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

**e-Meeting, August 16th – 27th, 2021**

**Agenda Item:** 8.2.5

**Source:** Moderator (LG Electronics)

**Title:** Summary #4 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:

[106-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 August 19, 24 and 27 – Seonwook (LGE)

# Multi-PDSCH/PUSCH scheduling

## Maximum # of scheduled PDSCHs/PUSCHs

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| Company | Views |
| [3] vivo | Proposal 9: The maximum number, i.e. 8, of PDSCHs/PUSCHs that can be scheduled with a single DCI is uniformly applied to all SCSs, with no further restriction or UE capability. |
| [5] InterDigital | Observation 6: Ability to schedule a single slot with SCSs 480 kHz and 960 kHz can be useful to support delay sensitive applications.  Proposal 9: Minimum number of slots that can be schedule by a single DCI for SCSs 480 kHz and 960 kHz is 1.  Proposal 10: The maximum number of PDSCHs or PUSCHs scheduled by a single DCI is 8 for both 480 kHz and 960 kHz SCS. Subject to the maximum configurable value, gNB can dynamically indicate the maximum number of PDSCHs/PUSCHs UE can expect. |
| [7] Lenovo | Proposal 2: For NR operation between 52.6 GHz and 71 GHz with 480 kHz, support scheduling up to 4 PDSCHs by single DCI  Proposal 3: For NR operation between 52.6 GHz and 71 GHz with 120 kHz and 480 kHz, support scheduling up to 8 PUSCHs by single DCI, like 960 kHz SCS |
| [9] CATT | Proposal 9: For SCS of 480 KHz, it is not needed to restrict the maximum number of PDSCHs to 4. |
| [10] ZTE | Proposal 3: Further restriction on the maximum number of PUSCH/PDSCHs scheduled by a single DCI for 120 kHz and 480 kHz SCS is not needed. |
| [11] Fujitsu | Proposal 1: For 120, 480 and 960 kHz SCS, the maximum number of PDSCHs or PUSCHs that can be scheduled with a single DCI in Rel-17 is 8. |
| [13] Ericsson | Proposal 2: No further restriction or UE capability for 120 and 480 kHz SCS on the maximum number of PDSCHs that can be scheduled with a single DCI.  Proposal 3: No further restriction or UE capability for 120 and 480 kHz SCS on the maximum number of PUSCHs that can be scheduled with a single DCI |
| [15] Nokia | Proposal 1: The maximum number of PxSCH that can scheduled with a single DCI in Rel-17 is 8 also for 480 kHz SCS. All UEs need to support at maximum 8 PxSCH for both 480 kHz and 960 kHz SCSs. |
| [17] OPPO | Proposal 1: The maximum number of PDSCHs/PUSCHs that can be scheduled with a single DCI should be 8 for all the supported SCSs. |
| [18] Qualcomm | Proposal 9: A UE capability to be defined per SCS, to indicate the maximum number of supported PDSCHs/PUSCHs per single DCI for SCS 120kHz and 480kHz. |
| [19] LG Electronics | Proposal #1: Do not restrict the maximum number of PDSCHs or PUSCHs that can be scheduled with a single DCI to less than 8 for 120 and/or 480 kHz SCS. |
| [22] Apple | Proposal 8: 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.  Proposal 11: 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. |
| [23] Panasonic | Proposal 1: The specification supports 8 as the maximum number of PDSCHs and PUSCH respectively in any SCS in licensed/unlicensed band usage. The UE capability should be discussed later. |
| [24] NTT DOCOMO | Proposal 3: For multi-PDSCH/PUSCH scheduling,   * No need to restrict the maximum number of scheduled PDSCHs/PUSCHs to be smaller than 8 for 480 kHz and/or 120 kHz SCS. |

### Summary on the maximum number of scheduled PDSCHs/PUSCHs:

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

Company views on the maximum number (=N\_max) of PDSCHs or PUSCHs that can be scheduled by a single DCI:

* N\_max =8 for all SCSs
  + Supported by vivo, InterDigital, CATT, ZTE, Fujitsu, Ericsson, Nokia, OPPO, LG Electronics, NTT DOCOMO
* Additional restriction for 120 kHz SCS or 480 kHz SCS
  + Supported by Lenovo (up to 4 PDSCHs, but up to 8 PUSCHs)
* UE capability
  + Supported by Qualcomm, Apple, Panasonic

[Moderator’s note] 10 companies suggest not to further restrict N\_max to less than 8 for 120 and/or 480 kHz SCS. 1 company suggests to restrict N\_max to 4 for multi-PDSCH case with 480 kHz SCS. 3 companies suggest to define UE capability on how many N\_max can be supported by a UE. Considering the majority view, the following conclusion can be made.

**Proposed conclusion #1 (Max. # of scheduled PDSCHs/PUSCHs):**

* No further restriction for 480 kHz on the maximum number of PDSCHs that can be scheduled with a single DCI.
* No further restriction for 120 kHz and 480 kHz on the maximum number of PUSCHs that can be scheduled with a single DCI.
* Note: UE capability for restricting the maximum number of PDSCHs or PUSCHs that can be scheduled with a single DCI can be separately discussed.

Companies are encouraged to provide views on proposed conclusion #1.

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| Company | Views |
| Lenovo, Motorola Mobility | Although, we support the restriction of maximum number of PDSCHs and PUSCHs for 480kHz, but for the sake of progress we are open to discuss this as UE capability. We suggest following update to the proposal and make this as a proposed agreement:   * No further restriction for 480 kHz on the maximum number of PDSCHs that can be scheduled with a single DCI. * No further restriction for 120 kHz and 480 kHz on the maximum number of PUSCHs that can be scheduled with a single DCI. * ~~Note:~~FFS: Whether UE capability is introduced for restricting the maximum number of PDSCHs or PUSCHs that can be scheduled with a single DCI ~~can be separately discussed.~~ |
| Ericsson | Support Conclusion #1 |
| Nokia/NSB | Support proposed conclusion #1. |
| Qualcomm | We are okay with not imposing a hardcoded restriction for 480kHz and 120kHz, instead we support define a UE capability based limitation |
| CATT | Support the conclusion. |
| Huawei, HiSilicon | Ok with the proposal conclusion #1 |
| Apple | We are fine with the conclusion. Okay with Lenovo’s update. |
| Intel | We are fine with the proposal.  It may be good to add that “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.” to avoid confusion as “no further restriction” may interpret no future restriction to the maximum number. |
| Fujitsu | Support conclusion #1 and fine with Intel’s update. |
| Futurewei | For SCS 480kHz, fine with no further restrictions on the maximum number of PxSCHs that can be scheduled with a single DCI. |
| Moderator | Based on comments and working assumption made in GTW session, the following proposal #0 can be made. |

**Proposal #0 (Max. # of scheduled PDSCHs/PUSCHs):**

* 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

Companies are encouraged to provide views on proposed #0.

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| Company | Views |
| Panasonic | We support the proposal#0 |
| DOCOMO | Support the proposal. |
| Samsung | Support proposal #0. We’re open for UE capability indication. |
| Fujitsu | We support Proposal #0. |
| ZTE, Sanechips | We support Proposal #0 |
| vivo | Support the proposal. |
| Qualcomm | We are fine with the proposal |
| Intel | We support proposal #0. |
| Ericsson | Support Proposal#0 |
| Sony | We support proposal#0 |
| Apple | We support the proposal |
| CATT | Support the proposal. |
| Spreadtrum | We support proposal#0. |
| Lenovo, Motorola Mobility | We support the proposal#0 |
| Xiaomi | Support the proposal#0 |
| OPPO | Support the proposal. |
| Moderator | Seems stable. Proposal #0 will be reported for email endorsement. |

During email discussion, the following agreement was made:

### Agreement:

* 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

## Multi-PDSCH scheduling for 120 kHz

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| Company | Views |
| [3] vivo | Proposal 18: Multi-PDSCH scheduling is applicable to 120 kHz SCS, as well as 480 and 960 kHz SCSs. |
| [7] Lenovo | Proposal 1: For NR operation between 52.6 GHz and 71 GHz with 120 kHz, multi-PDSCH scheduling enhancements are not considered in NR Rel-17, i.e., only single PDSCH can be scheduled by single DCI for 120 kHz SCS |
| [10] ZTE | Proposal 3: Multi-PDSCH scheduling for 120 kHz SCS is supported. |
| [13] Ericsson | Proposal 1: Support multiple PDSCH scheduling for 120 kHz SCS. |
| [15] Nokia | Proposal 3: Support multi-PDSCH also for 120 kHz SCS  • Consider multi-PDSCH also for FR2. |
| [18] Qualcomm | Proposal 8: 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. |
| [19] LG Electronics | Proposal #2: Apply scheduling multiple PDSCHs by single DL DCI to all SCSs including 480 and 960 kHz. |
| [21] Intel | Proposal 1: Maximum number of PDSCHs that can be scheduled with a single DCI is 8 for 120 kHz SCS. |
| [22] Apple | Proposal 11: For Rel-17 multi-PDSCH transmission  • Multiple PDSCH scheduling applies to 120 kHz SCS in addition to 480 and 960 kHz SCS |
| [24] NTT DOCOMO | Proposal 3: For multi-PDSCH/PUSCH scheduling,   * Multi-PDSCH scheduling can apply to 120 kHz in addition to 480 kHz and 960 kHz SCS. |

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

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.

Company views on the applicability of 120 kHz SCS for multi-PDSCH scheduling:

* Supported by vivo, ZTE, Ericsson, Nokia, Qualcomm, LG Electronics, Intel, Apple, NTT DOCOMO
* Objected by Lenovo

[Moderator’s note] 9 companies support multi-PDSCH scheduling for 120 kHz while 1 company opposes to it. Considering the majority view, the following proposal #1 can be made. This issue is indicated as “HIGH” since it may have an impact on other issues for multi-PDSCH scheduling and HARQ-ACK codebook design.

**[HIGH] Proposal #1 (Support of 120 kHz for multi-PDSCH scheduling):**

* Scheduling multiple PDSCHs by single DL DCI applies to 120 kHz in addition to 480 and 960 kHz.

Companies are encouraged to provide views on Proposal #1.

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| Company | Views |
| Lenovo, Motorola Mobility | Support the proposal#1 |
| Ericsson | Support Proposal #1.  Multi-PUSCH scheduling is supported for 120/480/960. We do not see reason to restrict multi-PDSCH scheduling to only 480/960. |
| Nokia/NSB | Support Proposal #1 |
| Qualcomm | We support the proposal |
| CATT | Support. |
| Huawei, HiSilicon | Ok with proposal #1, with the understanding (from earlier agreement) that scheduling multiple PDSCHs by a single DCI with 120 kHz SCS will rely on per-slot PDCCH monitoring UE capability for 120 kHz SCS. |
| Apple | Support the proposal |
| Convida Wireless | Multi-PUSCH scheduling can be supported for 120/480/960 KHz. Also, legacy scheduling (e.g., single PDSCH/PUCCH) can be supported for 120 KHz. |
| Intel | We are fine with the proposal. |
| Fujitsu | Support Proposal #1. Additionally, the maximum number of PDSCHs that can be scheduled by a single DCI for 120kHz is same as that for 480/960kHz. |
| ITRI | Support the proposal |
| Futurewei | We do not support scheduling multiple PDSCHs by single DL DCI applied to 120kHz. The reason is that we do not feel that there is any technical discussion on why multiple PDSCH should be supported for SCS 120kHz, given that the time of multi-slot could surpass the coherence time over 8 slots if scheduled with SCS 120kHz, which is against the initial intention to schedule multiple PDSCH for FR2-2.  In principle, multiple PDSCH can be scheduled if gNB decided that the channel is stationary i.e. based on some statistics and measurement. |
| CEWiT | Support the proposal#1 |
| OPPO | Support the proposal #1. |

On 8/17 GTW session, the following working assumption was made:

### Working assumption:

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

## Handling of collision with semi-static DL/UL symbols

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| Company | Views |
| [1] Huawei | Proposal 8: As for Rel-16 multi-PUSCH scheduling, determine the HARQ process ID for each PDSCH/PUSCH by incrementing the HARQ process ID by one starting from the first PDSCH/PUSCH, independently of potential resource collisions with UL/DL symbols. If the resource collides with a pre-configured resource, NACK corresponding to the collided PDSCH should be reported by the UE. |
| [3] vivo | Proposal 12: No HARQ process is required to be allocated to a scheduled PDSCH/PUSCH that is collided with semi-static uplink/downlink symbol(s). |
| [5] InterDigital | Proposal 8: Carefully evaluate the impact of PDSCHs that overlaps with semi-static UL symbol(s) on the HARQ design considering the impact on specifications. |
| [8] Samsung | Proposal 7: For Rel-16 NR-U multi-PUSCH scheduling DCI:   * HARQ process number: HARQ process number increments only for valid PUSCHs (no collision with semi-static DL symbol) |
| [9] CATT | Proposal 6: When the scheduled PDSCH overlaps with uplink slot/symbols, the corresponding PDSCH scheduled can be treated as an invalid SLIV.  Proposal 7: The HARQ process ID can be still consecutive when one or more SLIVs value is invalid.  Proposal 8: For some special HARQ process ID（e.g. ID that is assigned to SPS PDSCH by RRC, FFS whether/how to skip occupied HARQ process ID of SPS when the dynamic scheduling overlaps with these process ID. |
| [11] Fujitsu | Proposal 2: HARQ process numbering for multi-PDSCH/PUSCH scheduling should be based on the scheduled PDSCHs/PUSCHs which are not collided with the semi-statically configured UL/DL symbols. |
| [12] CEWiT | Proposal1: Two alternatives are proposed to deal with HARQ process numbering in case of mismatch between resource configuration and scheduling   * Alt 1. The HARQ process number will be incremented for all PDSCH including the PDSCHs scheduled in the slots where mismatch occurs. * Alt 2. The HARQ process number will be incremented by skipping the PDSCHs scheduled in the slots where mismatch occurs.   Proposal 2: In cases, where the HARQ process ID is incremented also for slots with mismatch between resource configuration and scheduling, reuse of the corresponding HARQ ID for some other PDSCH is supported. |
| [13] Ericsson | Proposal 7: If a scheduled PDSCH/PUSCH is dropped due to collision with semi-statically configured UL/DL OFDM symbol(s), the HARQ process ID is not incremented. Incrementing continues at the next valid PDSCH/PUSCH. |
| [14] Futurewei | Proposal 8. A consistent way to handle the HARQ processing number issues should be pursued for PDSCH and PUSCH, as a part of collision handling.  Proposal 9. If a PDSCH/PUSCH in the multi-PDSCH/PUSCH collides with a UL/DL symbol, the HARQ processing number of the colliding slot is canceled, and the following slots are renumbered. |
| [18] LG Electronics | 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*, the HARQ process number indicated by the DCI is incremented by one by excluding the PDSCH and 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*, the HARQ process number indicated by the DCI is incremented by one by excluding the PUSCH and NDI/RV fields corresponding to the PUSCH are absent in the DCI. |
| [20] MediaTek | Proposal 10: To improve gNB scheduling flexibility, reinterpret CGBTI field to indicate which scheduled PDSCHs corresponding to a DCI are transmitted/retransmitted. |
| [22] Apple | Proposal 18: In case of an uplink symbol (or other invalid symbol), the HARQ process number may be incremented assuming a virtual PDSCH is transmitted, or the increment may be skipped. The HARQ-ACK bits for all PDSCHs are kept in the codebook (as a virtual PDSCHs) and set to NACK even if intersecting with invalid symbol symbols. |
| [24] NTT DOCOMO | Proposal 4:   * For multi-PUSCH scheduled by single DCI,   + If a PUSCH among multiple PUSCHs that are scheduled by a single DCI collides with semi-static downlink symbol(s), the PUSCH is not accounted for HARQ process number accumulation. * For multi-PDSCH scheduled by single DCI,   + If a PDSCH among multiple PDSCHs that are scheduled by a single DCI collides with semi-static uplink symbol(s), the PDSCH is not accounted for HARQ process number accumulation. |

### Summary on whether/how to handle collision between PDSCHs (or PUSCHs) and semi-static UL (or DL) symbols:

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*.

Company views on whether/how to handle collision between PDSCHs (or PUSCHs) and semi-static UL (or DL) symbols:

* HARQ process number assignment
  + Alt 1: No assignment to the PDSCH (or PUSCH) that is collided with semi-static UL (or DL) symbol(s)
    - Supported by vivo, Samsung, CATT, Fujitsu, Ericsson, Futurewei, LG Electronics, NTT DOCOMO
  + Alt 2: HARQ process number is assigned, independently of resource collision with semi-static UL/DL symbol(s)
    - Supported by Huawei
  + Either of Alt 1 or Alt 2
    - Supported by CEWiT, Apple
* HARQ-ACK feedback (🡪 Can be discussed in Section 3.1)
  + Huawei and Apple: HARQ-ACK codebook is generated independently of resource collision with semi-static UL symbol(s), and NACK corresponding to the collided PDSCH should be reported by the UE.

[Moderator’s note] On the issue of HARQ process number assignment, 8 companies suggest not to assign HARQ process number to a PDSCH (or PUSCH) when the PDSCH (or PUSCH) is collided with semi-statically configured UL (or DL) symbols, 1 company suggests that HARQ process numbers are assigned independently of resource collision with semi-static UL/DL symbol(s), and 2 companies suggest both alternatives. Considering the majority view, the following proposal #2 can be made. This issue is indicated as “HIGH” since it may have an impact on HARQ-ACK codebook design.

**[HIGH] Proposal #2 (HARQ process numbering):**

* 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).

Companies are encouraged to provide views on Proposal #2.

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| Company | Views |
| Lenovo, Motorola Mobility | Support the proposal#2 |
| Ericsson | Support Proposal #2 |
| Nokia/NSB | Support Proposal #2 |
| Qualcomm | We support the proposal |
| CATT | Support Proposal #2 |
| Huawei, HiSilicon | The reason we proposed Alt2 is for handling cases where there might not be a common understanding between the network and the UE about the collision of PDSCH with an UL resource (of a PUSCH with a DL resource), which could happen if a UE misses a DCI format 2\_0. It was not clear to us whether companies supporting Alt1 had a solution in mind for handling this case. |
| Apple | We are fine with the proposal. However, agree with Huawei that missing a DCI may be problematic. |
| Intel | We are fine with the proposal |
| Fujitsu | Support Proposal #2 |
| Futurewei | Support Proposal #2. HARQ process number increment is skipped for the PDSCH/PUSCH and applied only for valid PDSCH(s)/PUSCH(s). |
| Moderator | The proposal #2 intended to handle the case of collision caused by semi-statically configured DL/UL resource, which is also aligned with the previous agreement. If companies see there is an issue to handle the case of collision caused by DL/UL resource dynamically indicated by DCI format 2\_0, please provide it, if any. |
| Panasonic | We support the proposal#2 |
| DOCOMO | Support the proposal. |
| Samsung | We support proposal#2.  We don’t see the issue for collision caused by SFI. |
| ZTE, Sanechips | We support Proposal #2 |
| vivo | Support the proposal. Here only the semi-static UL/DL symbol(s) is/are referred to, so there is no issue about DCI format 2\_0 miss-detection in our opinion. |
| CEWiT | We are fine with the proposal #2 |
| Sony | We support proposal#2 |
| MediaTek | We support the proposal. However, we also agree with Huawei and Apple that there might be an issue when DCI 2\_0 is missed by UE, which can be discussed separately. |
| InterDigital | We are fine with the proposal |
| Apple | Based on the Moderator’s clarification, we support the proposal. |
| CATT | We are fine with the proposal |
| Spreadtrum | We support proposal#2. |
| Xiaomi | Support the proposal#2 |
| OPPO | We support proposal#2. |
| Huawei, HiSilicon | Based on some companies’ comments, it seems that we could have different rules for HARQ process ID numbering depending on the type of collision, i.e. whether the collision is due to a DL/UL symbols in semi-static configuration (tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated) or due to a dynamic indication of DL/UL symbol in DCI format 2\_0. So the question could be re-formulated in how to handle flexible symbols signalled by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated. We would be fine with the addition of an FFS point for this case, such as:   * 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.   We think we should also discuss the case where the HARQ process number increment leads to a collision with a HARQ process number already allocated for DL SPS or UL configured grant. |
| Moderator | Based on comments from Huawei, FFS sub-bullet is added as shown in Proposal #2a below. |

**[HIGH] Proposal #2a (HARQ process numbering):**

* 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.

