
  + Samsung: Configure the time duration of bundling group

[Moderator’s note to Issue 3.5-2] Given split views, it is encouraged for companies to provide views on the above options, if any.

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| Company | Views |
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## Type-1 (semi-static) HARQ-ACK codebook

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| Company | Views |
| [4] ZTE | Proposal 3: The procedure for extending the K1 set and determining the association between each element of the extended K1 set and a set of SLIVs could be defined as following:   * Determine a set of slot offset between the last SLIV (PDSCH) and each SLIV for TDRA table. * Determine a set of SLIVs for each slot offset. * Determine extended K1 set based on K1 set and the set of slot offset. * Determine a set of SLIVs for each element of extended K1 set. |
| [10] CATT | Observation 1: For a given PUCCH carrying type-1 HARQ-ACK, the number of DCIs can be sent by gNB is less than the number of k1, and the redundant PDSCH occasions will be generated if all k1 values are looped.  Proposal 10: The scheme for pruning candidate PDSCH occasions is based on number of DCIs that can be scheduled for a given PUCCH carrying HARQ-ACK. |
| [12] Xiaomi | Proposal 2: For Type 1 HARQ-ACK codebook, if multi-slot PDSCH is configured, the new K1 set is determined as  ,and the k1 value indicated in the scheduling DCI can only be chosen from the original K1 set instead of the new K1 set. |
| [13] Ericsson | Observation 3: The semi-static codebook generation scheme agreed in RAN1#106-e can support single and multiple PDSCHs in a single slot in single and multiple TRP transmission scenarios. No impact is anticipated from whether or not a UE supports multiple PDSCHs in a single slot in various DL transmission scenarios. |
| [19] NTT DOCOMO | Proposal 2: K1 set is extended to obtain the extended DL slot set. The K1 extension is based on K0 configurations in each TDRA row. |
| [25] Convida | Proposal 1. For type-1 codebook HARQ-ACK generation, it is preferred to use the extension of K1 set and the set of candidates PDSCH reception occasions/slots for reducing specification impact for single DCI scheduling multi-PDSCH. |

### Summary on Type-1 HARQ-ACK codebook generation:

Agreement: (RAN1#106-e)

* For single TRP operation, for 480/960 kHz SCS,
  + FFS: A UE does not expect to be scheduled with more than one PDSCH in a slot, by a single DCI or multiple DCIs.
  + FFS: A UE does not expect to be scheduled with more than one PUSCH in a slot, by a single DCI or multiple DCIs.
* For single TRP operation, for 120 kHz SCS (same as current specification for FR2-1 for PUSCH),
  + Subject to UE capability, a UE can be scheduled with more than one PDSCH in a slot, by a single DCI or multiple DCIs.
  + Subject to UE capability, a UE can be scheduled with more than one PUSCH in a slot, by a single DCI or multiple DCIs.
* FFS for multi-TRP operation
* Note: The optimization of HARQ codebook size for Type 1 or Type 2 codebook design is considered as a low priority in Rel-17 (this does not preclude HARQ ACK bundling in time domain).
* The agreement made in RAN1#105-e is revised as follows.

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| Agreement: (RAN1#105-e)  For enhancements of generating type-1 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, the set of candidate PDSCH reception occasions corresponding to a UL slot with HARQ-ACK transmission is determined based on a set of DL slots and a set of SLIVs corresponding to each DL slot belonging to the set of DL slots.   * The set of DL slots contains all the unique DL slots determined by considering all combinations of the configured K1 values and the configured rows of the TDRA table. * The set of SLIVs corresponding to a DL slot (belonging to the set of DL slots) contains all the SLIVs for that slot determined by considering all combinations of the configured K1 values and the configured rows of the TDRA table. * The Rel-16 procedure is reused for determining the candidate PDSCH reception occasions for the set of SLIVs corresponding to each DL slot belonging to the set of DL slots   + Note: The Rel-16 procedure already handles pruning of multiple SLIVs corresponding to a DL slot, for both UEs that are and are not capable of receiving multiple PDSCHs per slot   + FFS impact of time domain bundling, if supported |

[Moderator’s note] Even though several companies suggest more details on type-1 HARQ-ACK codebook construction (e.g., by extending K1 set), moderator’s understanding is that the above revised agreement is sufficient and further details are up to spec editor’s discretion.

Please feel free to express views on Moderator’s note, if any.

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| Company | Views |
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## 3 options for Type-2 (dynamic) HARQ-ACK codebook with CBG configured

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| Company | Views |
| [1] Huawei | Proposal 22: For type-2 HARQ-ACK codebook construction, option 3 is preferred. |
| [2] Futurewei | Proposal 10. For the construction of type-2 HARQ-ACK codebook when CBG operation is configured, Option 2 can be considered unless only time-variance (but not interference-variance) of channel is prioritized for FR2-2. |
| [4] ZTE | Proposal 4: When CBG operation is configured, the following Option 3 is preferred   * UE does not expect to be configured with both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group. |
| [5] vivo | Proposal 15: For constructing Type-2 HARQ-ACK codebook when CBG operation is configured, support Option 2, i.e. HARQ-ACK bits corresponding to CBG-based PDSCH reception and HARQ-ACK bits corresponding to multi-PDSCH reception are contained in separate sub-codebooks. |
| [6] Fujitsu | Proposal 3: For the Type-2 HARQ-ACK codebook, Option 1 should be supported where HARQ-ACK bits corresponding to CBG-based PDSCH reception and multi-PDSCH reception are merged into the same sub-codebook. More specifically, the Type-2 HARQ-ACK codebook includes the following two sub-codebooks.   * The 1st sub-codebook includes HARQ-ACK bits for PDSCHs scheduled in a single-PDSCH and TB-based manner among all the CCs. * The 2nd sub-codebook includes HARQ-ACK bits for PDSCHs scheduled in a single-PDSCH and CBG-based manner, and PDSCHs scheduled in a multi-PDSCH manner. |
| [7] OPPO | Proposal 6: For Type-2 HARQ-ACK codebook construction, HARQ-ACK bits corresponding to CBG-based PDSCH reception and multi-PDSCH reception are merged into the same sub-codebook. |
| [8] NEC | Proposal 4: For Alt 1 of type-2 HARQ-ACK codebook determination:   * Three sub-codebooks should be generated if CBG based transmission is configured for a serving cell in the PUCCH cell group. * The HARQ-ACK of the SPS PDSCH release and SCell dormancy indication without scheduled PDSCH should belong to the first sub-codebook. * If time domain bundling is supported, similar grouping way as CBG can be reused, and spatial bundling and time bundling should not be simultaneously configured or applied. * If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, how to fill the NACK bits for the collision slot(s) needs to be determined. * If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, and only 1 actual scheduled PDSCH left in this DCI scheduling, this PDSCH will belong to sub-codebook 1. |
| [10] CATT | Proposal 12: Simultaneous configuration for both CBG-based scheduling and multi-PDSCH scheduling shall be avoided. |
| [12] Xiaomi | Proposal 4: Not support to configure both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group. |
| [13] Ericsson | Proposal 21: Support Option 2 for sub-codebook construction when CBG operation is configured (i.e., HARQ-ACK bits corresponding to CBG-based PDSCH reception and HARQ-ACK bits corresponding to multi-PDSCH reception are contained in separate sub-codebooks)  Proposal 22: Option 3 can be considered for sub-codebook construction when CBG operation is configured (i.e., UE does not expect to be configured with both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group). |
| [14] Nokia | Proposal 8: HARQ-ACK bits for CBG-based PDSCH reception and HARQ-ACK bits for multi-PDSCH reception are contained in separate sub-codebooks if same DCI configuration can be used for scheduling both CBG-based PDSCH reception and multi-PDSCH reception. Otherwise, HARQ-ACK reporting for CBG-based scheduling and multi-PDSCH scheduling is not supported simultaneously. |
| [15] Panasonic | Proposal 7: For Type-2 HARQ-ACK codebook, when CBG operation is configured,   * UE does not expect to be configured with both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group. |
| [16] Samsung | Proposal 19: For Type-2/enhanced type-2 HARQ-ACK codebook,   * 1st sub-codebook for single PDSCH reception, and PDCCHs requiring HARQ-ACK feedback. * 2nd sub-codebook for multi-PDSCHs reception and CBG-based reception. |
| [18] Intel | Proposal 9  Adapt Option 1, i.e. up to 2 sub-codebooks in Type-2 HARQ-ACK codebook generation   * The second sub-codebook is used to carry HARQ-ACK for CBG-based transmission and HARQ-ACK for multi-PDSCH scheduling by a DCI if more than 3 HARQ-ACK bits are associated with the DCI.   + Denote the maximum number of TBs that can be scheduled by a multi-PDSCH DCI as M and the number of configured CBGs for a PDSCH as N, the number of HARQ-ACK bits per DCI in the second sub-codebook equals to the maximum of all configured values M and N among all the configured cells * If the number of HARQ-ACK bits associated with a DCI for multi-PDSCH scheduling is two, HARQ-ACK bits associated with the DCI can be included in the first sub-codebook. * 1 HARQ-ACK bit is included in the first sub-codebook for the DCI indicating SPS PDSCH release and SCell dormancy indication without scheduled PDSCH. |
| [19] NTT DOCOMO | Proposal 3: Support option 3 for CBG consideration, i.e. UE does not expect to be configured with both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group. |
| [21] Lenovo | Proposal 6: For NR operation between 52.6 GHz and 71 GHz, support following option 2:   * Option 2: HARQ-ACK bits corresponding to CBG-based PDSCH reception and HARQ-ACK bits corresponding to multi-PDSCH reception are contained in separate sub-codebooks. |
| [22] InterDigital | Proposal 7: Type-2 HARQ-ACK codebook construction procedure when CBG is configured for a cell within the same PUCCH cell group should be carefully evaluated. |
| [23] LG Electronics | Observation #2: Provided that type-1 HARQ-ACK codebook is configured, when multi-PDSCH scheduling is configured for cell#1 and CBG is configured for cell#2, HARQ-ACK codebook can be constructed without any further issues.  Proposal #16: For (enhanced) type-2 HARQ-ACK codebook, HARQ-ACK bits corresponding to CBG-based PDSCH reception and multi-PDSCH reception are merged into the same sub-codebook.   * The number of HARQ-ACK bits corresponding to each DAI of the second sub-codebook depends on the maximum value between M\_max and C\_max where M\_max corresponds to the maximum configured number of PDSCHs for multi-PDSCH DCI across serving cells belonging to the same PUCCH cell group and C\_max corresponds to the maximum number of CBGs across serving cells belonging to the same PUCCH cell group. |
| [26] Qualcomm | Proposal 13: Regarding the construction of the HARQ codebook when CBG operation is configured, we support Option 1. |
| [28] WILUS | Proposal 1: We propose to support Option 1 that HARQ-ACK bits corresponding to CBG-based PDSCH reception and multi-PDSCH reception are merged into the same sub-codebook. |

### Summary on 3 options for Type-2 (dynamic) HARQ-ACK codebook with CBG configured:

Agreement: (RAN1#106-e)

Consider the following options to construct type-2 HARQ-ACK codebook when CBG operation is configured, and down-select to one of the following options in RAN1#106bis-e.

* Option 1: HARQ-ACK bits corresponding to CBG-based PDSCH reception and multi-PDSCH reception are merged into the same sub-codebook.
* Option 2: HARQ-ACK bits corresponding to CBG-based PDSCH reception and HARQ-ACK bits corresponding to multi-PDSCH reception are contained in separate sub-codebooks.
* Option 3: UE does not expect to be configured with both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group.
* Note: Multi-PDSCH reception refers to the case where multiple PDSCHs are scheduled by a DCI that is configured with TDRA table containing at least one row with multiple SLIVs.

Company views on 3 options for Type-2 (dynamic) HARQ-ACK codebook with CBG configured:

* Option 1 (7)
  + Supported by Fujitsu, OPPO, Samsung, Apple, LG Electronics, Qualcomm, WILUS
* Option 2 (6)
  + Supported by Futurewei, vivo, NEC, Ericsson, Nokia, Lenovo
* Option 3 (8)
  + Supported by Huawei, ZTE, CATT, Xiaomi, Ericsson, Nokia, Panasonic, NTT DOCOMO

[Moderator’s note] It is observed that companies have split view among 3 options. So, it seems difficult to make a consensus as is. Instead, the following two questions are asked to understand better each company’s view. Please note that the following questions are indicated as “HIGH” since the discussion on CBG-related fields is put on hold due to this issue.

### [HIGH] Q1: Which of 3 options is preferred? In addition, which option is NOT acceptable?

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| Company | Preferred option(s) | NOT acceptable option(s) | Comments |
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### [HIGH] Q2: If option 3 is selected, will multi-PDSCH scheduling be NOT configured, in case “type-1” HARQ-ACK codebook is configured and CBG is configured?

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| Company | Views |
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## Type-2 (dynamic) HARQ-ACK codebook