Companies are encouraged to provide views on Proposal #2a.

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| Company | Views |
| Qualcomm | We are fine with the proposal |
| Ericsson | We the support the proposal as well as the added FFS. |
| Intel | We are fine with the proposal. |
| DOCOMO | We are fine with the proposal.  For the FFS, considering ambiguity between gNB and UE due to SFI missing, we prefer to not skip HARQ process number for the PDSCH/PUSCH collided with semi-static flexible symbol. |
| Nokia/NSB | Support the proposal. |
| Samsung | We are fine with the proposal.  And we share same view with Docomo that any HPN ambiguity caused by SFI missing should be avoided, i.e. not skip HPN for PDSCH/PUSCH collided with semi-static Flexible. |
| vivo | Support the proposal. |
| CEWiT | We are fine with the proposal including added FFS. |
| Moderator | Seems stable so far, please continue discussion. |
| ZTE, Sanechips | We are fine with the proposal. |
| Apple | We are in general fine with the proposal. We do see an issue (UE behavior/HPN) in the case that the scheduled PDSCH/PUSCH collides with a SPS PDSCH/CG PUSCH. Should this be addressed here or later in section 2.13 ? |
| Lenovo, Motorola Mobility | Support the proposal |
| InterDigital | We are fine with the proposal. |
| Panasonic | We are fine with the proposal#2a. |
| Xiaomi | We are fine with the proposal#2a |
| Sony | We are fine with the proposal#2a |
| Futurewei | We are ok with the proposal#2a. |

During email discussion, the following agreement was made:

### Agreement:

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.

## TDRA enhancement

|  |  |
| --- | --- |
| Company | Views |
| [1] Huawei | Proposal 11: For TDRA table configuration supporting non-continuous resource indication, signal a separate k0 (k2) for each SLIV. K0 (k2) can be omitted for a SLIV to indicate that the SLIV corresponds to the next slot from the previous SLIV (i.e. in case of two consecutive slots allocation). |
| [3] vivo | Proposal 10: To enable that PDSCHs/PUSCHs in a row of the TDRA table can be indicated in consecutive or non-consecutive slots, each SLIV corresponding to a PDSCH/PUSCH is configured with a respective K0/K2 in the row. |
| [8] Samsung | Proposal 7: For Rel-16 NR-U multi-PUSCH scheduling DCI:   * PUSCH TDRA:   + Support separate k0, SLIV and mapping type to support non-continuous PUSCH transmissions. |
| [9] CATT | Proposal 5: Non-continuous time-domain allocation is indicated by invalid SLIV value in the configuration. |
| [10] ZTE | Proposal 1: Configuration of {SLIV, mapping type, scheduling offset K0/K2} for each PDSCH/PUSCH in a row of TDRA table is supported. |
| [13] Ericsson | Proposal 6: For a row of the TDRA table that supports scheduling of multiple PDSCH/PUSCHs, a separate scheduling offset K0/K2 is configured for each scheduled PDSCH/PUSCH. |
| [14] Futurewei | Proposal 5. To inform the gap between PDSCHs or between PUSCHs, separate K0/K2 values are assigned for each SLIV of a row in the TDRA table. |
| [15] Nokia | Proposal 4: For TDRA, *PUSCHTimeDomainAllocationListForMultiPxSCH* indicates only contiguous slots.   * Non-contiguous TDRA is indicated by means of slot-level gap. No support of sub-slot gaps. * Invalid slots are determined based on RateMatchPattern(s).   + RateMatchPattern(s) can be defined also for UL. * Non-contiguous transmission covers contiguous HARQ processes. |
| [16] NEC | Proposal 2: For each row index of TDRA table with multiple SLIVs, there is only a common K0/K2, and use a special SLIV to indicate the slot gap between the adjacent PDSCHs (or PUSCHs). |
| [18] Qualcomm | Proposal 18: For configuring a TDRA table that supports multi-PDSCH/PUSCH grants with a single DCI, two options can be considered:   * Option 1: each row in the TDRA table specifies explicitly only the slot offset of the first SLIV, i.e., a single value for defining the slot offset of the first allocation, i.e., k0/k2, and define a set of new rules   + For overlapping SLIVs: the second SLIV to be allocated in the next slot.   + Allow SLIV ‘0’ to indicate slot level gaps between the adjacent allocations. * Option 2: each row specifies explicitly the slot offset of each SLIV,   + Option 2-1: multiple values of k0/k2 equal to the number of the SLIVs   + Option 2-2: A single value of k0/k2 to indicate the slot offset of the first SLIV and number of parameters (di)’s equals to the number of SLIVs -1, to define the slot offsets between any two adjacent SLIVs   + Note: Option 2-2 has less configuration overhead |
| [19] LG Electronics | Proposal #7: In order to support non-continuous resource allocation in time-domain, the following options can be considered for TDRA enhancements and Option 1a is preferred.   * Option 1: {SLIV, mapping type, scheduling offset K0/K2} for each PDSCH/PUSCH in a row of TDRA table * Option 1a: {SLIV, mapping type, distance between PXSCHs} for each PDSCH/PUSCH in a row of TDRA table |
| [21] Intel | Proposal 4: For multi-PDSCH/PUSCH scheduling, separate k0/k2, mapping type and SLIV for each scheduled PDSCH/PUSCHs can be configured in each row of TDRA table. |
| [22] Apple | Proposal 13: In order to support non-continuous resource allocation in time-domain, the following options can be considered for TDRA enhancements:   * Option 1: {SLIV, mapping type, scheduling offset K0/K2} for each PDSCH/PUSCH in a row of TDRA table * Option 1a: {SLIV, mapping type, distance between PXSCHs} for each PDSCH/PUSCH in a row of TDRA table |
| [24] NTT DOCOMO | Proposal 4:   * For multi-PUSCH scheduled by single DCI,   + For multiple SLIVs in one TDRA row, separate K2 is configured for each SLIV. * For multi-PDSCH scheduled by single DCI,   + For multiple SLIVs in one TDRA row, separate K0 is configured for each SLIV. |
| [25] Xiaomi | Proposal 4: Support dynamic indication by DCI to determine the number of scheduled PDSCHs (or PUSCHs).  Proposal 6: To select one for slot gap indication between K0/K2 per SLIV and a single value of K0/K2 per row with distance between PDSCHs (or PUSCHs) per SLIV. |
| [26] ITRI | Proposal 1: To achieve higher scheduling flexibility for gNB, each PDSCH of the multiple PDSCHs scheduled by a DCI has separate slot offset K0 could be considered.  Proposal 2: if a row of TDRA table comprise a slot offset K0 is supported, following concepts could be considered   * The slot offset K0 is applied to the first scheduled PDSCH and incremented by 1 for subsequent PDSCHs. * UE does not perform a PDSCH reception associated with a SLIV, if the SLIV is an invalid SLIV |

### Summary on TDRA enhancement:

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 TDRA enhancement to support discontinuous allocation for multi-PDSCH/PUSCH scheduling:

* Option 1: {SLIV, mapping type, scheduling offset K0/K2} for each PDSCH/PUSCH in a row of TDRA table
  + Supported by Huawei, vivo, Samsung, ZTE, Ericsson, Futurewei, Qualcomm, LG Electronics, Intel, Apple, NTT DOCOMO, ITRI
* Option 1a: {SLIV, mapping type, distance between PXSCHs} for each PDSCH/PUSCH in a row of TDRA table
  + Supported by NEC (by using special SLIV), Qualcomm, LG Electronics, Apple, Xiaomi
* Option 2: Based on rate-matching pattern indicator (for PDSCH) or invalid symbol pattern indicator (for PUSCH)
  + Supported by Nokia
* Option 3: When n-th SLIV is overlapped with (n+1)-th SLIV, (n+1)-th SLIV is allocated in the next slot from the slot corresponding to n-th SLIV.
  + Supported by Qualcomm
* Option 4: Based on invalid SLIV
  + Supported by CATT, Qualcomm, ITRI

[Moderator’s note] Considering the majority view, Option 1 could be a way forward for TDRA enhancement. This issue is indicated as “HIGH” since it may have an impact on maximum gap between PDSCHs/PUSCHs (in Section 2.5) and potentially, HARQ-ACK codebook design.

**[HIGH] Proposal #3 (TDRA enh.):**

* 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/K2} for each PDSCH (or PUSCH) in the row of TDRA table.

Companies are encouraged to provide views on Proposal #3.

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| Company | Views |
| Lenovo, Motorola Mobility | Support the proposal#3 |
| Ericsson | Support Proposal #3 |
| Nokia/NSB | Fine with Proposal #3 |
| Qualcomm | Option 1-a provides the same scheduling flexibility as option 1 with less configuration overhead as the ranges for the distances can be much smaller that the ranges of the values of k0/k2, but either 1 or 1a is fine with us. |
| CATT | We still think this conclusion will complicate the HARQ-ACK procedure. |
| Huawei, HiSilicon | Proposal #3 is generally acceptable, but it may lead to large RRC overhead when some or all slots are consecutive. It should be relatively easy to decrease the RRC overhead by allowing not to signal K0 (or K2) when one slot is consecutive to the previous slot. In this case K0 (or K2) is signaled only if a slot is not directly consecutive to the slot of the previous SLIV, and of course for the first SLIV. If all slots are separated by a gap of at least one slot, then this falls back to proposal #3 (where full overhead cannot be avoided).  So our proposal is to add a sub-bullet:   * K0 (or K2) is signaled for a SLIV only if the slot is not directly consecutive to the slot of the previous SLIV, and for the first SLIV. |
| Apple | We are fine with the proposal. 1-a may provide the same flexibility with lower overhead. |
| Convida Wireless | We are fine with Proposal #3. |
| Intel | We are fine with the proposal. |
| Fujitsu | Fine with Proposal #3 |
| ITRI | Support the proposal#3 |
| Futurewei | Support Proposal #3. A separate K0/K2 is configured with SLIV and mapping type for each PxSCH in the row of TDRA table. |
| Moderator | If RAN1 can pursue RRC overhead reduction, we have several alternatives such as Option 1-a or K0/K2 omission as suggested by Huawei. However, without unanimous support of a specific scheme to reduce RRC overhead, it is preferred to a simple way (even though it can accompany RRC signaling increase), as is in Proposal #3. |
| Panasonic | If the maximum gap between scheduled PDSCHs/PUSCHs is applied to reduce the complexity of UE, we are ok with the proposal.  Separately, we think that “the maximum gap between scheduled PDSCHs/PUSCHs” in the next proposal/Section should be discussed first, i.e., before going to discuss the proposal #3. |
| DOCOMO | Support the proposal. |
| Samsung | We don’t see the need of RRC signaling optimization. Therefore, we still support proposal #3. |
| ZTE, Sanechips | We support Proposal #3 |
| vivo | Fine with the proposal. |
| NEC | We are fine with Proposal #3. |
| CEWiT | Support Proposal #3 |
| Sony | We support proposal#3 |
| MediaTek | In our understanding, the purpose of introducing the gap between scheduled PDSCHs is to provide some room for potential UL transmission or other DL transmission. We still think the gap can be naturally created by the collision rule we already agreed and no further optimization is needed. However, for the sake of progress, we can support the proposal if we are the only company to object this proposal. |
| InterDigital | We are fine with Proposal #3 |
| Spreadtrum | We support Proposal#3. |
| Xiaomi | Support the Proposal#3 |
| Huawei, HiSilicon | Solutions for reducing RRC overhead seem rather straightforward on top of the proposal, so it is not clear why such solutions should not be pursued. RRC overhead is not to be ignored. We would also be fine leaving it for RAN2 to optimize the signaling, based on the principle of proposal #3 in case some SLIV are indicated in consecutive slots. We would suggests adding a note to that effect as shown below.   * 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/K2} for each PDSCH (or PUSCH) in the row of TDRA table.   + Note: RRC overhead reduction may be achieved when a row of the TDRA table indicates SLIVs in two consecutive slots. Whether to optimize the signaling for this case is left to RAN2. |
| Moderator | To Panasonic,  Whether or not to define the maximum gap between PDSCHs/PUSCHs can be discussed after agreeing onto Proposal #3. I don’t think Proposal #3 excludes the possibility to define a certain gap between PDSCHs/PUSCHs.  To MediaTek,  Thanks for being flexible.  To all,  Based on comments from Huawei, NOTE is added as shown in Proposal #3a below. |

**[HIGH] Proposal #3a (TDRA enh.):**

* 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/K2} for each PDSCH (or PUSCH) in the row of TDRA table.
  + Note: Whether to further reduce RRC overhead for this case is left to RAN2.

Companies are encouraged to provide views on Proposal #3a.

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| Company | Views |
| Qualcomm | We are fine with the proposal |
| Ericsson | Generally agree with the proposal, and we agree that whether or not signaling overhead optimization can be done or is done should be left to RAN2. Also it should be clear that the scope of the overhead reduction is for the indication of K0/K2. So suggest changing the note as follows:  Note: RRC overhead reduction ~~may~~ for K0/K2 can possibly be achieved when a row of the TDRA table indicates two or more SLIVs in ~~two~~ consecutive slots. Whether to optimize the signaling for this case is left to RAN2. |
| Intel | We are fine with the first sub-bullet.  For the note, we prefer not to mention any specific solution for RRC overhead reduction, which should be investigated in RAN2. We suggest to delete the note or to update the note as   * Note: ~~RRC overhead reduction may be achieved when a row of the TDRA table indicates SLIVs in two consecutive slots.~~ Whether to future reduce RRC overhead ~~optimize the signaling~~ for this case is left to RAN2. |
| DOCOMO | We are fine with proposal. |
| Nokia/NSB | Support the proposal. Also fine with Ericsson and Intel version. |
| Samsung | We support 1st sub-bullet and 2nd sub-bullet revised by Intel |
| vivo | Support the proposal, and fine with the revised notes from Ericsson and Intel. |
| CEWiT | We agree with the Intel’s suggestion |
| Moderator | NOTE is not more generalized, as commented by Intel. Please make a comment if you have a concern on the NOTE. |
| Huawei, HiSilicon | What is the meaning of “this case”? We think the note revised by Ericsson is more accurate and would prefer Ericsson’s note. When RAN2 receives this information (presumably when RAN1 provides the list of PHY parameters for RRC) it would better be clear what RAN1 is talking about. |
| ZTE, Sanechips | We are generally fine with the proposal. As for the note, we agree with Intel that the specific solution could be discussed and decided in RAN2, “this case” may be confusing, so we suggest the following:   * Note: Whether and how to further reduce RRC overhead ~~for this case~~ is left to RAN2. |
| Apple | We are fine with the proposal. We are fine with ZTE’s update. |
| Ericsson | We are fine with generalizing the note. It's getting a bit crazy with all the revisions. So, in that spirit here's another one to avoid questions about what "further" means :-)  Note: Whether and how to ~~further~~ reduce RRC overhead ~~for this case~~ is left to RAN2 |
| Lenovo, Motorola Mobility | We are fine with the proposal and further updates from Ericsson |
| InterDigital | We prefer to have a general note rather than focusing RRC overhead reduction.  Note: Detailed RRC design is up to RAN2 |
| DOCOMO | We are fine with the proposal. And fine with Ericsson’s update. |
| Panasonic | We are fine with the proposal and Ericsson’s update. |
| Xiaomi | We are fine with the proposal and Ericsson’s update. |
| Sony | We are fine with the proposal and Ericsson’s update. |
| Moderator | Proposal #3a seems quite stable except detailed wording for the NOTE. Ericsson’s update is accepted since it is supported by majority companies. |

**[HIGH] Proposal #3b (TDRA enh.):**

* 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.

Companies are encouraged to provide views on Proposal #3b if you have a strong concern.

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| Company | Views |
| vivo | Support proposal #3b. |
| Huawei, HiSilicon | We are ok with the latest proposal #3b. Just saying that RRC decision is up to RAN2, as proposed by InterDigital, is unnecessary as everyone knows that already.  Editorially: to align with the “(or PUSCH)” formulation, we would suggest changing “K0/K2” to “K0 (or K2)” as shown below:   * 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. |
| Moderator | Huawei’s suggestion is reflected above. |
| Qualcomm | We support the proposal |
| DOCOMO | Support the proposal. |
| Intel | We support the proposal |
| ZTE, Sanechips | We support the proposal. |
| Ericsson | We support Proposal #3b also with Huawei's editorial change |
| Nokia/NSB | We support the proposal. |
| Samsung | We support the proposal. |
| Moderator | Seems stable. Proposal #3b can be reported for email endorsement. |

During email discussion, the following agreement was made:

### Agreement:

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.

## Maximum gap between PDSCHs/PUSCHs

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| Company | Views |
| [1] Huawei | Proposal 7: Support not limiting the maximum value of gap between two adjacent PDSCHs/PUSCHs. The maximum value of gap between the first PDSCH/PUSCH and the last PDSCH/PUSCH scheduled by a single DCI is limited by the maximum value of k0 and k2. |
| [5] InterDigital | Proposal 13: 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. |
| [7] Lenovo | Proposal 4: 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 5: 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 |
| [12] CEWiT | Proposal 3: Support the investigation on maximum K0/K2 value, HARQ latency and number of HARQ process IDs in order to limit the maximum gap between first and last PXSCH. |
| [13] Ericsson | Proposal 5: 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 configured value range of K0/K2. |
| [14] Futurewei | Observation 5. The coherence time is one key factor to select the maximum gap between the first scheduled PxSCH and the last scheduled PxSCH.  Observation 6. The gaps between multi-PxSCH are useful for handling the collision with semi-statically scheduled DL/UL and to allow dynamic scheduling for other Ues to reduce latency. But if longer gaps are used, there is a higher chance that the listen-before-talk (LBT) procedure is necessary for the unlicensed band, and if LBT failure happens the sequence of multi-PxSCH can be interrupted.  Proposal 4. Considering that there is ongoing discussion also at the 8.2.4 agenda item relating to the gap for muti-PxSCH from a beam management perspective, thus a joint decision may be necessary from the two agenda items for recommending the appropriate maximum value of the gap between two consecutively scheduled PxSCHs and maximum value of the gap between the first scheduled PDSCH and the last scheduled PxSCH. |
| [18] Qualcomm | Proposal 19: Define the maximum slot gap between any two SLIVs, it can be either SCS dependent or fixed values for all SCSs.  Proposal 20: Define a maximum allowed span per single DCI as X slots, where X >= 8. |
| [19] 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. |
| [20] MediaTek | Proposal 8: For multi-PDSCH scheduling, if M PDSCHs are scheduled by a DCI, the M PDSCHs should be contained within at most M consecutive slots |
| [22] Apple | Proposal 15: 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 16: 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.  • UE behaviour such as CQI feedback and transmission cancellation should be addressed. |
| [23] Panasonic | Proposal 2: 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 |
| [25] Xiaomi | Proposal 5: Suggest to define a maximum number of gaps among PDSCHs (or PUSCHs) scheduled by one DCI considering of the LBT. |

### 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: Huawei, Lenovo, Ericsson, LG Electronics
  + To be specified: Futurewei, Qualcomm, Apple, Panasonic, Xiaomi
* 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: Huawei, CEWiT, Ericsson, LG Electronics
  + To be specified: Lenovo, Futurewei, Qualcomm, MediaTek, Apple, Xiaomi

[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, this issue seems to be dependent on how to enhance TDRA configuration to support non-contiguous time domain resource allocation. Therefore, it is proposed to discuss this issue once the issue on TDRA enhancement is settled down or 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 |
| Lenovo, Motorola Mobility | We are okay to discuss this issue once the TDRA enhancement’s related proposals are agreed. |
| Ericsson | Agree with moderator’s assessment to de-prioritize. Also, we point out that the value range for k0 and k2 will automatically impose a restriction on how far apart the first and last PDSCH/PUSCH can be.  If needed, we can come back to this issue later once the TDRA table design and k0/k1/k2 value range discussion has completed. |
| Nokia/NSB | Fine with Moderator’s suggestion. W.r.t. gap, we think that the maximum gap between scheduled PDSCHs/PUSCH does not require additional impact on specification. |
| Qualcomm | Defining the gap limits helps in reducing the range of values of the distances between the PXSCH if we used Option 1-a to configure TDRA table, i.e., save some configuration overhead. In addition, it will ensure a reasonable span of the total slots occupied by a single DCI. |
| Apple | We are fine with the moderator’s position. Note that as we mention in our contribution, to account for the use of a single MCS in the DCI, a modification to the CQI feedback may be needed to enable CSR-RS configuration and CQI feedback suitable for multi-PDSCH transmission with a single DCI in the case there is no limit in the gap between the 1st and last PDSCH. |
| Convida Wireless | We are fine with moderator’s note. |
| Intel | We are fine to deprioritize this issue in this meeting |
| Futurewei | Agree that the maximum gap between PxSCH can be deprioritize in this meeting. Note that coordination with AI 8.2.4 for recommending the values for gap is suggested. |
| Panasonic | We are fine with Moderator’s note |
| ZTE, Sanechips | Agree with moderator’s assessment. |
| CEWiT | We are fine with Moderator’s suggestion |
| Sony | We are fine with moderator’s note |
| InterDigital | We are fine with deprioritizing |
| CATT | We are fine with the proposal |
| Spreadtrum | We agree with moderator’s note. |
| Xiaomi | The maximum number of gap in our contribution refer to the number of interruption between these PxSCHs. Anyway, define the limits on both the maximum number of gap and the maximum value of gap can reduce the signaling overhead of scheduling offset in TDRA. |

## TDMed PDSCHs/PUSCHs in a slot

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| Company | Views |
| [1] Huawei | Proposal 6: For single TRP operation:   * A UE is not expected to be scheduled more than one PDSCH in a slot with a single DCI or with multiple DCIs for 480 kHz and 960 kHz SCS. * A UE is not expected to be scheduled more than one PUSCH in a slot with a single DCI or with multiple DCIs for 480 kHz and 960 kHz SCS. |
| [3] vivo | Proposal 11: Support more than one PDSCH/PUSCH scheduled within a slot as legacy NR Rel-15/16. |
| [5] InterDigital | Proposal 7: Due to short slot duration, it is sufficient to support a single PDSCH per slot, at least for 480, 960 kHz SCS. |
| [8] Samsung | Proposal 7: For Rel-16 NR-U multi-PUSCH scheduling DCI:   * PUSCH TDRA:   + Support single PUSCH per slot for 480/960KHz SCS, and multi-PUSCHs per slot for 120KHz SCS. |
| [9] CATT | Proposal 4: For multiple PDSCH/PUSCH scheduling, no more than one PUSCH/PDSCH shall be transmitted in one slot by a DCI. |
| [10] ZTE | Proposal 2:   * In Rel-17 for NR 52.6-71GHz, do not support to schedule more than one PDSCH/PUSCHs in a slot by single DCI or separate DCIs for 480 kHz and 960 kHz. * In Rel-17 for NR 52.6-71 GHz, do not support to schedule more than one PDSCH/PUSCHs in a slot by single DCI for 120 kHz. |
| [13] Ericsson | Proposal 8: For multi-PUSCH scheduling with a single DCI for 120, 480, and 960 kHz SCS, a UE does not expect to be scheduled with multiple PUSCHs in a single slot. Accordingly, for a TDRA table that supports multi-PUSCH scheduling, do not consider multiple SLIVs for a single slot.  Proposal 9: Multi-TRP transmission is supported for multi-PDSCH scheduling for 120, 480, and 960 kHz SCS.  Proposal 10: For multi-PDSCH scheduling for both single- and multi-TRP for 120, 480, and 960 kHz SCS, a UE does not expect to be scheduled with multiple PDSCHs from the same TRP within a single slot. Accordingly, for a TDRA table that supports multi-PDSCH scheduling, do not consider multiple SLIVs for a single slot. 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 since each PDSCH corresponds to a different DCI. |
| [17] OPPO | Proposal 2: UE is not expected to be scheduled with more than one PDSCHs in one slot for both 480 kHz and 960 kHz SCS. |
| [18] Qualcomm | Proposal 21: The TDRA configuration should not allow scheduling more than one PDSCH per slot with a single DCI. |
| [19] LG Electronics | Proposal #8: For NR FR2-2, support TDMed PDSCHs (or PUSCHs) in a slot, subject to UE capability. |
| [20] MediaTek | Proposal 9: For multi-PDSCH scheduling, support at most one scheduled PDSCH within a slot |
| [21] Intel | Proposal 2: 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. |
| [22] Apple | Proposal 14: 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 |
| [27] Convida | Proposal 2. To simplify type-1 codebook HARQ-ACK generation in Rel-17, receiving more than one PDSCH in a slot is not considered. |

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

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

* Disallow TDMed PDSCHs/PUSCHs in a slot
  + Supported by Huawei (for 480/960 kHz), InterDigital (at least for 480/960 kHz), Samsung (for 480/960 kHz), CATT (for multi-PDSCH/PUSCH scheduling), ZTE, Ericsson, OPPO (480/960 kHz), Qualcomm, MediaTek (for multi-PDSCH scheduling), Apple, Convida
* Allow TDMed PDSCHs/PUSCHs in a slot
  + Supported by vivo, LG Electronics, Intel, ITRI

[Moderator’s note] 10 companies suggest not to allow TDMed PDSCHs/PUSCHs in a slot but have different views on what conditions to consider. On the other hand, 3 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 need more discussion on the detailed conditions. This issue is indicated as “HIGH” since it may have an impact on Type-1 HARQ-ACK codebook design.

### [HIGH] Proposal #4 (TDMed PDSCHs/PUSCHs in a slot):

* For single TRP operation, and at least 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.
  + FFS for 120 kHz SCS
* FFS for multi-TRP operation

Companies are encouraged to provide views on Proposal #4.

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| Company | Views |
| Lenovo, Motorola Mobility | Support the proposal#4 |
| Ericsson | Support Proposal #4 in principle; however, we prefer to remove the wording "in FR 2-2." According to the updated WID, the applicability of features from FR2-2 to FR2-1 and vice versa should be discussed separately on a case-by-case basis, most likely as part of UE capability discussions. FR2-2/2-1 designation is to be used only when necessary. |
| Nokia/NSB | Support Proposal #4. |
| Qualcomm | We are okay with the proposal |
| CATT | Support the proposal. |
| Huawei, HiSilicon | We agree with Proposal #4, and we are ok with Ericsson’s suggestion.  We think we could also agree for 120 kHz SCS at least for a single DCI scheduling multiple PDSCHs/PUSCHs |
| Apple | We are in general fine with the proposal. We would want to clarify the FFS for 120 kHz. Is this for PDSCH only (because it has not been decided) or is it for both? If for both, why the differentiation ? |
| Convida Wireless | We support the Proposal #4. |
| Intel | Given the fact that multiple PDSCHs in a slot is supported for SCS 120kHz, we prefer to allow the same operation for SCS 480/960 since there is no additional specification efforts. The concern from some companies may be addressed by defining on different UE capabilities. |
| Fujitsu | Fine with Proposal #4. |
| ITRI | Prefer to allow TDMed PDSCHs/PUSCHs in a slot for SCS 480/960 |
| Futurewei | Support Proposal #4. A UE is not expected to be scheduled with more than one PDSCH in a slot at least for 480/960kHz SCS. |
| Moderator | “in FR2-2” is not deleted as suggested by Ericsson.  One clarification for “FFS for 120 kHz SCS”: It is not only for PDSCH, but also PUSCH. Please provide more comments, if any. |
| Panasonic | Support the proposal#4 |
| DOCOMO | We can accept the proposal. |
| Samsung | Support proposal #4.  For “FFS for 120 kHz SCS”, same mechanism for PDSCH and PUSCH is preferred. But we’re open to consider slightly different limitation for PDSCH, e.g. multiple PDSCH reception within a slot is allowed, but do not support multiple PDSCH receptions within a slot associated with the same PUCCH to reduce HARQ-ACK feedback complexity. |
| ZTE, Sanechips | Fine with Proposal #4. For 120kHz, we slightly prefer to support multiple PUSCH/PDSCH in a single slot scheduled by multiple DCIs. |
| vivo | We share the same view as Intel. There are no additional specification efforts for 480/960K SCS if TDM PDSCH within a slot is supported for 120K. On the other hand, the benefit to reduce HARQ-ACK feedback complexity is not true since spec anyway needs to design that for 120KHz SCS. |
| Ericsson | We agree with the restriction for 480/960, and we think that 120 kHz should be decided at the same time. For 120 kHz, we agree with the comment from Samsung that allowing the UE to be scheduled with more than one PDSCH in a slot, either by single or multiple DCIs does complicate the HARQ-ACK feedback complexity, e.g., for the semi-static (Type-1) HARQ-ACK codebook. Hence, it seems Proposal #4 should be considered in combination with the pruning issue discussed in Section 3.2. It would be highly desirable to simplify this procedure.  For example, a simplification could be to introduce a restriction in the spec that if any cell in a PUCCH cell group is configured with a TDRA table that can schedule multiple-PDSCHs, then multiple PDSCHs in a slot are disallowed for 120, 480, and 960 kHz. This would avoid changing legacy Rel-15/16 behavior that multiple-SLIVs per slot are allowed for 120 kHz (where only single-PDSCH scheduling is supported). |
| Samsung | To Ericsson: In my understanding, for Type-1 codebook, HARQ-ACK for each cell is independently generated and concatenated. Therefore, it seems no need to disable multiple PDSCH receptions in a slot for a cell with a TDRA table only for single PDSCH scheduling. It would be sufficient to only disable multiple PDSCH receptions in a slot for a cell with a TDRA table for multiple PDSCH scheduling ☺ |
| Sony | We support proposal#4 in principle.  For multi-TRP operation, we think that FR2-1 behaviour could be reused for single PDSCH/PUSCH scheduling with 120 kHz SCS and FFS for other cases. |
| MediaTek | We support the proposal and agree with Samsung’s comment. |
| InterDigital | We are fine with proposal #4. |
| CATT | We are fine with the proposal |
| Spreadtrum | We support Proposal#4. |
| Xiaomi | Support the proposal#4 |
| Huawei, HiSilicon | We agree with the suggestion from Ericsson in order to simplify the Type-1 HARQ-ACK codebook design also for the case of multi-slot PDSCH scheduling with single DCI for 120 kHz. So basically if the network wants to be able to schedule multiple PDSCHs in the same slot for a UE, then the network should not configure the UE with a TRDA table that allows scheduling multiple PDSCHs with a single DCI. |
| Moderator | * For 480/960 kHz   + At most one PDSCH/PUSCH in a slot (20): Lenovo, Ericsson, Nokia, Qualcomm, CATT, Huawei, Apple, Convida, Fujitsu, Futurewei, Panasonic, NTT DOCOMO, Samsung, ZTE, Sony, MediaTek, InterDigital, CATT, Spreadtrum, Xiaomi   + Multiple PDSCHs/PUSCHs in a slot (3): Intel, ITRI, vivo * For 120 kHz   + Multiple PDSCHs/PUSCHs in a slot: Intel, ITRI, ZTE, vivo   + Multiple PDSCHs/PUSCHs in a slot, but with some restriction: Samsung (for PDSCH), Ericsson (only for PDSCHs?), MediaTek, Huawei * For multi-TRP   + Sony: Same with FR2-1 for 120 kHz, and FFS for other cases   Based on the summary above, clear majority of companies are OK with proposal #4 but several companies requested package proposal for 120 kHz in addition to 480/960 kHz. Given the small number of inputs for 120 kHz, the follow-up questions are asked as below. |

### [HIGH] Q1: Do you agree that more than one PDSCH (or more than one PUSCH) can be scheduled in a slot for 120 kHz, subject to UE capability (as in Rel-15)?

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| --- | --- |
| Company | Views |
| Qualcomm | For 120kHz, the legacy behavior should be maintained, i.e., DCIs that schedule single PDSCH can schedule multiple PDSCHs per slot subject to UE capability. We should not take out a legacy feature from the specs. |
| Futurewei | We do not support that more than one PDSCH can be scheduled in a slot for 120kHz SCS. The reason is that we do not find it convincing that reusing Rel-15 rule only applies here but does not apply for the previous issue on dis/allowing multi-PDSCH for 120kHz SCS.  Otherwise, in case in the future there are other issues like these two, where technical reason is not found for change over specified in Rel-15, do we support reuse as in here or do we support change anyway as with the multi-PDSCH for 120kHz SCS case? |
| Ericsson | Yes; more than one PDSCH/PUSCH can be scheduled in a slot for 120 kHz as in Rel-15/16, but please see our preference for additional restriction for PDSCH in Q2 for the case of multi-PDSCH scheduling in Rel-17.  We share the view with Qualcomm that we do not want to remove Rel-15/16 behavior. |
| Intel | We agree that more than one PDSCHs can be scheduled in a slot for 120kHz SCS, which was already supported in Rel-15. It is not clear why we can not support this for FR2-2 with same SCS. |
| DOCOMO | Yes. We share similar view with Qualcomm. |
| Nokia/NSB | Similar view with Qualcomm |
| vivo | Yes. We share the same view as Intel. |
| ZTE, Sanechips | We share similar view with Qualcomm. |
| LG | Yes. We share the same view with other companies. |
| Apple | Yes. Legacy behavior should be kept. |
| Lenovo, Motorola Mobility | Agree to keep the legacy behavior for 120kHz SCS |
| InterDigital | We also agree to keep the existing UE behavior for 120kHz. |
| Panasonic | Yes, we share the same view with Qualcomm. |
| Sony | Yes, we share the same view with Qualcomm |
| Moderator | All but one company agree that more than one PDSCH (or more than one PUSCH) can be scheduled in a slot for 120 kHz, subject to UE capability (as in Rel-15).  **To Futurewei,**  I think this is the different case from multi-PDSCH scheduling. Multi-PDSCH scheduling is not supported in Rel-15/16 at all and we introduced it in Rel-17. On the other hand, TDMed PXSCHs in a slot for 120 kHz SCS is already supported in Rel-15/16. With this regard, as most companies proposed, we can apply TDMed PXSCHs in a slot for 120 kHz as well in FR2-2. Hope it is also acceptable to Futurewei. |
| Futurewei | We’d like to thank the moderator for the follow-up. With this clarification, we find it easier to treat the two cases separately and there is no other issue that prevents us from accepting reusing the legacy here. We can follow up with the working assumption if revisited in the future for the multi-PDSCH scheduling issue. |

### [HIGH] Q2: If YES to Q1, do we need additional restriction (e.g., to simplify Type-1 HARQ-ACK codebook generation procedure)?

Please note that the following options for additional restriction are suggested, and if YES to Q2, please provide your preference between two options or any other suggestion.

* Option 1 (suggested by Samsung): Multiple PDSCH reception within a slot is allowed, but do not support multiple PDSCH receptions within a slot associated with the same PUCCH to reduce HARQ-ACK feedback complexity
* Option 2 (suggested by Ericsson and Huawei): If a cell is configured with a TDRA table that can schedule multiple-PDSCHs, then multiple PDSCHs in a slot cannot be scheduled for the cell.