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| Company | Views |
| [8] NEC | Proposal 4: For Alt 1 of type-2 HARQ-ACK codebook determination:   * Three sub-codebooks should be generated if CBG based transmission is configured for a serving cell in the PUCCH cell group. * The HARQ-ACK of the SPS PDSCH release and SCell dormancy indication without scheduled PDSCH should belong to the first sub-codebook. * If time domain bundling is supported, similar grouping way as CBG can be reused, and spatial bundling and time bundling should not be simultaneously configured or applied. * If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, how to fill the NACK bits for the collision slot(s) needs to be determined. * If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, and only 1 actual scheduled PDSCH left in this DCI scheduling, this PDSCH will belong to sub-codebook 1. |
| [10] CATT | Proposal 13: The HARQ-ACK bits for 2 PDSCHs scheduled by one DCI are included in the second sub-codebook. |
| [16] Samsung | Proposal 18: The number of HARQ-ACK bits for PDSCHs scheduled by a single DCI is determined as the maximum configured number of PDSCHs.   * FFS: If UE only receives a single DCI, the number of HARQ-ACK bits is determined as the number of valid PDSCHs scheduled by a single DCI   Observation 6: Including HARQ-ACK bits for 2 PDSCHs scheduled by a DCI in the first HARQ-ACK sub-codebook complicates the specification with marginal gain.  Observation 7: No enhancement is needed for a DCI indicating SPS release or Scell dormancy.  Proposal 20: The HARQ-ACK bits are ordered according to the time order of valid PDSCHs scheduled by a DCI.  Proposal 21: when a UE supports UE capability type2-HARQ-ACK-Codebook (FG 18-9), and there are >1 DCIs belonging to the same MOs and scheduling PDSCHs to the same serving cell. And these DCIs are configured to be able to schedule multiple PDSCHs. The counting procedure for the PDSCHs scheduled by these DCIs are:   * PDSCHs are separated into different sets and each set of PDSCHs are scheduled by the same DCI. PDSCHs are counted separately for different sets. * The counting order between different sets of PDSCHs are based on the reception time of the first PDSCH in each set. |
| [18] Intel | Proposal 9  Adapt Option 1, i.e. up to 2 sub-codebooks in Type-2 HARQ-ACK codebook generation   * The second sub-codebook is used to carry HARQ-ACK for CBG-based transmission and HARQ-ACK for multi-PDSCH scheduling by a DCI if more than 3 HARQ-ACK bits are associated with the DCI.   + Denote the maximum number of TBs that can be scheduled by a multi-PDSCH DCI as M and the number of configured CBGs for a PDSCH as N, the number of HARQ-ACK bits per DCI in the second sub-codebook equals to the maximum of all configured values M and N among all the configured cells * If the number of HARQ-ACK bits associated with a DCI for multi-PDSCH scheduling is two, HARQ-ACK bits associated with the DCI can be included in the first sub-codebook. * 1 HARQ-ACK bit is included in the first sub-codebook for the DCI indicating SPS PDSCH release and SCell dormancy indication without scheduled PDSCH. |
| [23] LG Electronics | Proposal #18: For the UE indicating 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, DAI is counted   * First, in increasing order of the “first” 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 , where . |
| [24] Apple | Proposal 21: For a CC that is configured with TDRA table containing at least one row with multiple SLIVs and schedules multiple PDSCHs, the HARQ-ACK for SPS PDSCH release and SCell dormancy indication without scheduled PDSCH should be included in the first HARQ-ACK sub-codebook.  Proposal 22: Consider introducing a configurable threshold (e.g., 2) to allow M PDSCHs scheduled by a single DCI to be included into the first HARQ-ACK sub-codebook where M<= threshold. |
| [26] Qualcomm | Proposal 12: If all PDSCHs scheduled by a DCI that schedules multi-PDSCHs (TDRA row has multiple SLIVs) except one PDSCH will not be transmitted due to overlap with semi-static UL symbols, then A/N bit of the valid PDSCH will be carried in the codebook of fallback and single-PDSCH grants. |

### Issue 3.5-1) HARQ-ACK bit corresponding to SPS PDSCH release, SCell dormancy indication without scheduled PDSCH:

Agreement: (RAN1#105-e)

If Alt 1 (C-DAI/T-DAI is counted per DCI) is adopted for generating type-2 HARQ-ACK codebook corresponding to a DCI that can schedule multiple PDSCHs,

* At least two sub-codebooks are generated for a PUCCH cell group where
  + The first sub-codebook is for the following cases:
    - Any DCI that is not configured with CBG-based scheduling and is configured with TDRA table containing rows each with a single SLIV
    - Any DCI that is not configured with CBG-based scheduling and is configured with TDRA table containing at least one row with multiple SLIVs and schedules only a single PDSCH
  + The second sub-codebook is for the following case:
    - Any DCI that is configured with TDRA table containing at least one row with multiple SLIVs and schedules multiple PDSCHs
      * FFS: Methods (if needed) to align the size of HARQ-ACK feedback corresponding to different DCIs
      * FFS: Whether HARQ-ACK bits for 2 PDSCHs scheduled by this DCI can be included in the first sub-codebook in some cases
  + FFS: SPS PDSCH release, SCell dormancy indication without scheduled PDSCH
* FFS: 2 or 3 sub-codebooks if CBG is configured for a serving cell in the PUCCH cell group
* FFS: impact of time domain bundling, if supported, e.g., the number of sub-codebooks including single codebook if all A/N bits are bundled into a single bit per DCI

Company views on HARQ-ACK bit corresponding to SPS PDSCH release, SCell dormancy indication without scheduled PDSCH:

* The corresponding HARQ-ACK bit belongs to the first sub-codebook.
  + Supported by NEC, Samsung?, Apple

[Moderator’s note to Issue 3.5-1] Given a small number of inputs, it is encouraged for companies to provide views on the above proposal, if any.

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| Company | Views |
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### Issue 3.5-2) Whether HARQ-ACK bits for 2 PDSCHs scheduled by a single DCI can be included in the first sub-codebook:

Agreement: (RAN1#105-e)

If Alt 1 (C-DAI/T-DAI is counted per DCI) is adopted for generating type-2 HARQ-ACK codebook corresponding to a DCI that can schedule multiple PDSCHs,

* At least two sub-codebooks are generated for a PUCCH cell group where
  + The first sub-codebook is for the following cases:
    - Any DCI that is not configured with CBG-based scheduling and is configured with TDRA table containing rows each with a single SLIV
    - Any DCI that is not configured with CBG-based scheduling and is configured with TDRA table containing at least one row with multiple SLIVs and schedules only a single PDSCH
  + The second sub-codebook is for the following case:
    - Any DCI that is configured with TDRA table containing at least one row with multiple SLIVs and schedules multiple PDSCHs
      * FFS: Methods (if needed) to align the size of HARQ-ACK feedback corresponding to different DCIs
      * FFS: Whether HARQ-ACK bits for 2 PDSCHs scheduled by this DCI can be included in the first sub-codebook in some cases
  + FFS: SPS PDSCH release, SCell dormancy indication without scheduled PDSCH
* FFS: 2 or 3 sub-codebooks if CBG is configured for a serving cell in the PUCCH cell group
* FFS: impact of time domain bundling, if supported, e.g., the number of sub-codebooks including single codebook if all A/N bits are bundled into a single bit per DCI

Company views on whether HARQ-ACK bits for 2 PDSCHs scheduled by a single DCI can be included in the first sub-codebook:

* Option 1: The HARQ-ACK bits for 2 PDSCHs scheduled by the DCI belongs to the first sub-codebook.
  + Supported by Intel, Apple
* Option 2: The HARQ-ACK bits for 2 PDSCHs scheduled by the DCI belongs to the second sub-codebook.
  + Supported by CATT, Samsung

[Moderator’s note to Issue 3.5-2] Given a small number of inputs, it is encouraged for companies to provide views on the above options, if any.

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| Company | Views |
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### Issue 3.5-3) How to handle the UE indicating by *type2-HARQ-ACK-Codebook* support:

Company views on how to handle the UE indicating by *type2-HARQ-ACK-Codebook* support:

* DAI is counted, first, in increasing order of the “first” PDSCH reception starting time for the same {serving cell, PDCCH monitoring occasion} pair
  + Supported by Samsung, LG Electronics

[Moderator’s note to Issue 3.5-3] Given a small number of inputs, it is encouraged for companies to provide views on the above proposal, if any.

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| Company | Views |
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### Issue 3.5-4) Whether/how to handle the case where only one PDSCH among multiple PDSCHs scheduled by a single DCI is valid:

Company views on whether/how to handle the case where only one PDSCH among multiple PDSCHs scheduled by a single DCI is valid:

* The remaining HARQ-ACK bit corresponding to the single PDSCH belongs to the first sub-codebook.
  + Supported by NEC, Qualcomm

[Moderator’s note to Issue 3.5-4] Given a small number of inputs, it is encouraged for companies to provide views on the above proposal, if any.