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| --- | --- |
| Company | Views |
| Qualcomm | We support Option 2 |
| Ericsson | Yes  We support Option 2.  @Samsung  Thank-you for clarifying that the restriction only needs to be for cell(s) within a PUCCH cell group configured with a TDRA table supporting multi-PDSCH scheduling, not necessarily for all cells within a PUCCH cell group. Double checking your statement that HARQ-ACK codebook is generated independently per cell and then concatenated, this seems to be confirmed by the pseudo-code in 38.213 Section 9.1.2.1 where the order of the while loops is as follows:  while  while |
| Intel | No. We do not support these two options. We prefer to allow more than one PDSCHs in a slot for multi-PDSCH scheduling. |
| DOCOMO | We understand the benefit of such additional restriction and we also desire for such benefit. However, one question is the feasibility of such restriction considering multiple SPS configurations can be activated? If the periodicity of SPS configurations can’t match well, how can such “multiple SPS PDSCHs in one slot” case be avoided? |
| Samsung | We support option 1 because it has less scheduling restriction than option 2, e.g. it is easier to support the case mentioned by DOCOMO . |
| vivo | No. We agree with Intel and prefer to allow more than one PDSCHs in a slot for multi-PDSCH scheduling. |
| Huawei, HiSilicon | We support introducing restrictions in order to save specification efforts, and we can accept option 1 or option 2 for 120 kHz SCS. We think there is no need to optimize for the case where the network would configure multi-slot scheduling and the UE would be expected to receive more than one PDSCH in a slot, as these two types of scheduling are addressing fundamentally different use cases. |
| ZTE, Sanechips | We prefer Option 2 since it can simplify the HARQ-ACK procedure. |
| LG | No. We agree with Intel and vivo that it is preferred to allow more than one PDSCHs in a slot for multi-PDSCH scheduling, and it is undesirable that whether to allow more than one PDSCHs in a slot or not would be different according to the type of HARQ-ACK codebook, even though the relevant agreements had been made so far based on the consensus among the companies, are able to cover the case of TDMed PDSCH transmission in a slot.  If the complexity increase due to further Type-1 codebook optimization is the only reason to hesitate allowing TDMed PDSCH transmission, then we can consider to stop further enhancements (e.g., by removing FFS points) and to finalize Type-1 codebook design only based on what had been agreed so far as below. It is obviously better than to make the agreements below useless by not allowing TDMed PDSCH at all just because of Type-1 codebook.  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 |
| Apple | We prefer Option 2. |
| MediaTek | We support option2 |
| Ericsson | Before deciding on a way forward, I'd like to understand all options on the table, and therefore have some questions:  On the WF proposed by LG: This *might* be a viable way forward, but just to confirm, by removing the FFSs, it means that for a cell with 120 kHz, multiple SLIVs per slot would be allowed (as in Rel-15/16), and for that case a candidate PDSCH occasion will be generated for all SLIVs in the same slot (no pruning), regardless of overlap or potential overlap. Then for a cell with 480/960 kHz, multiple SLIVs per slot would not be allowed, so there would be only one candidate PDSCH occasion in a slot anyway. Is this correct understanding? Does this solution allow to completely reuse Rel-15/16 procedures for the overlapping case? It would be nice if the discussion will be finished after we make this agreement, or do you think there are still some open issues? Our preference is to find a simple solution and not over-optimize the Type-1 codebook construction.  On Option 1: I don't understand how the scenario that DOCOMO raises is solved by Option 1. Can DOCOMO clarify? |
| Lenovo, Motorola Mobility | We prefer Option 2 |
| InterDigital | We don’t see the need to introduce additional restriction and prefer to keep the existing operation. |
| Samsung | To LG: if we remove 2 FFS, is it clear how to do pruning per slot, if we don’t discuss this PDSCH TDMed issue ? Do you suggest what we already agreed imply single candidate PDSCH occasion? Or, do you suggest not to do any pruning, and determine the number of candidate PDSCH occasions per slot according to the number of all SLIVs even they’re overlapped?  To E/// and Docomo, I think Docomo is talking about multiple SPS PDSCHs within a slot due to multiple SPS PDSCH configuration? And I think option 1 can allow such configuration, as long as the HARQ-ACK feedback for these PDSCHs is in different PUCCH resource. |
| LG | @Ericsson: Thank you for the question. I would try to clarify line-by-line on your questions. (I expect the following clarifications can also provide the answer to the Samsung’s question in above).  *This might be a viable way forward, but just to confirm, by removing the FFSs, it means that for a cell with 120 kHz, multiple SLIVs per slot would be allowed (as in Rel-15/16), and for that case a candidate PDSCH occasion will be generated for all SLIVs in the same slot (no pruning), regardless of overlap or potential overlap.*  [LG] Yes. For a cell with 120k, multiple SLIVs per slot would be allowed. Then, the pruning is only done within each slot (as in Rel-15/16) corresponding to extended K1 values (no pruning across different slots 🡪 I guess this is your intention). Our intention is not to consider any correlation between different slots or between different rows in preforming the pruning.  *Then for a cell with 480/960 kHz, multiple SLIVs per slot would not be allowed, so there would be only one candidate PDSCH occasion in a slot anyway. Is this correct understanding?*  [LG] Yes. Correct.  *Does this solution allow to completely reuse Rel-15/16 procedures for the overlapping case? It would be nice if the discussion will be finished after we make this agreement, or do you think there are still some open issues? Our preference is to find a simple solution and not over-optimize the Type-1 codebook construction.*  [LG] Yes. As I suggested in above, I think we could finalize main structure of Type-1 codebook construction based on the following two sentences. That is, firstly the extended K1 set is determined based on the first sentence, and secondly for each slot corresponding to each K1 value in the extended K1 set, the pruning is done (per slot) for all the possible SLIVs within each slot as in Rel-15/16.   * 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. |
| Panasonic | We have a similar view with DOCOMO |
| Sony | We support option 2 |
| Ericsson 2 | @LGE  Thank-you for providing answers to my questions. We have thought about your proposal for a simplified way forward, and we think it has a lot of merit. In fact, what have started to see is that there is very little that needs to be changed from Rel-15/16 procedures to support semi-static (Type-1) HARQ codebook + multi-PDSCH. In this spirit, we have tried to draft a revised proposal using the agreement from RAN1#105-e as a starting point that we think could capture the essence of what needs to be specified to support multi-PDSCH for Type-1. The important point is that it would not need either of the two restrictions (Option 1 or 2), i.e., multiple SLIVs per slot could still be supported for 120 kHz as in Rel-15/16. We think that the case of multiple (potentially overlapping) SLIVs per slot is already handled in the Type-1 codebook generation procedure for Rel-15/16.  Proposed Revised Agreement:  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~~ contains all the unique DL slots determined by considering all combinations of the configured K1 values and rows of the TDRA table ~~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~~ * The Rel-15/16 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-15/16 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   Regarding the 2nd sub-bullet and the note which can cover the case of multiple potentially overlapping SLIVSs in the same slot, we have this example scenario in mind where 3 combinations of {TRDA row, K1} are shown:    The Rel-15/16 procedure generates candidate PDSCH occasions as follows:   * Case 1: UE is not capable of receiving multiple PDSCHs per slot   + Only one candidate PDSCH occasion generated * Case 2: UE is capable of receiving multiple PDSCHs per slot   + Two candidate PDSCH occasions are generated since there are at most two non-overlapping PDSCHs. Hence 3 SLIVs are pruned down to 2 candidate PDSCH occasions. |
| LG 2 | @Ericsson: Thanks for sharing your thought and suggestion.  Although I agree that the change to Rel-15/16 procedure can be minimized (e.g. by preforming the pruning per each of slots as in Rel-15/16) and the scheduling of multiple SLIVs per slot can be supported for 120 kHz as in Rel-15/16 without any restriction, I think we don’t need to revise/remove what we had already agreed based on the consensus (except for some wording improvements).  But I also think we may need to consider the sentences you additionally suggested in above since those seem essential (for the clarification) to finalize the structure of Type-1 codebook construction, so my suggestion is to update the RAN1#105-e agreement as below.   |  | | --- | | Proposed update to Agreement in 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~~ contains 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~~ contains 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~~ * The Rel-15/16 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-15/16 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. |   Here I provide an example below showing the procedure of Type-1 codebook construction based on the update in above, where UE is configured with two K1 values {2,3} and two TDRA row indexes {0,1} each of which consists of two SLIVs. I guess you also have the same view, so please check the example and let me know if my guessing is correct. |
| Moderator | Summary of company views:   * Option 0: No further restriction   + Intel, NTT DOCOMO? (or do not prefer Option 2 considering multiple SPS PDSCHs in a slot?), vivo, InterDigital, Panasonic? (same view with NTT DOCOMO) * Option 1: Multiple PDSCH reception within a slot is allowed, but do not support multiple PDSCH receptions within a slot associated with the same PUCCH to reduce HARQ-ACK feedback complexity   + Supported by Samsung, Huawei * Option 2: If a cell is configured with a TDRA table that can schedule multiple-PDSCHs, then multiple PDSCHs in a slot cannot be scheduled for the cell.   + Supported by Qualcomm, Ericsson, Huawei, ZTE, Apple, MediaTek, Lenovo, Sony * Option 3: For Type-1 HARQ-ACK codebook generation, reuse legacy pruning procedure by considering the set of SLIVs corresponding to each DL slot belonging to the set of DL slots   + Supported by LG Electronics, Ericsson   Please continue discussion to better understand each other, and let me know if I missed something. |
| vivo | First we support Option 0 since there is no need to have such restriction.  We want to clarify Option 3 here: is it based on the assumption of no further restriction? If so, it seems more suitable to say “no further restriction with a baseline Type-1 HARQ-ACK codebook generation procedure, i.e. reuse legacy pruning procedure by considering the set of SLIVs corresponding to each DL slot belonging to the set of DL slots”. Based on this understanding, we support Option 3 and it could also apply to 480K and 960KHz SCS. |
| Huawei, HiSilicon | It is good that after further analysis companies are coming to the understanding that most of the Type-1 HARQ-ACK codebook construction can actually be reused with minimal changes, so we can also accept option 3 even if it does not intend optimizing the size of the Type-1 HARQ-ACK codebook.  It is not clear what impact is proposed by companies supporting option 0. But our understanding of options 1 and 2 is that they would also work based on the legacy pruning procedure.  So perhaps the common point of all the options is that the legacy pruning procedure per slot is reused after the candidate slots have been determined. |
| DOCOMO | We are now very confused about the listed options. In my understanding, LG and Ericssion’s discussion (i.e. option 3) for pruning in one slot is based on the assumption that there are multiple PDSCHs in one slot, right understanding? If correct understanding, what’s the difference/relationship between the above option 0 and option 3?  To Samsung: Not sure how option 1 can solve the issue when multiple SPS PDSCHs in the same slot. The K1 for each SPS configuration can’t be dynamically indicated. Considering the periodicity mismatch, how can gNB guarantee that HARQ-ACK information for the multiple SPS PDSCHs will be reported in different slots?  If our concern on multiple SPS PDSCHs in one slot can’t be resolved, we support option 0 without any further restriction. And we are fine with Ericsson proposed modifications for SLIV pruning in the same slot. But maybe the detailed pruning and SLIV set determination is better to be discussed in section 3.2 |
| Intel | In Rel-15/16, whether UE is capable of one or multiple PDSCHs per slot is a UE capability. The same handling can apply to FR2-2 too. For UE capable of only single PDSCH per slot, one occasion for candidate PDSCH reception is enough in Type1 HARQ-ACK codebook. Then, for advanced UE capable of multiple PDSCHs per slot, it is reasonable to consider certain advanced method to compress HARQ-ACK payload size. Therefore, we still prefer Option 0 for UE capable of multiple PDSCHs per slot. |
| Ericsson | We think Option 3 implies Option 0, meaning that multiple SLIVs per slot can be supported for 120 kHz (as in legacy Rel-15/16); furthermore, the legacy (Rel-15/16) pruning procedure can be reused, even for multi-PDSCH scheduling. Hence, there is no further restriction needed as in Option 1 or 2. Moreover, the only reason for discussing Option 1 and 2 in the first place was to potentially simplify the Type-1 HARQ-ACK codebook construction. But now, after further analysis it appears as these restrictions are not needed, and simplification can still be achieved.  **So, in summary, we support Option 3 which implies Option 0 (they go together). We don't think Option 1 and 2 are needed anymore.**  @LGE:  Thank-you for the nice drawing. Yes, our understanding is mostly aligned with yours. The only difference is that for a UE capable of receiving only 1 PDSCH in a slot, the Rel-15/16 pruning procedure will result in only 1 bit in each of the 3 slots you show. Hence, what you show represents an accurate picture for a UE capable of receiving multiple PDSCHs in a slot.  We still think our revised wording is more clear, but we will not insist on it. We can live with the proposal above (in LGE 2 comments), since it captures the important parts about completing the HARQ-ACK codebook construction procedure.  But just so you know, the reason we suggested a modification was that we thought the following wording was a bit confusing:  "… that can be scheduled by any row index r of TDRA table in DCI indicating the UL slot as HARQ-ACK feedback timing"  Since the proposal is all about HARQ-ACK codebook construction, we thought that it is not really necessary to talk about the DCI. The key point is that the codebook construction depends on the configured rows of the TDRA table and the configured K1 values. That is why we suggested the following:  "The set of DL slots contains all the unique DL slots determined by considering all combinations of the configured K1 values and rows of the TDRA table"  Anyway, like I said, we will not insist on this. |
| Nokia/NSB | We think option 2 seems simplest way to avoid complexity. |
| Samsung | Thanks for further explanation for option 3, but sorry, I still don’t understand what additional information option 3 tries to convey, in addition to option 0.  To Docomo: I see your point. I think for most cases, gNB can avoid by proper K1 for activation, especially when number of SPS config is not so large.  For option 1, my motivation is to simplify the codebook generation as well as reduce unnecessary reserved bits in codebook at the cost of some scheduling/configuration restriction. If companies have strong concern on such restriction and fine with larger codebook size, we’re ok for option 0. |
| Moderator | Several companies prefer to activate more than one PDSCH scheduling in a slot even for multi-PDSCH scheduling DCI. On the other hand, some companies prefer to give a restriction on network scheduling (i.e., Option 1) or simultaneous configuration of ‘more than one PDSCH in a slot’ and ‘multi-PDSCH scheduling’ (i.e., Option 2). It seems that the most fundamental reason to introduce such kinds of restriction is to reduce implementation complexity of type-1 HARQ-ACK codebook.  It is noted that Option 3 does not require any restriction on network scheduling or configuration, same as Option 0. Furthermore, Option 3 provides simple implementation for type-1 HARQ-ACK codebook generation, by considering SLIV(s) per slot (i.e., not handling overlapped SLIVs of different rows in other slots).  Therefore, Option 3 could be a middle ground solution to take both extreme sides into account. Let’s take Option 3 for the starting point and continue discussion. |

### [HIGH] Proposal #4a (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.
* For single TRP operation, for 120 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.
* FFS for multi-TRP operation
* 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 rows of the TDRA table. * 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. * The Rel-15/16 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-15/16 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 |

Companies are encouraged to provide views on Proposal #4a.

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| Company | Views |
| Moderator | It should be noted that the rationale behind modifying previous agreement is not to change the original intention but to make the implication clearer. In addition, by removing two FFS points and adding the third bullet, we can maximally reuse type-1 HARQ-ACK codebook generation mechanism as in Rel-15/16 without considering overlapped SLIVs from different rows in different DL slots. |
| Lenovo, Motorola Mobility | We are fine with the proposal |
| Huawei, HiSilicon | We are ok with the proposal and the revision of the agreement. Perhaps it should just be “R16” rather than “R15/R16” (I am not sure whether there was a change to that procedure in R16, so better take just the latest version). |
| Apple | We are fine with the proposal |
| Samsung | We can be OK with the proposal if we don’t revise the previous agreement.  As we previously commented, we think the simplified procedure as well as a reasonable codebook size should be the design target, thus we don’t prefer to exclude the possibility for codebook size reduction mechanisms now. |
| Ericsson | We support the proposal at least with Change #1.  @Sumsung, without at least the 3rd bullet, then the Type-1 codebook construction is not complete and more work will still be needed.  Change #1  We think the "at least" was left in the 2nd bullet by mistake – not needed anymore due to pruning step in the 3rd bullet. Also the word "contains" aligns better with the 1st bullet.   * The set of SLIVs corresponding to a DL slot (belonging to the set of DL slots) ~~at least~~ ~~include~~ contains 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.   Potential Change #2 for consideration:  If the group feels that there is a need for more clarity on the 2nd bullet and better alignment with the 1st bullet, then the following can be considered, but we do not insist on this.   * The set of SLIVs corresponding to a DL slot (belonging to the set of DL slots) ~~at least~~ ~~include~~ contains all the SLIVs for that slot determined by considering all combinations of the configured K1 values and rows of the TDRA table ~~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.~~ |
| Qualcomm | We are fine with the proposal |
| Intel | As mentioned previously, we prefer a unified design framework for all different SCSs. If multiple PDSCHs in a slot can be supported for 120kHz, it is not clear to us why this can not be supported for 480/960kHz SCS. We do not agree the following bullet:   * 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.   Further, regarding the revised agreement, our view is that in the current FL proposal results in too large HARQ codebook size. We prefer to consider some additional limitation factors to make a reasonable codebook size. We prefer Option 0 to report all necessary HARQ-ACK and eliminate redundancy.  If some factor for further compression is necessary, we do not prefer Option 1 or 2 since it results in much limitation on the gNB scheduling. We would like to check whether the following two multi-PDSCH transmissions can be scheduled together or not. That is, the scheduled PDSCHs of the two DCIs are interleaved. If this is not allowed, it could be one way to reduce Type1 codebook size.    On the other hand, it should be fine to support the following case (non-interleaving)    In general, it limits the handling of multiple PDSCHs per slot in only a subset of the DL slots (determined by set of K1 values). The above observation applies to both Option 0 and Option 3. |
| DOCOMO | Support the proposal.  We support modification by Ericsson which changed the original intention of the previous agreement by replacing “at least include” with “contains”. |
| OPPO | We are in general fine with the proposal.  Regarding the update of the agreement made in RAN1#105-e, we prefer to add “the configured” in front of the “rows of the TDRA table” to make it clearer.   |  | | --- | | 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) 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. * The Rel-15/16 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-15/16 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 | |
| Fujitsu | We support the proposal with Change #1 suggested by Ericsson. |
| Nokia/NSB | We are fine with the proposal. |
| vivo | We share the same view as Intel that a unified design framework for all different SCSs is preferred. So allowing more than one PDSCH in a slot should also be applied to 480/960 kHz SCS without any additional complexity, besides 120 kHz SCS.  In addition, companies have discussed to re-use the Rel-15/16 SLIV pruning operation for each DL slot belonging to the set of DL slots. We are fine to regard it as a baseline Type-1 codebook generation procedure in mind. But excluding the possibility for codebook size reduction mechanisms now is not preferred, so the agreement made in RAN1#105-e meeting for generation Type-1 codebook should not be revised in Proposal #4a, and we prefer to further discuss it in section 3.2. |
| ZTE, Sanechips | We are fine with the proposal. |
| Moderator | Summary on companies’ views:   * OK: Lenovo, Huawei (R15/R16🡪R16, reflected), Apple, Ericsson (proposed changes #1/2, reflected), Qualcomm, NTT DOCOMO, OPPO (add “the configured”, reflected), Fujitsu, Nokia, ZTE * Samsung, Intel: Do not support excluding the possibility for codebook size reduction mechanisms * Intel, vivo: Support TDMed PXSCH also for 480/960 kHz * Intel: Bring up the new issue of whether interleaved scheduling is allowed or not, and follow-up HARQ-ACK codebook issue   Regarding support of TDMed PXSCH in a slot for 480/960 kHz, as shown in the first round summary, clear majority prefers not to support it for 480/960 kHz considering shortened slot duration.  Regarding further codebook size reduction, my understanding on removing two FFS points in the previous agreement is that RAN1 will not discuss any more type-1 HARQ-ACK codebook issue related to overlapping SLIVs from different rows in different slot. On the other hand, if any other critical issue can be identified, we can discuss about it and introduce some schemes once consensus can be made.  In that sense, I hope the following Proposal #4b can be acceptable to all. |

### [HIGH] Proposal #4b (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.
* For single TRP operation, for 120 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.
* FFS for multi-TRP operation
* 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 |

Companies are encouraged to provide views on Proposal #4b and especially on three questions based on comments from GTW session.

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| Company | Views |
| Moderator | **Q1)** Do you agree that more than one PDSCH (or more than one PUSCH) can be scheduled in a slot for 480/960 kHz, subject to UE capability?  **Q2)** Do you agree that type-1 HARQ-ACK codebook generation procedure needs to be improved by considering overlapped SLIVs from different rows in different DL slots (as in the second FFS of the previous agreement above)?  **Q3)** Do you agree to revive “at least” (as highlighted in yellow above), which means keeping the possibility that all SLIVs (including the set of SLIVs corresponding to the set of all DL slots) can be pruned? |
| Intel | Q1: yes. Since all companies agree that multiple PDSCHs per slot can be supported for SCS 120kHz, there is no additional standardization effort to support SCS 480/960kHz. Defining different UE capability (single or multiple PDSCHs per slot) as done from NR Rel-15 is a good way to balance the flexibility and UE complexity.  Q2: yes. Type1 HARQ-ACK codebook has the big problem of large codebook size to maintain a semi-static codebook size. The issue becomes more serious when multi-PDSCH scheduling is used. For example, even when single K1 value is considered, the number of DL slots to allocate occasion of candidate PDSCH reception can be up to 8 (as in current FL proposal). If 8 K1 values are configured, the number of DL slots can be up to 23. Therefore, though gNB can control the codebook size by configuring the number of K1 values appropriately, it is quite important to adopt certain rule for payload size reduction.  Q3: No. As commented in Q2, the main issue for Type1 HARQ-ACK codebook is the large codebook size. We think it is just a simple checking to derive whether the SLIVs belongs to a slot.  Further, we would like to check other companies’ view regarding whether the multiple PDSCHs scheduled by different DCIs can be interleaved. Please refer to the figures in our early comments. |
| Lenovo, Motorola Mobility | Q1:Ok. Although, we don’t see a strong motivation to support multiple PDSCH/PUSCH within a slot for 480kHz an 960kHz,but considering the support based on UE capability, we are fine  Q2: Yes  Q3: Yes |

## FDRA enhancements

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| Company | Views |
| [1] Huawei | Observation 1: Further enhancements of FDRA are not essential for either multi-slot PDSCH scheduling or multi-slot PUSCH scheduling. |
| [3] vivo | Proposal 13: Legacy frequency domain scheduling in NR Rel-15/16 is reused for multi-PUSCH/PDSCH scheduling. |
| [4] Spreadtrum | Proposal 3: Apply same method rule compared to Rel-16 NR-U for FDRA. |
| [5] 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 17: The benefits from frequency domain resource allocation enhancements should be carefully evaluated. |
| [13] Ericsson | Proposal 12: Introduce new RBG configuration for PDSCH/PUSCH frequency resource allocation Type 0 to reduce FDRA granularity and DCI size.  Proposal 13: 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. |
| [15] Nokia | Proposal 6: For other multi-PxSCH enhancements:  • FDRA enhancements and frequency hopping enhancements are considered as secondary topics for multi-PxSCH transmission and they are considered only if time allows. |
| [18] Qualcomm | Proposal 16: For multi-PDSCH/PUSCH DCI fields enhancements:  • FDRA optimization can be deprioritized |
| [21] Intel | Proposal 6: For multi-PUSCH scheduling,   * Do not support enhancement on FDRA. |
| [22] Apple | Proposal 8: For Rel-17 multi-PUSCH transmission  • The FDRA size should be optimized to reduce the FDRA overhead.  Proposal 11: For Rel-17 multi-PDSCH transmission  • The FDRA size should be optimized to reduce the FDRA overhead. |
| [23] Panasonic | Proposal 6: No need to have the optimization of FDRA size. |
| [24] NTT DOCOMO | Proposal 4:   * For multi-PUSCH scheduled by single DCI,   + Support FDRA enhancement to reduce DCI overhead. * For multi-PDSCH scheduled by single DCI,   + Similar consideration on CBG based transmission, FDRA and URLLC fields as multi-PUSCH scheduling can be applied to multi-PDSCH scheduling. |
| [25] Xiaomi | Observation 1: The current DCI 0-2/1-2 can be reused to allow frequency domain resource by multi-PRB granularity. |

### Summary on FDRA enhancement:

Company views on FDRA enhancement:

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

[Moderator’s note] 3 companies suggest to enhance FDRA field to reduce DCI overhead while 7 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 |
| Lenovo, Motorola Mobility | We don’t see a strong motivation for FDRA enhancement and would suggest concluding that this enhancement is not further discussed. However, if supporting companies can provide strong justification, we can consider this in future meetings and deprioritize for now |
| Nokia/NSB | We’re fine with Moderator’s proposal. |
| Qualcomm | We are okay with deprioritizing this discussion |
| Huawei, HiSilicon | Agree |
| Apple | We can de-prioritize for this meeting but enhancing the FDRA is important as it could help in a reduction in the DCI overhead. |
| Intel | We are fine to deprioritize this issue in this meeting |
| Futurewei | Agree that the FDRA optimization can be deprioritized. |
| Panasonic | We are fine with Moderator’s note |
| ZTE, Sanechips | Fine with moderator’s assessment. |
| Vivo | OK with de-prioritizing it during this meeting. |
| Sony | We are fine with deprioritizing this discussion |
| InterDigital | We are fine with deprioritizing this discussion |
| CATT | Fine with deprioritizing. |
| Spreadtrum | We are fine with deprioritizing this discussion. |
| Convida Wireless | We are ok with deprioritizing this discussion. |

## 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] vivo | Proposal 15: 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. |
| [4] Spreadtrum | Proposal 2: CBG (re)transmission should not be supported when more than one PDSCHs/PUSCHs are scheduled. |
| [5] InterDigital | Proposal 14: 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.   * - 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 15: The same behavior for CBGTI field could be extended for multiple/single PDSCH transmission as well as multiple/single PUSCH transmission. |
| [6] Sony | Proposal 1: CBG-based transmission should not be supported for multi-PUSCH scheduling for 480/960 kHz SCS.  Proposal 3: CBG-based transmission should not be supported for multi-PDSCH scheduling. |
| [7] Lenovo | Proposal 6: 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 |
| [8] Samsung | Proposal 7: For Rel-16 NR-U 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.   Proposal 8: 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,   * CBG-based transmission is not applicable to single and multi-PDSCH scheduling |
| [13] Ericsson | Proposal 14: For 120 kHz SCS, for a DCI that can schedule multiple PDSCHs and is configured with a 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 PDSCH is scheduled, but are present when a single PDSCH is scheduled, analogous to Rel-16 behavior for multi-PUSCH.  Proposal 15: For 480/960 kHz SCS, for a DCI that can schedule single and/or multiple PDSCHs/PUSCHs, configuration of CBG-based (re)-transmission is not supported, and thus the CBGTI and CBGFI fields are not present. |
| [14] Futurewei | Proposal 12. For SCS 480kHz/960kHz, no CBGTI/CBGFI fields are supported in the DCI that can schedule multi-PUSCH or multi-PDSCH. |
| [15] Nokia | Proposal 6: For other multi-PxSCH enhancements:  • For 480/960 kHz PUSCH and for 120/480/960 PDSCH, there is no need to support configuration of the CBGTI/CBGFI fields |
| [16] NEC | Proposal 1: For 480 kHz and 960 kHz SCS, the same behavior with 120 kHz SCS PUSCH should be applied for the DCI that can schedule multiple PDSCH/PUSCHs. |
| [17] OPPO | Proposal 3: CBG-based (re)transmission can be configured when one PUSCH/PDSCH is scheduled for 120/480/960 kHz SCS. |
| [18] Qualcomm | Proposal 16: For multi-PDSCH/PUSCH DCI fields enhancements:   * CBGTI: Not to be supported for more than one PDSCH/PUSCH for SCS 480kHz and 960kHz |
| [19] LG Electronics | Proposal #5: Support CBG-based (re)transmission for 480/960 kHz SCS, subject to optional UE capability.  Proposal #6: For multi-PDSCH (or multi-PUSCH) scheduling DCI, if CBG-based (re)transmission is configured, CBGTI field is not present when more than one PDSCHs (or PUSCHs) are scheduled, but is present when a single PDSCH (or PUSCH) is scheduled, for all SCSs. |
| [20] MediaTek | Proposal 6: CBG (re)transmission is not supported with multi-PDSCH scheduling when more than one PDSCHs are scheduled. |
| [21] Intel | Proposal 3: For multi-PDSCH/PUSCH scheduling, CBG based transmission is supported for 120/480/960kHz subcarrier spacing when a single PDSCH/PUSCH is scheduled. |
| [22] Apple | Proposal 8: For Rel-17 multi-PUSCH transmission  • A clear use case should be made for CBG support for multi-PUSCH transmission.  Proposal 11: For Rel-17 multi-PDSCH transmission  • A clear use case should be made for CBG support for multi-PDSCH transmission. |
| [23] Panasonic | Proposal 4: 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 5: 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. |

### 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, Spreadtrum, InterDigital, Lenovo, NEC, OPPO, Qualcomm, LG Electronics, MediaTek, Intel, Panasonic
* Do not support CBGTI/CBGFI field configuration for multi-PDSCH/PUSCH scheduling DCI for 480/960 kHz
  + Supported by Sony, Samsung, Ericsson (but OK for 120 kHz multi-PDSCH scheduling DCI), Futurewei, Nokia

[Moderator’s note] 12 companies suggest to apply the same behaviour for all SCSs as in Rel-16 while 5 companies suggest not to support CBGTI/CBGFI field configuration for multi-PDSCH/PUSCH scheduling DCI for 480/960 kHz. Considering the majority view, the following proposal #5 can be made. This issue is indicated as “HIGH” since it may have an impact on HARQ-ACK codebook design.

### [HIGH] Proposal #5 (CBGTI/CBGFI):

* For 480/960 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 PUSCH is scheduled, but is present when a single PUSCH is scheduled.
* For 480/960 kHz SCS, 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 PDSCH is scheduled, but are present when a single PDSCH is scheduled.

Companies are encouraged to provide views on Proposal #5.

|  |  |
| --- | --- |
| Company | Views |
| Lenovo, Motorola Mobility | Support the proposal#5 |
| Ericsson | Compared to our position last meeting, we are okay to compromise and align multi-PDSCH behavior for 120 kHz (if supported) with Rel-16 behavior for multi-PUSCH. However, for 480/960 kHz we still see no benefit at all of CBG-based (re)transmission.  As we stated last meeting, any potential benefit of CBG-based (re)transmission occurs for the lower SCSs in FR1 (e.g., 15 kHz) where the slots are comparatively longer and time-selective fading within a slot can occur. In this case, it can happen that some CBs pass CRC and some fail, so re-transmission efficiency can potentially be gained by selectively retransmitting the CBs in certain CBGs. In contrast for the short slots with 480/960 kHz SCS (and even for 120 kHz), there is no value in supporting CBG based (re)transmission since virtually no time variation within a slot will occur. Hence either all CBs in a slot pass or all fail, thus providing no opportunity for improved re-transmission efficiency with CBGs. |
| Nokia/NSB | In order to achieve progress, we’re ready to compromise. Based on that, we’re fine with Proposal #5. |
| Qualcomm | We support the proposal |
| Huawei, HiSilicon | There was actually no explicit decision made on this for 120 kHz SCS in Rel-16. The support for multi-PUSCH scheduling by a single DCI was simply extended from 5 GHz unlicensed operation to licensed operation without limitation to FR1 or FR2. But whether CBG is a useful feature for very short transmission durations is questionable, as explained by Ericsson. Above 52.6 GHz even with multiple slots for 480 or 960 kHz SCS, it is also likely that multiple PDSCHs or PUSCHs transmitted in multiple consecutive slots (possibly with some gap) will fail at the same time, so it anyway will be a very rare occasion that just one PDSCH or PUSCH is requested for retransmission. But the additional complexity is not small for supporting CBG retransmissions in conjunction with HARQ feedback for multi-slot scheduling with a single DCI, whereas the benefit is questionable. |
| Apple | We also do not see a need for CBG operation for 480 kHz and 960 kHz. |
| Intel | We are fine with the proposal. |
| Fujitsu | Fine with Proposal #5 |
| Futurewei | Support Proposal #5. CBG related fields are only present when a single PxSCH is scheduled. |
| Moderator | Based on working assumption, we need to define a rule also for 120 kHz SCS multi-PDSCH scheduling case. Considering strong concerns on the need for CBG operation with 480/960 kHz, we can disallow CBG operation for 480/960 kHz but allow it for 120 kHz, both for DL and UL, as in Proposal #5a. |
| Panasonic | We support the proposal#5 |
| OPPO | We support proposal#5. |

### [HIGH] Proposal #5a (CBGTI/CBGFI):

* For 120 kHz SCS,
  + 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 PDSCH is scheduled, but are present when a single PDSCH is scheduled.
* For 480/960 kHz SCS,
  + CBG-based (re)transmission cannot be configured.

Companies are encouraged to provide views on Proposal #5a.

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| --- | --- |
| Company | Views |
| Panasonic | We are fine with the proposal#5a |
| DOCOMO | Support the proposal. |
| Samsung | OK with proposal #5a. |
| Fujitsu | Fine with Proposal #5a. |
| ZTE, Sanechips | Fine with Proposal #5a. |
| vivo | Proposal #5 is preferred. The same behavior can be applied to all SCSs due to negligible spec efforts, since the complexity is anyway involved due to 120 kHz SCS. |
| NEC | We are fine with the proposal#5a |
| Qualcomm | We are fine with the proposal |
| Intel | The slot length is 32 or 16 us for SCS 480 or 960kHz respectively, while the CCA slot length is just 5us. If there is hidden node problem, it is still possible that only part of the slots of SCS 480/960kHz are interfered. Consequently, CBG based retransmission can be helpful.  Therefore, we prefer to apply same behavior to all SCSs including 120/480/960kHz, i.e., CBGTI/CBGFI fields are not present when more than one PDSCH is scheduled, but are present when a single PDSCH is scheduled. |
| Ericsson | We think that Proposal #5a and Proposal #10 are linked. If Option 3 is supported in Proposal #10, then there is no need for Proposal #5a. Hence, we would prefer that a decision is made on Proposal #10 first, before deciding on Proposal #5a. |
| Sony | We are fine with proposal#5a |
| MediaTek | We support the proposal |
| InterDigital | We prefer same UE behavior for 120kHz, 480kHz and 960kHz. The need to support CBGTI/CBGFI fields may be smaller than 120kHz, however, we don’t see the need to remove the functionality. Anyway, gNB would not configure CBGTI/CBGFI field if the gNB does not need the functionality. |
| Apple | We support the proposal |
| CATT | we agree with Ericsson’s view for this issue. |
| Spreadtrum | We support Proposal#5a. |
| Lenovo, Motorola Mobility | We support the proposal#5a |
| Xiaomi | We are fine with the proposal#5a |
| Huawei, HiSilicon | Our preference is option 3 in proposal #10. In this sense, we agree with the comment from Ericsson. |
| Moderator | Based on comments, we can discuss Proposal #10 first. Depending on whether Option 3 in Proposal #10 is adopted or not, we can resume the discussion for Proposal #5a. |

## 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] vivo | Proposal 19: Two codewords should be supported for multi-PDSCH scheduling. |
| [4] Spreadtrum | Proposal 4: Support to indicate the MCS/NDI/RV for the 2nd TB for multi-PDSCH scheduling. |
| [5] InterDigital | Observation 7: Supporting a second TB per each PDSCH when multiple PDSCHs are scheduled by a single DCI can have a significant specification impact, UE processing time and complexity. Further, having more than 4 layers is not a typical use case in 52.6-71 GHz thus supporting a 2nd TB in lack motivated.  Proposal 11: Scheduling of the 2nd TB for each PDSCH when multiple PDSCHs are scheduled by a single DCI is not supported. |
| [6] Sony | Observation 1: Scheduling of 2nd TB for each PDSCH is not beneficial for NR above 52.6 GHz. |
| [8] Samsung | Proposal 8: 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,   * - MCS/RV/NDI for 2nd TB is not applicable to multi-PDSCH scheduling (only support single TB case) |
| [10] ZTE | Proposal 3: 2nd TB for multiple PDSCHs scheduling is not supported. |
| [13] Ericsson | Observation 1: When multiple PDSCHs are scheduled by a single DCI with DCI Format 1\_1, it is not necessary to explicitly prohibit the MCS/NDI/RV fields for the second transport blocks in the specification. These fields can be disabled via existing RRC configuration. |
| [15] Nokia | Proposal 5: Support two TBs with multi-slot PxSCH. |
| [17] OPPO | Proposal 4: Only one TB transmission is supported when more than one PDSCHs are scheduled. |
| [18] Qualcomm | Proposal 16: For multi-PDSCH/PUSCH DCI fields enhancements:   * Second TB can be supported for each PDSCH   + MCS for the 2nd TB: This appears only once in the DCI and applies commonly to the second TB of each PDSCH   + NDI for the 2nd TB: This is signaled per PDSCH and applies to the second TB of each PDSCH   + RV for the 2nd 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 second TB of each PDSCH |
| [19] LG Electronics | Proposal #11: For NR FR2-2, support 2-TB transmission, subject to UE capability. Taking DCI overhead into account, 2-TB transmission can be allowed only when a DCI schedules a single PDSCH. |
| [21] Intel | Proposal 5: For multi-PDSCH scheduling   * Scheduling of 2nd TB is supported. * 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. |
| [22] Apple | Proposal 10: For multi-PDSCH transmission support transmission of a second codeword and its associated signaling based on UE capability. |
| [23] Panasonic | Proposal 3: For a DCI that can schedule multiple PDSCHs,  • MCS for the 2nd TB: This field is present when only a single PDSCH is scheduled, but is absent when more than one PDSCHs are scheduled  • NDI for the 2nd TB: This field is present when only a single PDSCH is scheduled, but is absent when more than one PDSCHs are scheduled  • RV for the 2nd TB: This field is present with 2 bits when only a single PDSCH is scheduled, but is absent when more than one PDSCHs are scheduled  • Note: In NR, support of the number of layers more than 4 is subject to UE capability |
| [24] NTT DOCOMO | Proposal 4:   * For multi-PDSCH scheduled by single DCI,   + Not support two TBs in one PDSCH at least when multiple PDSCHs are scheduled by one DCI. |

### Summary on 2-TB transmission:

Company views on 2-TB transmission for multi-PDSCH scheduling DCI:

* Supported (w/o constraint) by Huawei, vivo, Spreadtrum, Ericsson, Nokia, Qualcomm, Intel, Apple
* Supported (only for single PDSCH scheduling case) by InterDigital, Samsung, ZTE, OPPO, LG Electronics, Panasonic, NTT DOCOMO
* Objected by Sony

[Moderator’s note] Based on company views, the common factor that can be extracted is to support 2-TB transmission at least when a single PDSCH is scheduled. Therefore, the following proposal #6 can be made. This issue is indicated as “HIGH” since it may have an impact on HARQ-ACK codebook design.

**[HIGH] Proposal #6 (2-TB TX):**

* For a DCI that can schedule multiple PDSCHs, and if the higher layer parameter *maxNrofCodeWordsScheduledByDCI* indicates that two codeword transmission is enabled,
  + MCS/NDI/RV fields for the 2nd TB are present at least when only a single PDSCH is scheduled
    - FFS: Whether those fields are present or absent when more than one PDSCH is scheduled

Companies are encouraged to provide views on Proposal #6.

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| Company | Views |
| Lenovo, Motorola Mobility | Support the proposal#6 |
| Ericsson | Support Proposal #6 |
| Nokia/NSB | Support Proposal #6.  We don’t need to specify any new restriction. This can be handled by UE capability and NW configuration. |
| Qualcomm | We support the proposal |
| Huawei, HiSilicon | It is not really clear to us why the number of MIMO layers would be different for different PDSCHs, when we have already assumed to use the same MCS with the assumption that the channel conditions are similar in the scheduled slots. So why wouldn’t the rank also be the same? In this sense, we don’t understand the reason for limiting the support of 2 TBs only when a single PDSCH is scheduled. If the reason is related to DCI overhead, we think the benefit is limited since NDI and RV fields anyway need to be reserved for the maximum number of scheduled PDSCHs with a single TB, so that overhead will be there even if a single PDSCH is scheduled with 2 TBs. It is true that additional NDI and RV bits would need to be reserved for the second TB with the maximum number of scheduled PDSCH, but in the end the overhead is configurable by the gNB. |
| Apple | We can support the proposal for progress. We agree with Huawei that the behavior for the single and multiple PDSCH should be identical. |
| Intel | We do not support this proposal. We think we should allow 2nd TB in case of more than one PDSCHs scheduled by a single DCI in order to achieve higher data rate, which would be a critical factor to differentiate this band compared to NR operating in FR1 or FR2. This is also preferrable when comparing 5G technology with other competing solutions for this frequency band.  We can consider separate UE capability for this if needed. |
| Fujitsu | Fine with Proposal #6 |
| Futurewei | Support this proposal and FFS whether MCS/NDI/RV fields for 2nd TB are present when more than one PDSCH is scheduled. Our view is that >4 layers is a rare case for FR2-2. |
| Moderator | Please note that this proposal is suggested as a compromise to accommodate most company views. However, please express your views explicitly on whether 2-TB transmission for all cases is preferred or 2-TB transmission only for single PDSCH case is preferred. |
| Panasonic | We are fine with the proposal#6 |
| DOCOMO | Although we don’t prefer to support 2-TB at least for multiple PDSCHs scheduled case, we can compromise to accept the principle of the proposal for sake of progress, with additional limitation that “2-TB for single PDSCH scheduling case” and “2-TB for multiple PDSCH scheduling case” are enabled separately to address the DCI payload concern.  For example, *maxNrofCodeWordsScheduledByDCI* indicates for single PDSCH scheduling case, and *maxNrofCodeWordsMultiPdschScheduledByDCI* indicates for multiple PDSCH scheduling case. Therefore, we propose to modify the proposal as:   * For a DCI that can schedule multiple PDSCHs, ~~and if the higher layer parameter~~ *~~maxNrofCodeWordsScheduledByDCI~~* ~~indicates that two codeword transmission is enabled,~~   + if the higher layer parameter *maxNrofCodeWordsScheduledByDCI* indicates that two codeword transmission is enabled, MCS/NDI/RV fields for the 2nd TB are present at least when only a single PDSCH is scheduled   + FFS: Whether ~~those fields are~~ MCS/NDI/RV fields for the 2nd TB can be present ~~or absent~~ when more than one PDSCHs ~~is~~ are scheduled.     - If yes, FFS how to enable two codeword transmission for the multiple PDSCH scheduled case. |
| Samsung | We didn’t identify any practical scenario to support 2-TB in 60GHz, no matter it is single or multi-PDSCH scheduling. Please note, as is captured in TR 38.807, only up to two spatial layers could be supported using polarization diversity. Therefore, we prefer to disable 2-TB for all cases.  We’re ok to compromise to support 2-TB for single PDSCH scheduling, i.e. proposal #6. |
| ZTE, Sanechips | We are fine with Proposal #6. |
| Vivo | Support the proposal. We think it should also be supported when multiple PDSCHs are scheduled. |
| Sony | Although we don’t see benefit to support 2-TB in frequencies above 52.6 GHz, we are ok with proposal#6 as compromise. |
| MediaTek | We still don’t see the need and benefit to support 2 TB transmission in FR2-2 but we are ok to support the proposal as a compromise. |
| InterDigital | We are fine with proposal #6. |
| CATT | It seems the need to support 2TB is not sufficient but for progress we are OK if this is the majority view. |
| Spreadtrum | We support Proposal#6. |
| OPPO | We are fine with proposal #6. |
| Moderator | * OK: Lenovo, Ericsson, Qualcomm, Fujitsu, Futurewei, Panasonic, ZTE, InterDigital, Spreadtrum, OPPO * Prefer not to allow 2-TB, but OK: NTT DOCOMO, Samsung, Sony, MediaTek, CATT * Prefer 2-TB for all cases, but OK: Nokia, Apple, vivo * Prefer 2-TB for all cases, not OK: Huawei, Intel   I fully understand the reasoning of each party. But as the moderator, it seems that the best way we can go is Proposal #6 in principle. Based on NTT DOCOMO’s suggestion, Proposal #6a can be made as follows. The main motivation of the modification is to consider the possibility to introduce a separate RRC parameter to configure 2-TB transmission for the case where multiple PDSCHs are scheduled. |

**[HIGH] Proposal #6a (2-TB TX):**

* For a DCI that can schedule multiple PDSCHs,
  + If the higher layer parameter *maxNrofCodeWordsScheduledByDCI* indicates that two codeword transmission is enabled, MCS/NDI/RV fields for the 2nd TB are present at least when only a single PDSCH is scheduled
    - FFS: Whether MCS/NDI/RV fields for the 2nd TB can be present when more than one PDSCH is scheduled, and if yes, whether to enable two codeword transmission for multi-PDSCH case by new RRC parameter or by *maxNrofCodeWordsScheduledByDCI*

Companies are encouraged to provide views on Proposal #6a.