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| Company | Views |
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## Multi-PUCCH corresponding to single multi-PDSCH DCI

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| Company | Views |
| [4] ZTE | Proposal 5: HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s) considering HARQ-ACK feedback delay. |
| [7] OPPO | Proposal 7: Separate the scheduled PDSCHs into two groups, consider two PUCCH resources allocated for the two PDSCH groups, an earlier PUCCH is used to report HARQ-ACK information of the earlier PDSCH group. |
| [8] NEC | Proposal 3: HARQ-ACK information corresponding to the PDSCHs scheduled by a single DCI can be carried in an uplink slot or at most 2 uplink slots. |
| [12] Xiaomi | Proposal 8: For latency sensitive service, separate HARQ-ACK PUCCH resources for multiple PDSCHs scheduled by single DCI can be considered. |
| [13] Ericsson | Proposal 25: Do not support HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI to be carried by different PUCCH occasions. |
| [14] Nokia | Proposal 6: Single transmission of HARQ feedback per multi-PDSCH DCI is only supported. |
| [15] Panasonic | Proposal 6: Not to support HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s) in Rel. 17.  Observation 1: Different PUCCHs for multi-PDSCH scheduling from a span can be achieved by multiple DCIs using the functionality of FG3-5b specified in TR 38.822. |
| [16] Samsung | Proposal 16: HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI carried by different PUCCH(s) is not supported in Rel-17. |
| [17] MediaTek | Proposal 4: The HARQ-ACK information corresponding to the PDSCHs scheduled by a DCI should only be carried by single PUCCH to simplify Type-2 codebook design. |
| [21] Lenovo | Proposal 5: For NR operation between 52.6 GHz and 71 GHz, for HARQ-ACK information corresponding to PDSCHs scheduled by the DCI, different PUCCH(s) can be used where the PUCCH carrying the HARQ-ACK can be transmitted in the middle of non-contiguous PDSCHs transmissions to allow earlier/faster transmission of HARQ-ACK associated with earlier PDSCHs |
| [22] InterDigital | Observation 3: Supporting only one PUCCH transmission for HARQ-ACK of all the PDSCHs scheduled by a single DCI introduces excessive HARQ-ACK round trip delay and negative impact on the expected performance gains.  Proposal 2: Support multiple PUCCHs carrying HARQ information of multiple PDSCHs scheduled by a single DCI. To this end, multiple sub-codebooks, one for each PUCCH, with HARQ-ACK information of a sub-set of scheduled PDSCHSs can be constructed.  Proposal 3: To support multiple PUCCHs carrying HARQ-ACK information of a group of PDSCHs scheduled by a single DCI, extend TDRA table such that each row indicates multiple slot offsets (K0 values) corresponding to multiple HARQ-ACK sub codebooks. |
| [24] Apple | Proposal 13: For Rel-17 multi-PDSCH transmission   * The maximum number of PDSCHs that can be scheduled for 120 kHz and 480 kHz SCS can be further restricted based on UE capabilities. * For a DCI that can schedule multiple PDSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs, do not support/configure CBGTI/CBGFI fields * The FDRA size should be optimized to reduce the FDRA overhead. * Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz * New signaling is be needed for the PRI and DAI to support HARQ compared with multi-PUSCH transmission.   Observation 3: HARQ-ACK information corresponding to different PDSCHs scheduled by a single DCI carried by different PUCCHs affects the UE complexity, signaling overhead and transmission latency.  Proposal 23: RAN1 should decide whether a multi-PxSCH transmission can occur across multiple COTs and the specify the UE HARQ-ACK feedback behavior in the case that one or more of the PDSCH transmissions occurs outside a valid COT.  Proposal 24: RAN1 should support a single HARQ-ACK feedback for multi-PDSCH transmissions within a single COT only. |
| [26] Qualcomm | Proposal 9: All HARQ-ACK information corresponding to different PDSCHs scheduled by the same DCI to be carried by the same PUCCH. |

### Summary on whether or not HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s):

Company views on whether or not HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s):

* Supported by ZTE, OPPO, NEC, Xiaomi, Lenovo, InterDigital
* Objected by Ericsson, Nokia, Panasonic, Samsung, MediaTek, Qualcomm
* Apple: Single HARQ-ACK feedback for multi-PDSCH transmissions within a single COT only

[Moderator’s note] At least 6 companies suggest to support that HARQ-ACK information corresponding to different PDSCHs scheduled by a DCI is carried by different PUCCHs while 6 companies are against it. Therefore, it is proposed to deprioritize this issue in this meeting.

Please feel free to express views on Moderator’s note, if any.

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| Company | Views |
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## Others

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| Company | Views |
| [4] ZTE | Proposal 7: For NR FR2-2, at least for 480/960 kHz SCS, increasing the PDSCH-to-HARQ\_feedback timing indicator field to 4 or 5 bits should be supported. |
| [12] Xiaomi | Proposal 6: For multi-slot PDSCH scheduling, the HARQ-ACK PUCCH resource for the scheduled multi-slot PDSCH is determined by the last PDSCH among the multiple PDSCHs scheduled by a single DCI, even if the last PDSCH exceeds the COT. |
| [13] Ericsson | Observation 1: The HARQ process ID fields in various DCI formats need to be extended to support 32 HARQ processes. The bit field extension can be handled by the on-going work in the Rel-17 NTN WI.  Proposal 3: Monitor the progress on feedback-disabled HARQ process and its impact on Type-1 and Type-2 HARQ-ACK codebook construction in the Rel-17 NTN WI to capture any potential conflicts with HARQ-ACK codebook enhancement for multi-PDSCH scheduling in the Rel-17 60GHz WI.  Observation 6: For dynamic HARQ-ACK codebook with NACK padding, the positions of the padding bits have impact on the UCI decoding performance. It is preferable to map the padding bits to the less reliable Polar bits (i.e., Polar bits with lower reliability value) so as to improve the decoding performance at the receiver.  Proposal 24: Introduce a bit sequence manipulation scheme that is not dependent on the actual number of PDSCHs scheduled by a DCI but still able to relocate padding bits to the beginning of a HARQ-ACK codebook, e.g., based on block interleaver, so that the HARQ-ACK codebook is better optimized for Polar coding. |
| [17] MediaTek | Proposal 6: The UCI information bits including HARQ-ACK information bits should reuse the existing PUCCH payload size limit 1706. |
| [24] Apple | Proposal 25: In the case of BWP switching during multi-PxSCH transmission   * Option 1: The UE does not expect an UL or DL BWP change on the serving cell after the DCI scheduling the multi-PDSCH transmission and until the PUCCH is transmitted * Option 2: The UE will only send HARQ-ACK bits for the effective K1 values after the BWP switch. |

### Summary on other aspects for multi-PDSCH/PUSCH scheduling:

The following issues are brought up by several companies:

* ZTE: Increment of the PDSCH-to-HARQ\_feedback timing indicator field to 4 or 5 bits, at least for 480/960 kHz
* Xiaomi: HARQ-ACK PUCCH resource corresponding the scheduled multiple PDSCHs is determined by the last PDSCH, even if the last PDSCH exceeds the COT
* Ericsson: Monitor the progress on feedback-disabled HARQ process and its impact on Type-1 and Type-2 HARQ-ACK codebook construction in the Rel-17 NTN WI, if any
* Ericsson: Introduce a bit sequence manipulation scheme that is not dependent on the actual number of PDSCHs scheduled by a DCI but still able to relocate padding bits to the beginning of a HARQ-ACK codebook, e.g., based on block interleaver, so that the HARQ-ACK codebook is better optimized for Polar coding.
* MediaTek: Reuse the existing PUCCH payload size limit 1706.
* Apple: Clarification on BWP switching during multi-PDSCH reception (or multi-PUSCH transmission)

[Moderator’s note] Given a small number of inputs for those issues, it is proposed to deprioritize them in this meeting but please feel free to express views on above issues, if any.