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| Company | Views |
| Qualcomm | We are fine with the proposal |
| Futurewei | To clarify our view regarding Proposal #6, we were OK to support the proposal for making progress after discussion in recent meetings, while prefer not to allow 2nd TB since >4 layers is a rare case for FR2-2. We recall that one of the main argument was that 2nd TB is allowed is that the AI does not want to be too ‘restrictive’ by not allowing 2nd TB, however, we see this more of a direct result of the characteristic of the FR2-2 and such ‘restriction’ may not imply negative impact.  However, for the reason of making progress on this one issue we are fine with Proposal #6 and Proposal #6a, where the multi-PDSCH case is to be further studied. |
| Intel | We do not support this proposal. It is still not clear to us if we can support 2 TBs for a single PDSCH case, why can not support 2 TBs for multiple PDSCHs by a single DCI. The channel conditions are expected to be similar for multiple PDSCHs. Further, as we commented before, this is an important factor to differentiate FR2-2 compared to FR1 or FR2-1. This is also preferrable when comparing 5G technology with other competing solutions for this frequency band.  We can consider separate UE capability for this if needed. |
| DOCOMO | We are fine with the proposal.  For the FFS, we prefer not to support 2nd TB when more than one PDSCHs are scheduled considering the additional DCI payload (e.g. NDI/RV fields for the 2nd TB should be reserved for max#PDSCH). But it should be supported, we prefer to enable the 2-TB for multiple PDSCH by new RRC parameter. |
| Nokia/NSB | We prefer keeping the existing spec as it is. No restriction is required. It can be handled by UE capability and NW scheduling. |
| Samsung | For the sake of progress, we are fine with the proposal. For the FFS, we prefer not to support 2nd TB for multiple PDSCHs.  We share same understanding with Futurewei that not allowing 2TB is a direct result of the characteristic of the FR2-2 and the feasible implementation, rather than a restriction. |
| Vivo | We are fine with the proposal #6a, but prefer the same RRC parameter is used for both single-PDSCH case and multi-PUSCH case. |
| Moderator | Based on online discussion, this proposal is updated as follows. |

**[HIGH] Proposal #6b (2-TB TX):**

* For NR FR2-2, two codeword transmission is supported, subject to UE capability.
  + RRC parameter configures that two codeword transmission is enabled or disabled.
  + FFS whether/how to handle DCI size overhead for a DCI that can scheduling multiple PDSCHs when two codeword transmission is enabled
  + FFS whether different RRC parameters can be used to enable/disable two codeword transmission depending on whether one or more than one PDSCH is scheduled

Companies are encouraged to provide views on Proposal #6b.

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| --- | --- |
| Company | Views |
| Huawei, HiSilicon | We generally support the proposal, although we would prefer resolving the FFS points at the same time. As long as RRC allows configuring whether two codewords can be scheduled, and therefore determine whether the extra DCI overhead is present, then we don’t see the need for additional restrictions related to the number of scheduled PDSCHs. But we can live with the second FFS.  We don’t understand the second FFS because RRC configuration cannot depend on scheduling decision, it is the other way around. We would prefer not to have the last FFS point. If this results in discussing the same proposal again (2 TBs can only be scheduled if a single PDSCH is scheduled), then we don’t see the practicality of such scheme. Why would a gNB choose to even configure in such a way? If the UE can receive 2 TBs but not multiple PDSCHs then most likely the gNB would just schedule multiple PDSCHs with 1 TB each and not configure multiple TBs by RRC. Otherwise, the gNB would not configure the TDRA table with multiple SLIVs and just schedule each PDSCH one by one. If just seems like a useless feature to schedule multiple PDSCHs with a single DCI but just one of them can be scheduled with 2 TBs. |
| Apple | We are fine with the 1st three bullets of the proposal. Need clarification on the 2nd FFS. |
| MediaTek | We share the same view with Apple that the 2nd FFS should be clarified. |
| Qualcomm | We share the same view with Apple |
| Intel | We are generally fine with the proposal. Need some clarification on the 2nd FFS. |
| Lenovo, Motorola Mobility | Similar view as Apple, not clear about the motivation to have 2nd FFS. First sub-bullet related to RRC parameter should suffice. |
| InterDigital | We are fine with the proposal. |
| DOCOMO | We would like to clarify our position first. Our first preference is to not support 2-TB scheduling at least when multiple PDSCHs are scheduled. But we can compromise for progress to support it with condition that 2-TB for single PDSCH scheduling and 2-TB for multiple PDSCH scheduling should be independently enabled.  As discussions in GTW, there are technical motivations/concerns for “supporting 2-TB for multiple PDSCHs” and “not supporting 2-TB for multiple PDSCHs”. Whether the performance gain (benefit) deserved the additional DCI payload (cost) is the main issue. If we can’t reach consensus on this point, the simplest method for trade-off is to leave it to gNB configuration. However, we think the “benefit and cost” for multiple PDSCH case may be different from the case for single PDSCH case. That’s why we suggest to enable the 2-TB for single PDSCH scheduling and 2-TB for multiple PDSCH scheduling independently.  In summary we support the proposal with modification. To make the last FFS bullet clearer, we suggest to modify it into:   * + FFS whether different RRC parameters can be used to enable/disable two codeword transmission ~~depending on whether one or more than one PDSCH is scheduled~~ for single PDSCH scheduled case and for multiple PDSCHs scheduled case |
| Samsung | No.  I don’t want to repeat the same comments for channel environment in 60GHz. I just want to ask companies, why when you’re discussing RS enhancement in the same AI (8.2.5), companies all agree that existing DMRS pattern can not work properly even for rank-1, with a lot of evaluations. And companies all agree to study enhancement, e.g. disable frequency domain OCC, for up to rank-2. Now, you change your position, you suggest that >4 rank is also possible and we should support it. Isn’t it weird ? Can any companies supporting 2-TB provide simulation results to prove that existing DMRS pattern can work well for > 4 layers ? |
| Panasonic | As the proposal#6b is to subject to UE capability, we are fine with the principle for a sake of progress, but we would like to clarify a motivation of the 2nd FFS point. |
| OPPO | We do not support proposal#6b. We echo Samsung’s comment that in TR phase we have extensive discussions on rank number and eventually agreed to evaluate simulation up to rank 2. It is not sure that if performance of 2 TB will lead to some serious issue. For the sake of progress, we can only compromise to proposal#6a. |
| Futurewei | We slightly prefer proposal#6a over proposal#6b. We understand that proposal#6b has ‘subject to UE capability’ as a compromise, and we are fine with it for sake of progress. While it might be beneficial to make sure that such UE capability that supports >4 layers is needed for FR2-2. |
| Moderator | Summary of company views:   * OK: InterDigital, NTT DOCOMO (with clarification on FFS regarding RRC parameter), Futurewei * OK but need clarification for the FFS regarding RRC parameter: Huawei, Apple, MediaTek, Qualcomm, Intel, Lenovo, Panasonic * Objected by Samsung and OPPO   **To NTT DOCOMO,**  As argued by Huawei, if we introduce the separate RRC parameter to enable 2-TB transmission for multi-PDSCH scheduling case, we need to additionally deal with the case where 2-TB transmission is enabled for single PDSCH scheduled case but not for multiple PDSCHs scheduled case. Considering that 2-TB transmission is normally useful not only for single PDSCH scheduling case but also for multi-PDSCH scheduling case and majority companies have a concern for the corresponding FFS point, unified RRC parameter would be sufficient. If the concern is DCI overhead, it is covered by the first FFS.  **To Samsung,**  As we discussed online, we don’t need to restrict peak throughput of NR operating beyond 52.6 GHz by ourselves, considering competitors operated in this band support up to 8 layer spatial multiplexing. Regarding FD-OCC off or DM-RS enhancement which is discussed in other thread, my understanding is that it could be beneficial in some scenarios but not critical in other scenarios (e.g., low delay spread environment, fixed wireless access). 2-TB transmission is subject to UE capability and gNB’s configuration, and does not have a large impact on specification. What is the harm to have it?  **To OPPO,**  If a UE benefits from 2-TB transmission, the benefit is still valid regardless of either single-PDSCH scheduling or multi-PDSCH scheduling. If the concern is in terms of DCI overhead, it is covered by the first FFS. As I commented to Samsung, 2-TB transmission is subject to UE capability and gNB’s configuration, and does not have a large impact on specification. What is the harm to have it? What is your main concern to support 2-TB transmission for all cases? |

**[HIGH] Proposal #6c (2-TB TX):**

* For NR FR2-2, two codeword transmission is supported, subject to UE capability.
  + RRC parameter configures that two codeword transmission is enabled or disabled.
  + FFS whether/how to handle DCI size overhead for a DCI that can scheduling multiple PDSCHs when two codeword transmission is enabled

Companies are encouraged to provide views on Proposal #6c and moderator’s comments in the summary above.

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| Company | Views |
| vivo | Support proposal #6c. |
| Huawei, HiSilicon | We are ok with the proposal #6c, although we are still not sure exactly what will be discussed under the remaining FFS point. But at least we will have to discuss signaling of MCS, NDI and RV for the 2nd TB for each scheduled PDSCH. If that’s the common understanding then it’s ok. |
| Qualcomm | We are fine with the proposal |
| DOCOMO | We want more clarification for what specific handling is talking about in the first FFS to address the DCI overhead concern? If we support 2-TB for multi-PDSCH scheduling, the NDI/RV for the 2nd TB will always be present, according to current indication principle of NDI/RV for 1st TB. Is the intention of the 1st to change the principle of NDI/RV indication? Or other enhancements that can make the DCI overhead in control?  From our point of view, we still think enabling 2-TB for single PDSCH scheduling and for multiple PDSCH scheduling by separate parameters is a potential solution to flexibly trade-off between expected 2-TB gain and resulted DCI overhead. Therefore, we suggest following modification:   * For NR FR2-2, two codeword transmission is supported, subject to UE capability.   + RRC parameter configures that two codeword transmission is enabled or disabled.     - FFS whether unified or separate parameter to enable/disable 2-TB for single and for multiple PDSCH scheduling   + FFS whether/how to handle DCI size overhead for a DCI that can scheduling multiple PDSCHs when two codeword transmission is enabled   To better clarify the motivation of separate enabling/disabling 2-TB for single and multiple PDSCH scheduling case:  For example, we now have two features (i.e. feature A is 2-TB for single PDSCH case, feature B is 2-TB for multiple PDSCH case) with similar advantages (i.e. throughput improvement) but applying for different scenarios. Feature A is already supported and can be ON/OFF by RRC configuration. Feature B was objected by some companies due to certain reasons (i.e. DCI overhead), but supported by other companies due to its advantage. And now the case is we are stuck here to determine whether feature B should be supported. A reasonable compromise solution is to support feature B but leave the enabling/disabling independently from other existing features. Isn’t it more acceptable for objecting companies?  We can have four cases if separate enabling/disabling is supported.   * Case 1: 2-TB disabled for single PDSCH scheduling, 2-TB disabled for multiple PDSCH scheduling (MCS/NDI/RV for the 2nd TB are absent, 2-TB gain is not available for any scheduling case) * Case 2: 2-TB enabled for single PDSCH scheduling, 2-TB enabled for multiple PDSCH scheduling (at least NDI/RV for the 2nd TB are present for the maximum number of PDSCHs, 2-TB gain is available for any scheduling case) * Case 3: 2-TB enabled for single PDSCH scheduling, 2-TB disabled for multiple PDSCH scheduling (MCS/NDI/RV for the 2nd TB are present only once, 2-TB gain is available for single PDSCH scheduling case) * Case 4: 2-TB disable for single PDSCH scheduling, 2-TB enabled for multiple PDSCH scheduling [Meaningless case]   We can only two cases if separate enabling/disabling is NOT supported:   * Case 1: 2-TB disabled (MCS/NDI/RV for the 2nd TB are absent, 2-TB gain not available for any scheduling case) * Case 2: 2-TB enabled (at least NDI/RV for the 2nd TB are present for the maximum number of PDSCHs, 2-TB gain available for any scheduling case)   In our understanding, the Case 3 is the desired case for objecting companies. It can be achieved by separate enabling/disabling case. But it can’t be achieved by unified enabling/disabling. |
| Intel | Support proposal #6c. |
| ZTE, Sanechips | We are generally fine with Proposal #6c. As for the FFS part, we prefer to jointly discuss it with the main bullet. |
| Futurewei | Agree with DOCOMO’s modifications. |
| Nokia/NSB | Support the proposal #6c. All the other aspect can be discussed as part of FFS. |
| Samsung | We don’t support proposal #6c.  Sorry, we can not accept 2-TB for uncertain scenario/deployment without any evaluation results.   1. Companies suggest that 8 layers is supported by 802.11 ay, so of course NR should support it to achieve comparable throughput. However, it is unclear to us, the channel model 802.11 ay considers is a well-proved practical channel environment rather than just a paper work. What antenna deployment is assumed, which is also feasible for product? It does not make sense to just simply say, we want it, just because another system can support it. Please note, many parameters and procedures in 802.11 ay is different from NR. As far as I know, MIMO/beam procedure adopted in 802.11 ay for 60GHz unlicensed band is very different from NR. Do we also need to adopt same procedure to be ‘competitive’? 2. Since we never evaluate 8 layer case throughout SI, we can not just imagine 8 layers can work properly with 3GPP channel model and antenna model. We need evaluation results to decide whether 8 layers can be supported with current channel model and antenna model. If companies prefer new channel model and antenna model for better support of 8 layers, please provide the proper channel model and antenna model in your mind, e.g. how small delay spread we assume as suggested by FL, how many panels we assume ? We’re open for the discussion for any potential new simulation assumption. And then, we can evaluate 8 layer case. |
| Intel | To respond to Samsung’s comment.  Regarding whether 8 layers is feasible or not. Today there are already pre-commercial products that can do 8x line of sight operation in E-band. I do not wish to market specific vendor’s products, but you can just search (e.g. on google) for “8x8 line-of-sight MIMO E-band” to find one example. So we don’t need a channel model study to know whether 8 layer transmission is possible or not, since there are already commercial and pre-commercial products that deliver this feature.  As for supporting feature to stay “competitive”, we would argue this may not be just for paper specification but we believe there are real world applications and use cases, especially with fixed wireless access, such as using customer premise equipment (CPE). With that said, I would argue that having a competitive system with other wireless technologies in the same domain is incredibly important. Everyone knows products just don’t sell by themselves simply because of the technological features, but require well executed marketing to jump boost the eco system and user base. There have been many instances, where 3GPP has spent effort to optimize on somewhat speculative peak rate features because of marketing. Peak rate for LTE Cat 5 is a classical example where this has happened. So, I am not sure if staying competitive is something we can simply brush aside. I would say it is fairly important for NR to be able to tout and market the extremely high peak rates as well. |
| Moderator | **To Samsung,**  I can understand your argument, but hope Intel’s explanation helps Samsung to be open minded about 2-TB transmission.  **To NTT DOCOMO,**  We have to admit that the system can be complicated if we allow enabling 2-TB TX for single-PDSCH case but disabling 2-TB TX for multi-PDSCH case. However, let’s see adding FFS can be a compromise to opponents of 2-TB transmission.  **To all,**  According to the discussion on the reflector, the first FFS (for DCI overhead) is modified and another FFS (with square bracket) is added based on NTT DOCOMO’s suggestion. |

**[HIGH] Proposal #6d (2-TB TX):**

* For NR FR2-2, two codeword transmission is supported, subject to UE capability.
  + RRC parameter configures that 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]

Companies are encouraged to provide views on Proposal #6d.

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| --- | --- |
| Company | Views |
| Lenovo, Motorola Mobility | We are generally fine with the proposal, but would suggest to update the second FFS as follows:  FFS ~~whether unified or separate parameter to~~ details to enable/disable 2-TB for single and for multiple PDSCH scheduling |
| Huawei, HiSilicon | We are ok with the proposal. |
| InterDigital | We are fine with the proposal. |
| Apple | We are fine with the proposal |
| Samsung | Thanks Intel for the value information. My apologize, google is inaccessible in my place ☹ And sorry, we’re not very familiar with details of pre-commercial product out 3GPP, we just focus on the channel model and deployment assumption under 3GPP. So, we’re a bit cautious to agree that NR can work properly for 8 layers with a channel model which can work for 802.11 ay but different from what we used in SI phase, especially considering the system parameters for NR and 802.11 ay is different. For example, different SCS, different RS design, different modulation order, and different MIMO/beamforming procedure, which may all lead to different performance even in the same channel model.  We fully agree with you that being competitive with other wireless technologies is very important. But, we can’t rush into a decision to support 2-TB without any evaluation result for NR system, because we don’t know whether support it would make NR more competitive or less competitive, e.g. due to larger DCI overhead or UCI overhead (if at least one cell is configured with 2-TB, all cells within one sub-codebook have to reserve HARQ-ACK bits for 2-TB).  So, we suggest to give more time to take all these factors into account, and make the decision in next meeting. |
| Qualcomm | We support the proposal |
| Intel | We understand, companies have there own opinion on various matters and we respect that.  With regards to the proposal we are fine to support it. |
| DOCOMO | We are fine with the proposal. |
| Futurewei | We are OK with the updated proposal with the second FFS. If the 2-TB configuration for multi-PDSCH is properly addressed in the future meeting, it should still add on value to this key feature (multi-PDSCH) that belongs to FR2-2.  While we are also OK if the issue is to be given more time and be decided in the next meeting. |
| OPPO | We share the same view as Samsung. |
| Fujitsu | We are fine with the proposal. |
| Nokia/NSB | We are fine with the proposal. |
| vivo | We are fine with the proposal. |
| ZTE, Sanechips | We are fine with the proposal. |
| Moderator | Summary on companies’ views:   * OK: Lenovo, Huawei, InterDigital, Apple, Qualcomm, Intel, NTT DOCOMO, Futurewei, Fujitsu, Nokia, vivo, ZTE * Defer any decision in the next meeting: Samsung, OPPO   To be honest, I’m reluctant to postpone the whole discussion on 2-TB TX in the next meeting. We sufficiently exchanged views each other and majority view is OK with this proposal. Let’s discuss more during GTW session to see if we can converge somewhere. |

**[HIGH] Proposal #6e (2-TB TX):**

* For NR FR2-2, two codeword transmission is supported, subject to UE capability.
  + RRC parameter configures that 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

Companies are encouraged to provide views on Proposal #6e.