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| Company | Views |
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# Reference

1. R1-2108771 PDSCH/PUSCH enhancements for 52-71GHz spectrum Huawei, HiSilicon
2. R1-2108786 Discussions on timeline, reference signal, and multi-PxSCH scheduling for 52.6GHz to 71GHz FUTUREWEI
3. R1-2108904 Discussion on PDSCH and PUSCH enhancements for above 52.6GHz Spreadtrum Communications
4. R1-2108938 Discussion on the data channel enhancements for 52.6 to 71GHz ZTE, Sanechips
5. R1-2108963 Discussions on PDSCH/PUSCH enhancements for NR operation from 52.6GHz to 71GHz vivo
6. R1-2109033 Considerations on multi-PDSCH/PUSCH with a single DCI and HARQ for NR from 52.6GHz to 71 GHz Fujitsu
7. R1-2109074 Discussion on PDSCH/PUSCH enhancements OPPO
8. R1-2109118 Discussion on PDSCH enhancements supporting NR from 52.6GHz to 71 GHz NEC
9. R1-2109163 PT-RS enhancements for NR from 52.6GHz to 71GHz Mitsubishi Electric RCE
10. R1-2109212 PDSCH/PUSCH enhancements for up to 71GHz operation CATT
11. R1-2109214 Some issues on SPS for one DCI scheduling multiple PDSCHs case CATT
12. R1-2109404 PDSCH and PUSCH enhancements for NR 52.6-71GHz Xiaomi
13. R1-2109438 PDSCH-PUSCH Enhancements Ericsson
14. R1-2109446 PDSCH/PUSCH enhancements Nokia, Nokia Shanghai Bell
15. R1-2109460 Discussion on PDSCH/PUSCH enhancements for NR 52.6-71 GHz Panasonic Corporation
16. R1-2109480 PDSCH/PUSCH enhancements for NR from 52.6 GHz to 71 GHz Samsung
17. R1-2109562 Multi-PDSCH scheduling design for 52.6-71 GHz NR operation MediaTek Inc.
18. R1-2109602 Discussion on PDSCH/PUSCH enhancements for extending NR up to 71 GHz Intel Corporation
19. R1-2109669 PDSCH/PUSCH enhancements for NR from 52.6 to 71 GHz NTT DOCOMO, INC.
20. R1-2109838 Enhancements of PDSCH/PUSCH Scheduling for 52.6 GHz to 71 GHz Band CEWiT
21. R1-2109901 PDSCH/PUSCH scheduling enhancements for NR from 52.6 GHz to 71GHz Lenovo, Motorola Mobility
22. R1-2109908 Discussion on PDSCH/PUSCH enhancements for supporting 52.6 GHz to 71 GHz Band InterDigital, Inc.
23. R1-2109965 PDSCH/PUSCH enhancements to support NR above 52.6 GHz LG Electronics
24. R1-2110025 Discussion on PDSCH and PUSCH Enhancements for NR above 52.6 GHz Apple
25. R1-2110113 PDSCH design consideration for NR from 52.6 GHz to 71 GHz Convida Wireless
26. R1-2110176 PDSCH/PUSCH enhancements for NR in 52.6 to 71GHz band Qualcomm Incorporated
27. R1-2110242 Discussion on multiple PDSCHs scheduled by a DCI ITRI
28. R1-2110321 Discussion on multi-PDSCH/PUSCH scheduling for NR from 52.6GHz to 71GHz WILUS Inc.

# Appendix: Previous agreements

Agreement: (RAN1#104-e)

* For a UE and for a serving cell, scheduling multiple PDSCHs by single DL DCI and scheduling multiple PUSCHs by single UL DCI are supported.
  + Each PDSCH or PUSCH has individual/separate TB(s) and each PDSCH/PUSCH is confined within a slot.
  + FFS: The maximum number of PDSCHs or PUSCHs that can be scheduled with a single DCI
  + FFS: Whether multiple PDSCH scheduling applies to 120 kHz in addition to 480 and 960 kHz
  + At least for 120 kHz SCS, single-slot scheduling with slot-based monitoring will still be supported as specified in Rel-15/Rel-16
* The followings will not be considered in this WI.
  + Single DCI to schedule both PDSCH(s) and PUSCH(s)
  + Single DCI to schedule one or multiple TBs where any single TB can be mapped over multiple slots, where mapping is not by repetition
  + Single DCI to schedule N TBs (N>1) where a TB can be repeated over multiple slots (or mini-slots)
* Note: This does not imply that existing slot aggregation and/or repetition for PDSCH and PUSCH by single DCI is precluded for the serving cell.

Agreement: (RAN1#104-e)

* For a DCI scheduling multiple PDSCHs, HARQ-ACK information corresponding to PDSCHs scheduled by the DCI is multiplexed with a single PUCCH in a slot that is determined based on K1,
  + where K1 (indicated by the PDSCH-to-HARQ\_feedback timing indicator field in the DCI or provided by *dl-DataToUL-ACK* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the DCI) indicates the slot offset between the slot of the last PDSCH scheduled by the DCI and the slot carrying the HARQ-ACK information corresponding to the scheduled PDSCHs.
    - It is noted that granularity of K1 can be separately discussed.
* FFS: If needed, further discuss whether or not HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s)

Agreement: (RAN1#104-e)

For generating type-2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, the following alternatives can be considered to DAI counting and will be down-selected in RAN1#104bis-e.

* Alt 1: C-DAI/T-DAI is counted per DCI.
* Alt 2: C-DAI/T-DAI is counted per PDSCH.
* Alt 3: C-DAI/T-DAI is counted per M scheduled PDSCH(s), where M is configurable (e.g., 1, 2, 4, …).
* FFS: Codebook generation details
* FFS: How to signal DAI values (e.g., increase of DAI bits for Alt 2 and Alt 3)
* FFS: Whether to apply time domain bundling of HARQ-ACK feedback

Agreement: (RAN1#104-e)

The multi-PUSCH scheduling defined in Rel-16 NR-U is the baseline for multi-PUSCH scheduling in Rel-17.

* FFS: Applicability to multi-PDSCH scheduling.