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| Company | Views |
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On 8/25 GTW session, the following working assumption was made:

### Working assumption:

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

## URLLC-related fields

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| Company | Views |
| [3] vivo | Proposal 14: It can be clarified that the URLLC related fields in the DCI scheduling multiple PUSCHs are applied equally to each scheduled PUSCH, including priority indicator and open-loop power control parameter set indication. |
| [5] InterDigital | Proposal 12: For PUSCH priority indication for multi-PUSCH scheduling, signaling overhead and scheduling flexibility should be carefully considered. |
| [6] Sony | Proposal 2: URLLC related fields should be supported for multi-PUSCH scheduling  • Single field related to URLLC should be applied to multiple PUSCHs scheduled by single DCI.  Proposal 4: Priority indicator should be supported for multi-PDSCH scheduling  • Further study whether single or multiple fields related to URLLC are applied to multiple PDSCH scheduled by single DCI if multiple PUCCH scheduled by the single DCI is supported. |
| [8] Samsung | Proposal 7: For Rel-16 NR-U multi-PUSCH scheduling DCI:   * URLLC related field: Support same priority for all PUSCHs scheduled by a single DCI |
| [13] Ericsson | Proposal 20: When DCI Format 0\_1 is used for scheduling multiple PUSCHs, priority indicator and open-loop power control parameter set indication fields in the DCI should apply to all PUSCHs being scheduled. |
| [15] Nokia | Proposal 6: For other multi-PxSCH enhancements:  • For URLLC related fields, one value of each field is applied for all scheduled PUSCHs |
| [19] LG Electronics | Proposal #9: For the multi-PUSCH scheduling in Rel-17,   * URLLC related fields such as priority indicator and/or open loop power control parameter set indication   + Alt 1: Apply to all of scheduled PUSCHs.   + Alt 2: Present if only a single PUSCH is scheduled, but absent otherwise.   Proposal #10: For multi-PDSCH scheduling with a single DCI,   * Priority indicator:   + Alt 1: Apply to all of scheduled PDSCHs.   + Alt 2: Present if only a single PDSCH is scheduled, but absent otherwise. |
| [22] Apple | Proposal 8: For Rel-17 multi-PUSCH transmission  • a single URLLC priority should be assigned to a single DCI  Proposal 11: For Rel-17 multi-PDSCH transmission  • a single URLLC priority should be assigned to a single DCI |
| [24] NTT DOCOMO | Proposal 4:   * For multi-PUSCH scheduled by single DCI,   + For URLLC related fields, one value of each related field is applied for all scheduled PUSCHs. * For multi-PDSCH scheduled by single DCI,   + Similar consideration on CBG based transmission, FDRA and URLLC fields as multi-PUSCH scheduling can be applied to multi-PDSCH scheduling. |

### Summary on URLLC-related fields:

Company views on enhancement for URLLC related field such as priority indicator and open-loop power control parameter set indication:

* Apply commonly to all PDSCHs or PUSCHs
  + Supported by vivo, Sony (FFS multi-PDSCH case if multiple PUCCH scheduled by the single DCI is supported), Samsung, Ericsson, LG Electronics, Apple, NTT DOCOMO
* Present if only a single PDSCH or PUSCH is scheduled, but absent otherwise
  + Supported by LG Electronics

[Moderator’s note] At least 6 companies commonly suggest to apply URLLC related fields to all scheduled PDSCHs or PUSCHs, so the following proposal #7 can be made.

**Proposal #7 (URLLC-related fields):**

* 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.

Companies are encouraged to provide views on Proposal #7.

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| Company | Views |
| Lenovo, Motorola Mobility | We are okay with proposal#7 |
| Ericsson | Support Proposal #7 |
| Nokia/NSB | Support Proposal #7 |
| Qualcomm | We support the proposal |
| Huawei, HiSilicon | OK with proposal #7 |
| Apple | We support the proposal |
| Intel | We are fine with the proposal. |
| Fujitsu | Fine with Proposal #7 |
| Futurewei | Support Proposal #7. Since this issue had been deprioritize in the previous meeting and it is not of high importance, there is reason to conclude it by this meeting. |
| Panasonic | We support the proposal#7 |
| DOCOMO | Support the proposal. |
| Samsung | Support Proposal #7 |
| ZTE, Sanechips | Support Proposal #7. |
| Vivo | Support the proposal. |
| Sony | We support proposal#7 |
| CATT | We are fine with the proposal |
| Spreadtrum | We support Proposal#7 |
| OPPO | We are fine with proposal #7. |
| Moderator | Seems stable. Proposal #7 will be reported for email endorsement. |
| InterDigial | We are fine with the proposal. |

During email discussion, the following agreement was made:

### Agreement:

* 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.

## Frequency hopping

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| --- | --- |
| Company | Views |
| [1] Huawei | Observation 6: Further enhancements of frequency hopping for multi-slot PUSCH scheduling are not essential. |
| [3] vivo | Proposal 17: For frequency hopping for multi-PUSCH scheduling, it should be clarified which frequency hopping mode(s) is/are supported for multi-PUSCH scheduling in NR-U Rel-16, before any further potential enhancement is discussed. |
| [4] Spreadtrum | Proposal 1: Frequency hopping should be supported for scheduled PUSCH. |
| [5] InterDigital | Proposal 16: When multiple PUSCHs are scheduled using the same DCI, support only intra-slot frequency hopping |
| [8] Samsung | Proposal 7: For Rel-16 NR-U multi-PUSCH scheduling DCI:   * Frequency hopping: Support intra-PUSCH hopping |
| [10] ZTE | Proposal 3:   * Further enhancement of frequency hopping is not supported. |
| [13] Ericsson | Proposal 16: Support intra-slot frequency hopping for multi-PUSCH scheduling with a single DCI, which is what is specified for multi-PUSCH scheduling in Rel-16 according to our interpretation. Do not support inter-slot hopping for multi-PUSCH scheduling with a single DCI. |
| [15] Nokia | Proposal 6: For other multi-PxSCH enhancements:   * FDRA enhancements and frequency hopping enhancements are considered as secondary topics for multi-PxSCH transmission and they are considered only if time allows.   + No support for inter-slot frequency hopping. |
| [18] Qualcomm | Proposal 17: Consider the impact of RF retuning delay on the frequency hopping when operating over larger SCS  • Frequency hopping discussion can be deprioritized |
| [21] Intel | Proposal 6: For multi-PUSCH scheduling,   * Support intra-slot frequency hopping for scheduled PUSCHs. |
| [22] Apple | Proposal 8: For Rel-17 multi-PUSCH transmission  • Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz |
| [24] NTT DOCOMO | Proposal 4: For multi-PUSCH scheduled by single DCI,   * Support frequency hopping for multi-PUSCH scheduling. Newly introduced frequency hopping scheme for multi-PUSCH scheduling can be considered. |
| [25] Xiaomi | Proposal 7: Support to study intra-TTI frequency hopping and its enabling mechanism for multi-TTI scheduling. |

[Moderator’s note] Considering that the clarification on frequency hopping for multi-PUSCH scheduling in Rel-16 is discussed in [106-e-NR-NRU-02] for this meeting, it is proposed to discuss this issue once a conclusion will be drawn from [106-e-NR-NRU-02] or 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 |
| Lenovo, Motorola Mobility | Agree to deprioritize this issue in this meeting |
| Ericsson | Agree with moderator’s assessment |
| Nokia/NSB | We support Moderator’s proposal. |
| Qualcomm | Frequency hopping discussions can be deprioritized |
| Huawei, HiSilicon | OK with the moderator’s proposal |
| Apple | We are fine with the moderator’s proposal. |
| Intel | We are fine to deprioritize this issue in this meeting |
| Fujitsu | Support moderator’s proposal. |
| Futurewei | Agree that if decision relies on conclusion from [106-e-NR-NRU-02], the issue needs to be deprioritized in this meeting. |
| Panasonic | Agree to deprioritize this issue in this meeting |
| Samsung | OK with the moderator’s proposal |
| ZTE, Sanechips | Agree with moderator’s assessment. |
| Vivo | Agree with moderator’s assessment. |
| Sony | We are fine with moderator’s proposal. |
| InterDigital | We are fine with the proposal. |
| Spreadtrum | We are fine with moderator’s note. |

## Remaining issues for multi-PDSCH scheduling DCI

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| --- | --- |
| Company | Views |
| [1] Hauwei | Observation 2: The interleaved VRB-to-PRB mapping for 120 kHz SCS can be reused for 480 kHz and 960 kHz SCS.  Observation 3: PRB bundling mechanism defined in Rel-15 can be reused as a baseline for multi-PDSCH scheduling in this new frequency range.  Observation 4: The existing configuration and indication related to *RateMatchPattern* can be reused. |
| [3] vivo | Proposal 20: Each of resource allocation related fields in the DCI scheduling multiple PDSCHs is applied equally to each scheduled PDSCH, including VRB-to-PRB mapping, PRB bundling size indicator, rate matching indicator, and ZP CSI-RS trigger. |
| [13] Ericsson | Proposal 17: When multiple PDSCHs are scheduled by a single DCI with DCI Format 1\_1, the triggered ZP CSI-RS field applies to all the PDSCHs scheduled by the DCI.  Proposal 18: When multiple PDSCHs are scheduled by a single DCI with DCI Format 1\_1, the VRB-to-PRB mapping and PRB bundling size indicator fields apply to all the PDSCHs scheduled by the DCI.  Proposal 19: When multiple PDSCHs are scheduled by a single DCI with DCI Format 1\_1, the Rate Matching Indicator field applies to all the PDSCHs scheduled by the DCI. |
| [18] Qualcomm | Proposal 16: For multi-PDSCH/PUSCH DCI fields enhancements:  • VRB-to-PRB mapping and PRB bundling size indicator: to be applied for all granted data allocations by the same DCI  • ZP CSI trigger: to be applied to all the slots granted by the same DCI. |
| [19] LG Electronics | Proposal #10: For multi-PDSCH scheduling with a single DCI,   * Rate matching indicator and ZP-CSI-RS trigger: This can be applied to all or part of scheduled PDSCHs (e.g., the first PDSCH). |
| [21] Intel | Proposal 7: For multi-PDSCH scheduling   * Carrier indicator, BWP indicator, frequency domain resource allocation, VRB-to-PRB mapping, PRB bundling size indicator, rate matching indicator, ZP CSI-RS trigger and DMRS configuration including antenna port, DMRS sequence initialization, etc., can be applied for all the scheduled PDSCHs. |
| [22] Apple | Proposal 12: 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, |
| [24] NTT DOCOMO | Proposal 4:   * For multi-PDSCH scheduled by single DCI,   + VRB-to-PRB mapping, PRB bundling size indicator, rate matching indicator, and ZP CSI-RS trigger are applied to all slots of scheduled PDSCHs. |

### Summary on VRB-to-PRB mapping, PRB bundling size indicator, ZP-CSI-RS trigger, and rate matching indicator fields for multi-PDSCH scheduling DCI:

Company views on VRB-to-PRB mapping, PRB bundling size indicator, ZP-CSI-RS trigger, and rate matching indicator fields for multi-PDSCH scheduling DCI:

* For VRB-to-PRB mapping, PRB bundling size indicator, and ZP-CSI-RS trigger fields
  + Applies to all scheduled PDSCHs: vivo, Ericsson, Qualcomm, LG Electronics, Intel, Apple, NTT DOCOMO
* For rate matching indicator field
  + Applies to all scheduled PDSCHs: vivo, Ericsson, Qualcomm, LG Electronics, Intel
  + Applies per PDSCH: Apple

[Moderator’s note] Considering the majority view, the following Proposal #8 can be made.

**Proposal #8 (Remaining fields for multi-PDSCH scheduling DCI):**

* For a DCI that can schedule multiple PDSCHs,
  + VRB-to-PRB mapping, PRB bundling size indicator, ZP-CSI-RS trigger, and rate matching indicator fields are applied to all the PDSCHs scheduled by the DCI.

Companies are encouraged to provide views on Proposal #8.

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| --- | --- |
| Company | Views |
| Lenovo, Motorola Mobility | Support the proposal#8 |
| Ericsson | Support Proposal #8 |
| Nokia/NSB | We are fine with VRB-to-PRB mapping, PRB bundling size indicator. However, the usecase of repeating the same rate-matching pattern (including ZP-CSI-RS) is unclear.  Propose,   * For a DCI that can schedule multiple PDSCHs,   + VRB-to-PRB mapping and PRB bundling size indicator fields are applied to all the PDSCHs scheduled by the DCI.   + FFS: ZP-CSI-RS trigger, and rate matching indicator fields |
| Qualcomm | We support the proposal |
| Huawei, HiSilicon | OK with proposal #8 |
| Apple | We are fine with the VRB-to\_PRB mapping, PRB bundling size indicator and ZP-CSI-RS fields. Would like an understanding of the use case for repeating the same rate matching indicator field. |
| Intel | We are fine with the proposal. |
| Fujitsu | Fine with Proposal #8. |
| Futurewei | Agree with Proposal #8, and like the URLLC related fields, it is better that this issue be concluded and closed by this meeting. |
| Panasonic | We support the proposal#8 |
| DOCOMO | Support the proposal. |
| Samsung | In our understanding, in Rel-15/16, aperiodic ZP CSI-RS is applied to all slots, while rate matching pattern is applied to slots according to rate matching pattern configuration. So, we’d like to ask any particular reason to change legacy behavior ? |
| ZTE, Sanechips | Fine with the proposal #8. |
| Vivo | Support the proposal. |
| Sony | We support proposal#8. |
| MediaTek | We share the same view with Apple and Nokia that rate matching indicator field need more discussion. |
| CATT | We are fine with the proposal |
| Spreadtrum | We support Proposal#8. |
| OPPO | We are fine with proposal #8. |
| Huawei, HiSilicon | After reading the companies’ comments there seems to be a potential misunderstanding of the proposal. It could be clarified that each of these parameter is a common field applicable to all scheduled PDSCHs. In our reading, the proposal is not “repeating the same rate matching indicator field”. There would still be just one such field. The DCI may activate the rate matching, which would then apply to all the slot(s) of the scheduled PDSCHs. Similarly, the ZP CSI-RS field triggers one aperiodic ‘ZP-CSI-RS-ResourceSet’, which would then apply to all the slot(s) of the scheduled PDSCHs. |
| Moderator | With the understandings   * For rate matching indicator field, indicated rate matching pattern is applied to all PDSCHs and there is only one field in a DCI. * For ZP-CSI-RS trigger field, triggered aperiodic ZP CSI-RS resource set is applied to all PDSCHs repeatedly and there is only one field in a DCI.   Proposal #8 can be updated as below. |

**Proposal #8a (Remaining fields for multi-PDSCH scheduling DCI):**

* 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) of the PDSCH scheduled by the DCI.
  + 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.

Companies are encouraged to provide views on Proposal #8a.

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| --- | --- |
| Company | Views |
| Futurewei | Support Proposal #8a. |
| Ericsson | Support Proposal #8a. We think the clarifications are good.  Also, regarding the ZP-CSI-RS trigger field, we’d like to point out that Proposal #8a is aligned with Rel-15/16 behavior for the case of multi-slot PDSCH (38.214 Section 5.1.4.2):  *When the UE is configured with multi-slot and single-slot PDSCH scheduling, the triggered aperiodic ZP CSI-RS is applied to all the slot(s) of the PDSCH scheduled or the PDSCHs with SPS activated by the PDCCH containing the trigger.* |
| Intel | We are fine with the proposal. |
| DOCOMO | Support Proposal #8a. |
| Nokia/NSB | Thanks for clarification. Support the proposal. |
| Vivo | Support Proposal #8a. |
| Huawei, HiSilicon | We support proposal #8a |
| ZTE, Sanechips | We are fine with the proposal. |
| Apple | Clarification question: the rate-matching field will be long enough to span all the PxSCH resources so that each PxSCH resource can technically have a unique pattern ? |
| MediaTek | We are generally fine with the proposal. Just want to clarify that PDSCH rate-matching patterns are RRC configured in *rateMatchPatternToAddModList* and *DCI* can dynamically enable or disable the configured rate-matching patterns associated with *rateMatchPatternGroup1* or *rateMatchPatternGroup2.* Based on this understanding, the resources indicated by rate-matching patterns not in *rateMatchPatternGroup1* or *rateMatchPatternGroup2* are also not available to the scheduled PDSCHs. We hope this is the common understanding.  To Apple: based on our understanding to TS 38.214 section 5.1.4.1, our answer is Yes. The rate-matching pattern has periodicity, which is long enough to cover all the scheduled PDSCH. However, whether each scheduled PDSCH resource can face different patterns will depend on the configuration. |
| Qualcomm | We are fine with the proposal |
| Ericsson | We still support the proposal.  But just noticed that a minor correction/clarification is needed. Without this clarification, it seems that one of the PDSCHs can span more than one slot, which is not the case for a DCI that can schedule multiple-PDSCHs.   * + For ZP-CSI-RS trigger field, the triggered aperiodic ZP CSI-RS is applied to all the slot(s) in which ~~of~~ the PDSCH(s) scheduled by the DCI are contained. |
| InterDigital | We are fine with the proposal. |
| Samsung | We support proposal #8a |
| Panasonic | We are fine with the proposal #8a |
| Sony | We support proposal#8a |
| Apple | Thanks to MTK for the clarification. We are fine with the proposal. |
| Futurewei | We support Proposal#8a. |
| Moderator | To MediaTek,  I also confirm that the resources configured by rate-matching patterns but not indicated by *rateMatchPatternGroup1* or *rateMatchPatternGroup2* are also not available to the scheduled PDSCHs, as specified in 214 specification, as follows:  *The REs corresponding to the union of resource-sets configured by RateMatchPattern(s) that are not included in either of the two groups are not available for a PDSCH scheduled by a DCI format 1\_0, a PDSCH scheduled by a DCI format 1\_1, and PDSCHs with SPS.*  **To all,**  Proposal 8a seems acceptable to all and Ericsson’s modification should be fine considering a PDSCH cannot span multiple slots. Proposal 8b reflecting Ericsson’s modification is shown below. |

**Proposal #8b (Remaining fields for multi-PDSCH scheduling DCI):**

* 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.

Companies are encouraged to provide views on Proposal #8b if you have a strong concern.

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| --- | --- |
| Company | Views |
| vivo | Support proposal #8b. |
| Qualcomm | We support the proposal |
| DOCOMO | Support Proposal #8b. |
| Intel | We are fine with the proposal. |
| ZTE, Sanechips | We are fine with the proposal. |
| Ericsson | We support Proposal #8b |
| Nokia/NSB | We support Proposal #8b |
| Samsung | We support Proposal #8b |
| Moderator | Seems stable. Proposal #8b can be reported for email endorsement. |

During email discussion, the following agreement was made:

### Agreement:

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.