Agreement: (RAN1#104-e)

* For the multi-PUSCH scheduling in Rel-17, study the enhancement of the following in addition to Rel-16 multi-PUSCH scheduling.
  + CBGTI: Whether or not CBG (re)transmission is supported when more than one PUSCHs are scheduled (Already supported when only one PUSCH is scheduled).
  + CSI-request: Whether to apply same or different rule compared to Rel-16 (e.g., the PUSCH that carries the AP-CSI feedback is the first PUSCH that satisfies the multiplexing timeline).
  + TDRA: Down-select among
    - Alt 1: TDRA table is extended such that each row indicates up to [X, FFS for X] multiple PUSCHs (continuous in time-domain). Each PUSCH has a separate SLIV and mapping type. The number of scheduled PUSCHs is signalled by the number of indicated valid SLIVs in the row of the TDRA table signalled in DCI.
    - Alt 2: TDRA table is extended such that each row indicates up to [X, FFS for X] multiple PUSCHs (that can be non-continuous in time-domain). Each PUSCH has a separate SLIV and mapping type. The number of scheduled PUSCHs is signalled by the number of indicated valid SLIVs in the row of the TDRA table signalled in DCI.
    - Alt 3: TDRA table is extended such that each row indicates up to 8 multiple PUSCH groups (that can be non-continuous between PUSCH groups). Each PUSCH group has a separate SLIV, mapping type and number of slots/PUSCHs N. Within each PUSCH group, N PUSCHs occupy the same OFDM symbols indicated by the SLIV and mapping type. The number of scheduled PUSCHs is the sum of number of PUSCHs in all PUSCH groups in the row of the TDRA table signalled in DCI.
  + FDRA: Whether/how to enhance FDRA e.g., by increasing RBG size or changing allocation granularity
  + Frequency hopping: Whether/how to support frequency hopping for scheduled PUSCHs, e.g., inter-PUSCH/intra-PUSCH hopping
  + URLLC related fields such as priority indicator and open-loop power control parameter set indication: Whether/how to apply URLLC related fields for scheduled PUSCHs
  + Applicability to multi-PDSCH scheduling in Rel-17.
  + Note: Other enhancements are not precluded.

Agreement: (RAN1#104bis-e)

* The maximum number of PDSCHs that can be scheduled with a single DCI in Rel-17 is 8 for SCS of 480 and 960 kHz.
  + FFS: Further restrictions for 480 kHz to 4
  + FFS: A UE capability to select between 4 and 8 for 480 kHz SCS
  + Note: Multi-PDSCH scheduling for the case of 120 kHz SCS is still FFS as per prior agreement. This case can be addressed after this FFS has been decided.
* The maximum number of PUSCHs that can be scheduled with a single DCI in Rel-17 is 8.
  + FFS: Further restrictions for 120 kHz and 480 kHz SCS
  + FFS: A UE capability to select between different values for 120 kHz and 480 kHz SCS

Agreement: (RAN1#104bis-e)

For a DCI that can schedule multiple PDSCHs,

* MCS for the 1st TB: This appears only once in the DCI and applies commonly to the first TB of each PDSCH
* NDI for the 1st TB: This is signaled per PDSCH and applies to the first TB of each PDSCH
* RV for the 1st TB: This is signaled per PDSCH, with 2 bits if only a single PDSCH is scheduled or 1 bit for each PDSCH otherwise and applies to the first TB of each PDSCH
* HARQ process number: This applies to the first scheduled PDSCH and is incremented by 1 for subsequent PDSCHs (with modulo operation, if needed)
* FFS:
  + MCS/NDI/RV for the 2nd TB for each PDSCH, including whether scheduling of the 2nd TB for each PDSCH can be supported or not
  + Details of resource allocation related fields such as VRB-to-PRB mapping, PRB bundling size indicator, rate matching indicator, and ZP CSI-RS trigger
  + Whether/how to signal CBGFI/CBGTI if CBGFI/CBGTI is supported for multi-PDSCH scheduling
  + Details of fields that are common with multi-PUSCH scheduling, e.g., TDRA, FDRA, priority indicator, including potential enhancements

Agreement: (RAN1#104bis-e)

* For a DCI that can schedule multiple PUSCHs,
  + TDRA: Alt 2 (TDRA table is extended such that each row indicates up to 8 multiple PUSCHs (that can be non-continuous in time-domain). Each PUSCH has a separate SLIV and mapping type. The number of scheduled PUSCHs is implicitly indicated by the number of indicated valid SLIVs in the row of the TDRA table signalled in DCI.), as per agreement made in RAN1#104-e
    - FFS: signaling details
  + Note: Alt 2 does not preclude continuous resource allocation in time-domain.
* For a DCI that can schedule multiple PDSCHs,
  + TDRA: TDRA table is extended such that each row indicates up to 8 multiple PDSCHs (that can be non-continuous in time-domain). Each PDSCH has a separate SLIV and mapping type. The number of scheduled PDSCHs is implicitly indicated by the number of indicated valid SLIVs in the row of the TDRA table signalled in DCI.
    - FFS: signaling details
  + Note: This does not preclude continuous resource allocation in time-domain.
  + Note: Multi-PDSCH scheduling for the case of 120 kHz SCS is still FFS as per prior agreement. This case can be addressed after this FFS has been decided.

Agreement: (RAN1#104bis-e)

For enhancements of generating type-1 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, the following options can be considered,

* Option 1: The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set
* Option 1a: The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table
* Option 2: The set of candidate PDSCH reception occasions is determined according to the last SLIV of each row in the TDRA table
* FFS: Codebook generation details, including how to handle the collision with TDD DL/UL configuration and whether/how to extend K1 set based on K1 and slot offset between last PDSCH and other PDSCHs in a row in the TDRA table

Conclusion: (RAN1#104bis-e)

The following is observed for alternative 1 from prior agreement.

* For Alt 1 (C-DAI/T-DAI is counted per DCI) of generating type-2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs,
  + C-DAI/T-DAI in DL DCI: Same DAI overhead with Rel-16 single-PDSCH DCI
  + T-DAI in UL DCI:
    - In case of single codebook handling feedback for both single and multi-PDSCH scheduling, same DAI overhead with Rel-16 UL DCI
    - In case of separate sub-codebooks, need additional DAI field (with same bit-width of DAI with Rel-16 UL DCI), in UL DCI for all serving cells including a serving cell not configured with multi-PDSCH DCI
      * Note that DAI field increment for this case is similar for the case in Rel-15 where CBG is configured
  + HARQ-ACK codebook generation:
    - A separate sub-codebook can be generated when multi-PDSCH DCI is configured for a serving cell, similar to the way as 2nd sub-codebook is defined to handle CBG-based scheduling
      * FFS: whether single codebook or separate sub-codebooks is(are) generated when multi-PDSCH DCI is configured for a serving cell
      * FFS: how many sub-codebooks are generated when multi-PDSCH DCI is configured for a serving cell and CBG is configured for the serving cell and/or the other serving cell(s)
    - HARQ-ACK payload size is increased compared to single PDSCH scheduling only, since the number of HARQ-ACK bits corresponding to each DAI of the (sub-)codebook for multi-PDSCH DCI in case of separate sub-codebooks (or for all DL DCIs in case of single codebook) depends on the maximum configured number of PDSCHs for multi-PDSCH DCI across serving cells belonging to the same PUCCH cell group.
    - The number of HARQ-ACK bits for multi-PDSCH DCI in case of separate sub-codebooks, or for all DL DCIs in case of single codebook, does not depend on the number of actually scheduled PDSCHs, rather, it is fixed as the maximum configured number of PDSCHs.
    - FFS: time domain bundling of HARQ-ACK feedback, as per agreement in RAN1#104-e
  + Note that multi-PDSCH DCI refers to a DL DCI where at least one entry of the TDRA table allows scheduling more than one PDSCH

Conclusion: (RAN1#104bis-e)

The following is observed for alternative 2 from prior agreement.

* For Alt 2a (C-DAI/T-DAI is counted per PDSCH with a single codebook) of generating type-2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs,
  + C-DAI/T-DAI in DL DCI: Bit-width can be increased (FFS: by how much), in DL DCI not only for multi-PDSCH DCI but also for single-PDSCH DCI for all serving cells including a serving cell not configured with multi-PDSCH DCI
  + T-DAI in UL DCI: Bit-width can be increased (FFS: by how much), in UL DCI for all serving cells including a serving cell not configured with multi-PDSCH DCI
  + C-DAI/T-DAI in DL DCI and T-DAI in UL DCI shall be designed such that at most 3 consecutive DCI missing can be resolved, same as in Rel-15/16 NR.
    - FFS: details on increment of DAI field size
    - FFS: whether/how to handle the case where different DCI formats (e.g., DCI format 1\_0 and DCI format 1\_1) have different field sizes for C-DAI/T-DAI
  + HARQ-ACK codebook generation:
    - The number of HARQ-ACK bits depends on the number of scheduled PDSCHs.
    - FFS: ordering of the PDSCHs for DAI counting
    - FFS: time domain bundling of HARQ-ACK feedback, as per agreement in RAN1#104-e
  + Note that multi-PDSCH DCI refers to a DL DCI where at least one entry of the TDRA table allows scheduling more than one PDSCH

Conclusion: (RAN1#104bis-e)

The following is observed for alternative 3 from prior agreement.

* For Alt 3 (C-DAI/T-DAI is counted per M scheduled PDSCH(s), where M is configurable) of generating type-2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs,
  + If M equals to the maximum configured number of PDSCHs, Alt 3 is the same with Alt 1, if the same number of codebooks is assumed.
  + Else if M equals to 1, Alt 3 is the same with Alt 2.
  + Otherwise (i.e., 1<M<the maximum configured number of PDSCHs), Alt 3 is similar to Alt 2, except that
    - The number of HARQ-ACK bits corresponding to each DAI increases by M times.
    - NACK bits may be padded if the number of scheduled PDSCHs is not an integer multiple of M.
    - FFS: details on DAI field size
    - FFS: whether single codebook or separate sub-codebooks is(are) generated when multi-PDSCH DCI is configured for a serving cell
  + In addition, new RRC parameter to configure M needs to be introduced.
  + Note that multi-PDSCH DCI refers to a DL DCI where at least one entry of the TDRA table allows scheduling more than one PDSCH

Agreement: (RAN1#105-e)

* Do not use fallback DCI (i.e., DCI formats 0\_0 and 1\_0) for multi-PDSCH/PUSCH scheduling.
* Use DCI format 0\_1 to schedule multiple PUSCHs with a single DCI.
* Use DCI format 1\_1 to schedule multiple PDSCHs with a single DCI.

Conclusion: (RAN1#105-e)

For a DCI that can schedule multiple PUSCHs,

* CSI-request: When the DCI schedules M PUSCHs, the PUSCH that carries the aperiodic CSI feedback is M-th scheduled PUSCH for M <= 2, or (M-1)-th scheduled PUSCH for M > 2.

Agreement: (RAN1#105-e)

* If a PDSCH among multiple PDSCHs that are scheduled by a single DCI is collided with uplink symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, the UE does not receive the PDSCH.
  + FFS on how to handle HARQ-related issue for the PDSCH (e.g., HARQ process numbering)
* The UE does not expect to be scheduled with multiple PDSCHs by a single DCI, where every PDSCH is collided with uplink symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*.
* If a PUSCH among multiple PUSCHs that are scheduled by a single DCI is collided with downlink symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, the UE does not transmit the PUSCH.
  + FFS on how to handle HARQ-related issue for the PUSCH (e.g., HARQ process numbering)
* The UE does not expect to be scheduled with multiple PUSCHs by a single DCI, where every PUSCH is collided with downlink symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*.

Agreement: (RAN1#105-e)

For TDRA in a DCI that can schedule multiple PDSCHs (or PUSCHs),

* A row of the TDRA table can indicate PDSCHs (or PUSCHs) that are in consecutive or non-consecutive slots.
  + FFS: The maximum value of the gap between two consecutively scheduled PDSCHs or between two consecutively scheduled PUSCHs
  + FFS: The maximum value of the gap between the first scheduled PDSCH and the last scheduled PDSCH or between the first scheduled PUSCH and the last scheduled PUSCH
  + FFS: Details to introduce the gap between PDSCHs or between PUSCHs

Agreement: (RAN1#105-e)

For enhancements of generating type-1 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, the set of candidate PDSCH reception occasions corresponding to a UL slot with HARQ-ACK transmission is determined based on a set of DL slots and a set of SLIVs corresponding to each DL slot belonging to the set of DL slots.

* The set of DL slots includes all the unique DL slots that can be scheduled by any row index r of TDRA table in DCI indicating the UL slot as HARQ-ACK feedback timing.
* The set of SLIVs corresponding to a DL slot (belonging to the set of DL slots) at least include all the SLIVs that can be scheduled within the DL slot by any row index r of TDRA table in DCI indicating the UL slot as HARQ-ACK feedback timing.
  + FFS: details of further pruning of the set of SLIVs
  + FFS: impact if receiving more than one PDSCH in a slot is allowed, e.g., handling of overlapped SLIVs from different rows in the same and different DL slot
  + FFS impact of time domain bundling, if supported

Agreement: (RAN1#105-e)

* At least for 120 kHz SCS, for a DCI that can schedule multiple PUSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs,
  + If CBG-based (re)transmission is configured, CBGTI field is not present when more than one PUSCHs are scheduled, but is present when a single PUSCH is scheduled, as in Rel-16.
* FFS:
  + For 480/960 kHz SCS, whether to apply the same behavior with 120 kHz SCS or not to support CBGTI field configuration in the DCI that can schedule multiple PUSCHs
  + For a DCI that can schedule multiple PDSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs, whether/how to configure CBGTI/CBGFI fields

Agreement: (RAN1#105-e)

If Alt 1 (C-DAI/T-DAI is counted per DCI) is adopted for generating type-2 HARQ-ACK codebook corresponding to a DCI that can schedule multiple PDSCHs,

* At least two sub-codebooks are generated for a PUCCH cell group where
  + The first sub-codebook is for the following cases:
    - Any DCI that is not configured with CBG-based scheduling and is configured with TDRA table containing rows each with a single SLIV
    - Any DCI that is not configured with CBG-based scheduling and is configured with TDRA table containing at least one row with multiple SLIVs and schedules only a single PDSCH
  + The second sub-codebook is for the following case:
    - Any DCI that is configured with TDRA table containing at least one row with multiple SLIVs and schedules multiple PDSCHs
      * FFS: Methods (if needed) to align the size of HARQ-ACK feedback corresponding to different DCIs
      * FFS: Whether HARQ-ACK bits for 2 PDSCHs scheduled by this DCI can be included in the first sub-codebook in some cases
  + FFS: SPS PDSCH release, SCell dormancy indication without scheduled PDSCH
* FFS: 2 or 3 sub-codebooks if CBG is configured for a serving cell in the PUCCH cell group
* FFS: impact of time domain bundling, if supported, e.g., the number of sub-codebooks including single codebook if all A/N bits are bundled into a single bit per DCI

Agreement: (RAN1#105-e)

If Alt 2 (C-DAI/T-DAI is counted per PDSCH) is adopted for generating type-2 HARQ-ACK codebook corresponding to a DCI that can schedule multiple PDSCHs,

* PDSCH(s) scheduled by a single DCI is counted firstly, serving cell(s) in the same PUCCH cell group and same PDCCH monitoring occasion is counted secondly, and PDCCH monitoring occasion(s) is counted thirdly.
* The bit width of counter DAI field in fallback DCI (i.e., DCI formats 0\_0 and 1\_0) remains the same as in Rel-15 NR.
* Note: The DAI bit width and number of sub-codebooks shall ensure that at most 3 consecutive missed DCIs can be resolved, same as in Rel-15/16 NR
  + This shall not impose additional gNB’s scheduling restriction.
* In case where CBG retransmission is not configured for any serving cell in a same PUCCH cell group, the number of bits for each of counter DAI and total DAI in non-fallback DCI is extended (if needed) at least based on
  + The number of SLIVs associated with the row indexes in TDRA table
    - FFS: details
* FFS: the case with configuration of CBG retransmission
* FFS: the number of sub-codebooks
* FFS: for the UE indicating 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

Working assumption: (RAN1#106-e)

Scheduling multiple PDSCHs by single DL DCI applies to 120 kHz in addition to 480 and 960 kHz at least in FR2-2.

* FFS: Further limitations on maximum number of PDSCHs

Agreement: (RAN1#106-e)

Adopt Alt 1 (C-DAI/T-DAI is counted per DCI) for generating type-2 HARQ-ACK codebook corresponding to a DCI that can schedule multiple PDSCHs.

Agreement: (RAN1#106-e)

* The maximum number of PDSCHs/PUSCHs that can be scheduled with a single DCI in Rel-17 is 8 for SCS of 120, 480 and 960 kHz.
* FFS: Whether UE capability is introduced for restricting the maximum number of PDSCHs or PUSCHs that can be scheduled with a single DCI

Agreement: (RAN1#106-e)

If a scheduled PDSCH/PUSCH is dropped due to collision with UL/DL symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, HARQ process number increment is skipped for the PDSCH/PUSCH and applied only for valid PDSCH(s)/PUSCH(s).

* FFS: HARQ process number determination for the case where a scheduled PDSCH/PUSCH collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*) if the UE is configured to monitor DCI format 2\_0.

Agreement: (RAN1#106-e)

* For a DCI that can schedule multiple PUSCHs,
  + Priority indicator and open loop power control parameter set indication fields are applied to all of scheduled PUSCHs.
* For a DCI that can schedule multiple PDSCHs,
  + Priority indicator field is applied to all of scheduled PDSCHs.

Agreement: (RAN1#106-e)

For TDRA in a DCI that can schedule multiple PDSCHs (or PUSCHs),

* A row of the TDRA table can indicate PDSCHs (or PUSCHs) that are in consecutive or non-consecutive slots, by configuring {SLIV, mapping type, scheduling offset K0 (or K2)} for each PDSCH (or PUSCH) in the row of TDRA table.
* Note: Whether and how to reduce RRC overhead is left to RAN2.

Agreement: (RAN1#106-e)

For a DCI that can schedule multiple PDSCHs,

* Each of VRB-to-PRB mapping, PRB bundling size indicator, ZP-CSI-RS trigger, and rate matching indicator fields appears only once in the DCI.
* VRB-to-PRB mapping and PRB bundling size indicator fields are applied to all the PDSCHs scheduled by the DCI.
* For ZP-CSI-RS trigger field, the triggered aperiodic ZP CSI-RS is applied to all the slot(s) in which the PDSCH(s) scheduled by the DCI are contained.
* When receiving a PDSCH scheduled by the DCI, the REs corresponding to configured resources in *rateMatchPatternGroup1* or *rateMatchPatternGroup2* (according to indication of rate matching indicator field) are not available for the scheduled PDSCH.

Working assumption: (RAN1#106-e)

For NR FR2-2, two codeword transmission is supported, subject to UE capability.

* RRC parameter configures whether two codeword transmission is enabled or disabled.
  + FFS: Details on signaling of MCS/NDI/RV for the second TB in a DCI that can schedule multiple PDSCHs when two codeword transmission is enabled
  + FFS: Whether unified or separate parameter to enable/disable 2-TB for single and for multiple PDSCH scheduling
  + Strive to minimize the increase in the number of bits in the DCI needed to support this feature

Agreement: (RAN1#106-e)

* For single TRP operation, for 480/960 kHz SCS,
  + FFS: A UE does not expect to be scheduled with more than one PDSCH in a slot, by a single DCI or multiple DCIs.
  + FFS: A UE does not expect to be scheduled with more than one PUSCH in a slot, by a single DCI or multiple DCIs.
* For single TRP operation, for 120 kHz SCS (same as current specification for FR2-1 for PUSCH),
  + Subject to UE capability, a UE can be scheduled with more than one PDSCH in a slot, by a single DCI or multiple DCIs.
  + Subject to UE capability, a UE can be scheduled with more than one PUSCH in a slot, by a single DCI or multiple DCIs.
* FFS for multi-TRP operation
* Note: The optimization of HARQ codebook size for Type 1 or Type 2 codebook design is considered as a low priority in Rel-17 (this does not preclude HARQ ACK bundling in time domain).
* The agreement made in RAN1#105-e is revised as follows.

|  |
| --- |
| Agreement: (RAN1#105-e)  For enhancements of generating type-1 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, the set of candidate PDSCH reception occasions corresponding to a UL slot with HARQ-ACK transmission is determined based on a set of DL slots and a set of SLIVs corresponding to each DL slot belonging to the set of DL slots.   * The set of DL slots contains all the unique DL slots determined by considering all combinations of the configured K1 values and the configured rows of the TDRA table. * The set of SLIVs corresponding to a DL slot (belonging to the set of DL slots) contains all the SLIVs for that slot determined by considering all combinations of the configured K1 values and the configured rows of the TDRA table. * The Rel-16 procedure is reused for determining the candidate PDSCH reception occasions for the set of SLIVs corresponding to each DL slot belonging to the set of DL slots   + Note: The Rel-16 procedure already handles pruning of multiple SLIVs corresponding to a DL slot, for both UEs that are and are not capable of receiving multiple PDSCHs per slot   + FFS impact of time domain bundling, if supported |

Agreement: (RAN1#106-e)

Consider the following options to construct type-2 HARQ-ACK codebook when CBG operation is configured, and down-select to one of the following options in RAN1#106bis-e.

* Option 1: HARQ-ACK bits corresponding to CBG-based PDSCH reception and multi-PDSCH reception are merged into the same sub-codebook.
* Option 2: HARQ-ACK bits corresponding to CBG-based PDSCH reception and HARQ-ACK bits corresponding to multi-PDSCH reception are contained in separate sub-codebooks.
* Option 3: UE does not expect to be configured with both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group.
* Note: Multi-PDSCH reception refers to the case where multiple PDSCHs are scheduled by a DCI that is configured with TDRA table containing at least one row with multiple SLIVs.

Agreement: (RAN1#106-e)

For NR FR2-2 at least for 480/960 kHz SCS, support 32 as the maximum number of HARQ processes for DL and UL, subject to UE capability.

* Note: Up to 32 maximal supported HARQ process number is already agreed in Rel-17 NTN WI.
* Working assumption: The same solution to support up to 32 HARQ process number in Rel-17 NTN WI is reused for NR FR2-2.