## Others

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| --- | --- |
| Company | Views |
| [1] Huawei | Observation 5: 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. |
| [8] Samsung | Proposal 9: For a DCI capable of scheduling multi-PDSCH/PUSCHs, gNB can only indicate a row with single SLIV for SPS PDSCH/CG PUSCH activation. |
| [9] CATT | Proposal 10: For scheduling multiple PDSCHs, out of order scheduling is not supported. |
| [13] Ericsson | Proposal 11: 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. |
| [15] Nokia | Proposal 2: Consider dynamic indication of the number of repetitions also for PDSCH. |
| [18] Qualcomm | Proposal 23: 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. |
| [24] NTT DOCOMO | Proposal 4:   * 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. |
| [25] Xiaomi | Proposal 8: Support to indicate more than one channel access types in a single DCI. |

### 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
* Samsung: SPS PDSCH/CG PUSCH activation of multi-PDSCH/PUSCH scheduling DCI
* CATT: Out-of-order of multi-PDSCH scheduling case
* Ericsson: TDRA table configuration by allowing only one of repetition and multi-PXSCH scheduling in a DCI format
* Nokia: Support of dynamic indication of the number of repetitions for PDSCH
* Qualcomm: Support scheduling a single TB to be repeated over multiple allocations and multiple TBs, with no repetitions, using the same DCI format
* NTT DOCOMO: TDRA table configuration by allowing PUSCH repetition and multi-PUSCH scheduling in a DCI format
* Xiaomi: Support of more than one channel access type indication fields in a single DCI

[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 |
| Lenovo, Motorola Mobility | In general, we also agree to further discuss if and how to support multiple PDSCH/PUSCH with repetitions. |
| Ericsson | In the previous meeting, there was discussion about the following agreement (specifically the highlighted part). It seemed like the view was that some clarification was needed for the N = 1 case. For example, for multi-PDSCH scheduling, i.e., when a TDRA table is configured with at least one row with multiple SLIVs, is it allowed to schedule a single PDSCH from the same TDRA table (using a row with single SLIV) using legacy repetition? In other words, can repetition and multi-PDSCH be mixed in the same TDRA table? We think the answer is “no” (consistent with Rel-16 design for multi-PUSCH), and that this should be clarified.  Agreement:   * 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. |
| Futurewei | Agree to deprioritize the issues that brought up by a single company and focus on higher priority issues that need progress. |
| ZTE, Sanechips | Agree with moderator’s assessment. |
| InterDigital | We are fine with deprioritizing |
| Spreadtrum | We agree with moderator’s note. |
| Apple | We are fine with deprioritizing but we would like to add the issue of the HPN adjustment/transmission behavior in the case that there is a CG/SPS resource within the first and last resources for the multi-PxSCH transmission. |

# HARQ

## Impact of collision between PDSCHs and semi-static UL on HARQ-ACK codebook generation

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| Company | Views |
| [1] Huawei | Proposal 8: As for Rel-16 multi-PUSCH scheduling, determine the HARQ process ID for each PDSCH/PUSCH by incrementing the HARQ process ID by one starting from the first PDSCH/PUSCH, independently of potential resource collisions with UL/DL symbols. If the resource collides with a pre-configured resource, NACK corresponding to the collided PDSCH should be reported by the UE. |
| [3] vivo | Proposal 23: As the starting point, for the set of SLIVs corresponding to each DL slot of the set of DL slots, SLIV pruning and grouping operations in Rel-15/16 can be reused to determine the subset of occasions corresponding to the DL slot. |
| [8] Samsung | Proposal 12: For Type-1 codebook,   * The set of SLIVs corresponding to a DL slot only includes SLIVs that can be scheduled within the DL slot by any row index r of TDRA table. * Support pruning based on TDD UL/DL configuration is performed for each PDSCH SLIV within each slot respectively. * Support pruning based on overlapped SLIVs can be performed for each PDSCH SLIV within each slot respectively, or for set of SLIVs across multiple slots.   + If only single PDSCH reception per slot, or single PDSCH reception in a slot associated with one PUCCH is allowed, the pruning for overlapped SLIVs can be simplified. * Support redundancy reduction with the consideration of validity of PDCCH MO. |
| [15] Nokia | Proposal 12: For Type-1 codebook,  • Pruning of the set of DL slots against UL symbols in *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* is supported  • Receiving of only one PDSCH in a slot is supported on serving cells with multi-PDSCH scheduling configured  • Time domain bundling, including configurable partial bundling of HARQ-ACKs is supported by selecting the last SLIV(s) of TDRA row for bundled HARQ-ACK bit(s). |
| [16] 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. |
| [19] LG Electronics | Proposal #12: Do not consider the SLIV corresponding to a PDSCH skipped due to the collision with semi-static UL symbols, for pruning procedure of type-1 HARQ-ACK codebook generation. |
| [20] MediaTek | Proposal 1: For Type-1 codebook construction, details of further pruning on the candidate PDSCH occasions and the handling of more than one PDSCH in a slot can reuse the same Rel-15/16 Type-1 codebook construction procedure based on TDD configuration and UE capability on the number of PDSCH reception per slot |
| [21] Intel | Proposal 8  For Type-1 HARQ-ACK codebook generation,   * the set of SLIVs just 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, considering the TDD UL-DL configuration. * to allocate the occasion(s) for a DL slot, the overlap checking is performed across the SLIVs in the multiple slots of the rows in TDRA table |
| [22] Apple | Proposal 18: In case of an uplink symbol (or other invalid symbol), the HARQ process number may be incremented assuming a virtual PDSCH is transmitted, or the increment may be skipped. The HARQ-ACK bits for all PDSCHs are kept in the codebook (as a virtual PDSCHs) and set to NACK even if intersecting with invalid symbol symbols. |

### Summary on HARQ-ACK codebook issue due to collision with semi-static UL symbols:

Company views on HARQ-ACK codebook issue due to collision with semi-static UL symbols:

* Common issue to Type-1 and Type-2 HARQ-ACK codebook generation
  + Huawei and Apple: HARQ-ACK codebook is generated independently of resource collision with semi-static UL symbol(s), and NACK corresponding to the collided PDSCH should be reported by the UE.
* For Type-1 HARQ-ACK codebook generation
  + Do not account for invalid PDSCHs for SLIV pruning procedure: vivo, Samsung, Nokia, LG Electronics, MediaTek, Intel, Fujitsu
  + Perform SLIV pruning procedure regardless of the validity of SLIV:
* For Type-2 HARQ-ACK codebook generation
  + NEC: NACK padding for invalid PDSCHs, and inclusion corresponding HARQ-ACK bit in the first sub-codebook if only a single PDSCH is valid

[Moderator’s note] 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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| Company | Views |
| Lenovo, Motorola Mobility | We tend to have similar views as Huawei and Apple that HARQ-ACK codebook could be generated independent of collision with semi-static UL symbols and NACK is reported for the collided PDSCH |
| Nokia/NSB | For Type-2 codebook, it is better to first decide on DAI counting principle. |
| Qualcomm | NACK bits of the skipped PDSCHs does not need to be reported in HARQ-ACK codebooks |
| Huawei, HiSilicon | The main benefit of Type-1 HARQ-ACK codebook is its robustness. In this case, robustness against missing a DCI format 2\_0 and risking a misalignment between UE and gNB on the collisions understanding. |
| Apple | HARQ-ACK codebook is generated independently of resource collision with semi-static UL symbol(s), and NACK corresponding to the collided PDSCH should be reported by the UE. |
| Intel | The handling of collision between PDSCH and UL symbols may depend on the codebook design,   * For Type1 codebook, it is necessary to handle such collision in the codebook generation since it is the way to reduce codebook size which is a key issue for Type1 codebook. Note: such collision is considered in Rel-15 Type1 codebook design. * For Type2 codebook Alt1, it doesn’t matter whether HARQ-ACK for such invalid PDSCH with collision is skipped or NACK padded, since anyway a maximum number of HARQ-ACK bits are to be reported per DCI * For Type2 codebook Alt2, since C-DAI is designed to count PDSCH, it is beneficial to skip the invalid PDSCH with collision   Based on the analysis, we prefer to make a decision on the collision handling at least for Type1 codebook. On the other hand, it may not be an urgent issue for Type2 codebook. |
| Fujitsu | For Type-1 codebook, we share the views that invalid PDSCHs should be excluded in SLIV pruning procedure. We added our preference in the summary above. |
| Futurewei | Support that not to account for invalid PDSCHs for SLIV pruning procedure.  Agree that NACK corresponding to the collided PDSCH should be reported by the UE. |
| ZTE, Sanechips | For Type-1 codebook, invalid PDSCHs should not be accounted for SLIV pruning procedure.  For Type-2 codebook, since Alt1 is agreed, NACK padding should be performed for invalid PDSCHs. |
| InterDigital | One possibility is to consider SLIV which is collided with the configured uplink symbols as invalid SLIV. This option will not reserve HARQ processes for PDSCHs collided with semi-static UL symbol(s). Second option could be to report NAK for the PDSCHs collided with the UL symbols. However, this will hold HARQ ID. |
| CATT | We think invalid PDSCHs should be excluded in SLIV pruning procedure |
| OPPO | We think the definition of K1 should be firstly clarified before we discuss the pruning procedure of Type-1 HARQ-ACK codebook, at least for the case that the last SLIV of the SLIVs in one row is an invalid SLIV, e.g.,   * Alt-1: K1 indicates the slot offset between the last configured SLIV of the SLIVs in one row and the PUCCH slot * Alt-2: K1 indicates the slot offset between the last valid SLIV of the SLIVs in one row and the PUCCH slot   The above two definitions may have impacts on the codebook construction. |

## Type-1 (semi-static) HARQ-ACK codebook

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| Company | Views |
| [1] Huawei | Proposal 17: If more than one PDSCH is allowed to be scheduled in the same slot by different DCI, for enhancements of generating type-1 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, for each pair of {row of SLIVs, k1}, if at least one SLIV from a pair is overlapped with one SLIV from another pair, these pairs will be grouped together, the number and position of the candidate PDSCH receptions for each group are determined according to the procedure in step 2, the HARQ-ACK information is generated in group based sequence according to the start time of the first candidate PDSCH reception of each group.  Proposal 18: If only one PDSCH is allowed to be scheduled in the same slot, for enhancements of generating type-1 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, for cells belonging to FR2.2, the number and position of the candidate PDSCH receptions are determined by the unique number of 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 HARQ-ACK information is generated according to the index of DL slots. |
| [3] vivo | Proposal 23: As the starting point, for the set of SLIVs corresponding to each DL slot of the set of DL slots, SLIV pruning and grouping operations in Rel-15/16 can be reused to determine the subset of occasions corresponding to the DL slot.  Proposal 24: For the set of SLIVs corresponding to each DL slot of the set of DL slots, SLIV grouping within the set of SLIVs can be enhanced based on overlapping among different rows considering not only overlapping within the DL slot but also that in other DL slots occupied by any row, in order to avoid redundant bits and reduce codebook size.  Proposal 25: Study Type-1 HARQ-ACK codebook in conjunction with time domain bunding for multi-PDSCH scheduling. |
| [5] InterDigital | Proposal 6: Support bundling of HARQ-ACK information bits for multiple PDSCHs. The number of HARQ-ACK information bits for a candidate PDSCH reception occasion is determined based on the number of bundled PDSCHs. |
| [8] Samsung | Proposal 12: For Type-1 codebook,   * The set of SLIVs corresponding to a DL slot only includes SLIVs that can be scheduled within the DL slot by any row index r of TDRA table. * Support pruning based on TDD UL/DL configuration is performed for each PDSCH SLIV within each slot respectively. * Support pruning based on overlapped SLIVs can be performed for each PDSCH SLIV within each slot respectively, or for set of SLIVs across multiple slots.   + If only single PDSCH reception per slot, or single PDSCH reception in a slot associated with one PUCCH is allowed, the pruning for overlapped SLIVs can be simplified. * Support redundancy reduction with the consideration of validity of PDCCH MO. |
| [9] CATT | Proposal 11: The scheme for pruning candidate PDSCH occasions is based on number of DCIs that can be scheduled for a given PUCCH carrying HARQ-ACK. |
| [10] ZTE | Proposal 4: A method for extending the K1 set and determining the association between each element of the extended K1 set and a set of SLIVs should be defined. |
| [11] Fujitsu | Proposal 3: To generate type-1 HARQ-ACK codebook in case of multi-PDSCH scheduling, for determination of candidate PDSCH reception occasions, the set of SLIVs corresponding to a DL slot (belonging to the set of DL slots) ONLY includes 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.  • A row index in the TDRA table used for pruning of SLIVs (i.e., the union of TDRA tables for DCI formats) maintains the SLIV numbering of SLIVs as defined by the corresponding row index in a TDRA table for a DCI format. |
| [12] CEWiT | Proposal 4: A set of priority rules should be defined in the case when SLIVs from multi-PDSCH entry of the TDRA table overlaps with any other SLIV from the table in a slot.  Proposal 5: Consider the SLIV scheduled by the first DCI and discard the other SLIVs when SLIVs from multi-PDSCH entry of the TDRA table overlaps with any other SLIV from the table in a slot. |
| [13] Ericsson | Observation 5: Assuming that TDRA table that supports multi-PDSCH scheduling with a single DCI does not allow multiple SLIVs for a single slot, semi-static HARQ-ACK codebook generation needs not consider multiple candidate PDSCH reception occasions in a single slot.  Observation 6: For enhancements of generating semi-static HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, assuming that TDRA table that supports multi-PDSCH scheduling with a single DCI does not allow multiple SLIVs for a single slot, the set of candidate PDSCH reception occasions is determined solely based on the set of unique DL slots.  Observation 7: For enhancements of generating semi-static HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, assuming that TDRA table that supports multi-PDSCH scheduling with a single DCI does not allow multiple SLIVs for a single slot, further pruning of the set of SLIVs is not needed.  Proposal 22: Enhancement of semi-static HARQ-ACK codebook generation for multi-PDSCH scheduling can be specified as the following:  • For each K1 in the configured list of slot timing values *dl-DataToUL-ACK*, and for each row *r* of the configured TDRA table that schedules *M* PDSCHs, a set of DL slots are identified as {nU – (K1+ Koffset,i)}, where nU is the slot number for the HARQ ACK codebook transmission and Koffset,I (*I* = 0,…,*M*-1) is the slot offset from PDSCH I to the last PDSCH.  • The sets of DL slots derived from the combinations of K1 values and row indices in the TDRA table are concatenated and further pruned to generate a set of unique DL slots.  Proposal 24: 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. |
| [14] Futurewei | Proposal 6. No further pruning of the set of SLIVs is necessary beyond the agreed procedure in RAN1#105-e.  Proposal 7. Time-domain bundling can be supported for type-1 HARQ-ACK codebook with a configurable bundling size for the benefit of reduced codebook size. Neither much standard effort nor standard impact is expected. |
| [15] Nokia | Proposal 12: For Type-1 codebook,  • Pruning of the set of DL slots against UL symbols in *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* is supported  • Receiving of only one PDSCH in a slot is supported on serving cells with multi-PDSCH scheduling configured  • Time domain bundling, including configurable partial bundling of HARQ-ACKs is supported by selecting the last SLIV(s) of TDRA row for bundled HARQ-ACK bit(s). |
| [17] OPPO | Proposal 5: The candidate DL slots for PDSCH reception are determined by the configured SLIVs.  Proposal 6: Support a distance between the last slot for reception and the slot for feedback is larger than the corresponding K1 value. |
| [19] LG Electronics | Proposal #12: Do not consider the SLIV corresponding to a PDSCH skipped due to the collision with semi-static UL symbols, for pruning procedure of type-1 HARQ-ACK codebook generation. |
| [20] MediaTek | Proposal 1: For Type-1 codebook construction, details of further pruning on the candidate PDSCH occasions and the handling of more than one PDSCH in a slot can reuse the same Rel-15/16 Type-1 codebook construction procedure based on TDD configuration and UE capability on the number of PDSCH reception per slot |
| [21] Intel | Proposal 8  For Type-1 HARQ-ACK codebook generation,   * the set of SLIVs just 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, considering the TDD UL-DL configuration. * to allocate the occasion(s) for a DL slot, the overlap checking is performed across the SLIVs in the multiple slots of the rows in TDRA table   Proposal 10   * Time domain bundling can be supported in Type-2 HARQ-ACK codebook.   + FFS how to determine the number of sub-codebooks   + The same grouping of the two sub-codebooks by the number of bundled HARQ-ACK bits as the case that time bundling is not configured. * Time domain bundling can be supported in Type-1 HARQ-ACK codebook.   + A bundled occasion corresponds to multiple HARQ-ACK bits that are associated with same multi-PDSCH DCI. |
| [22] Apple | Proposal 17: 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. |
| [24] NTT DOCOMO | Proposal 5: K1 set is extended to obtain the extended DL slot set. The K1 extension is based on K0 configurations in each TDRA row.  Proposal 6: Set of SLIVs in each DL slot is determined as all unique SLIVs in the TDRA table. |
| [26] ITRI | Observation 1: There may have redundant HARQ-ACK bits of type-1 codebook considering multiple PDSCHs scheduled by a DCI, if R-15/16 prune procedure is applied.  Proposal 3: Multiple slots jointly to determine a number of HARQ-ACK bits could be considered. |
| [27] 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.  Proposal 2. To simplify type-1 codebook HARQ-ACK generation in Rel-17, receiving more than one PDSCH in a slot is not considered. |

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

Company views on Type-1 HARQ-ACK codebook generation:

* Pruning considering SLIVs from other slots
  + Supported by Huawei, vivo, Samsung, CEWiT, Intel, ITRI
  + Objected by Ericsson, Futurewei, MediaTek, ZTE
* Time domain bundling
  + Supported by vivo, InterDigital, Ericsson, Futurewei, Nokia, Intel, Apple
* Other aspects
  + Samsung: Redundancy reduction considering valid PDCCH MO
  + CATT: Pruning based on the number of DCIs that can be scheduled for a given PUCCH carrying HARQ-ACK
  + NTT DOCOMO: Set of SLIVs in each DL slot is determined as all unique SLIVs in the TDRA table

[Moderator’s note] More company views are needed to draw a proposal and some issues above (e.g., pruning considering SLIVs from other slots) are relevant to other issues in Section 2. Therefore, it is proposed to deprioritize this issue in this meeting but companies can provide more views for type-1 HARQ-ACK codebook generation including above issues.

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

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| Company | Views |
| Lenovo, Motorola Mobility | Agree to deprioritize in this meeting |
| Nokia, NSB | In addition to the points listed above, we see that it should be also discussed whether receiving more than one unicast PDSCH per slot is supported with multi-PDSCH scheduling for Type 1 codebook, as it can impact the codebook determination considerably. We do not see need to support multiple PDSCH receptions per slot with multi-PDSCH scheduling due to short slot duration. |
| Intel | We prefer to try to progress a bit on the design considering there are 10 days for the August meeting. |
| Futurewei | It seems to us that quite a number of supports are shown for time-domain bundling for type-1 HARQ-ACK codebook while other aspects might need further inputs, so we prefer TDB not be deprioritized in this meeting. |
| Panasonic | Agree to deprioritize in this meeting |
| Samsung | We prefer to try to progress in this meeting.  But we don’t support discussion for time-domain bundling for type-1 HARQ-ACK codebook, before any discussion on how to perform time-domain bundling. |
| ZTE, Sanechips | We agree with moderator’s assessment. Our preference is added in the summary. |
| CEWiT | Agree with moderator’s assessment. |
| InterDigital | We are fine with the proposal. |
| CATT | We are fine with the proposal. |
| Spreadtrum | We agree with moderator’s note. |
| OPPO | Agree to deprioritize in this meeting |

## Type-2 (dynamic) HARQ-ACK codebook

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| Company | Views |
| [1] Huawei | Proposal 19: Support Alt 2 (C-DAI/T-DAI is counted per PDSCH) for type-2 HARQ-ACK codebook with separate sub-codebooks for single PDSCH without CBG transmission, for multi-PDSCH scheduling without CBG transmission, and for fallback DCI.  Proposal 20: If time domain bundling of HARQ-ACK is supported for multi-PDSCH scheduling, this feature could be configured per cell group.  Proposal 21: When time domain bundling of HARQ-ACK per DCI is configured for multi-PDSCH scheduling with Alt2, C-DAI/T-DAI could be counted per DCI as Alt1.  Proposal 22: 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, the C-DAI could be accumulated in increasing order according to the starting time of the first PDSCH reception of multi-PDSCH. |
| [3] vivo | Proposal 26: For Type-2 HARQ-ACK codebook for multi-PDSCH scheduling, support Alt 2, i.e. C-DAI/T-DAI is counted per PDSCH.  Proposal 27: C-DAI/T-DAI in DL non-fallback DCI format and T-DAI in UL non-fallback DCI format are increased to 2+log2(N\_max) bits for each field, where N\_max equals to the maximum configured number of PDSCHs for multi-PDSCH scheduling DCI across serving cells belonging to the same PUCCH cell group.  Proposal 28: When for non-fallback DCI formats the corresponding DAI bit widths are increased, each DAI bit width can correspond to a respective sub-codebook, and there can be two sub-codebooks, one for fallback DCI formats and the other for non-fallback DCI formats.  Proposal 29: Study Type-2 HARQ-ACK codebook in conjunction with time domain bunding for multi-PDSCH scheduling. |
| [4] Spreadtrum | Proposal 5: Regarding the generation of type 2 codebook, C-DAI/T-DAI should be counted per PDSCH. |
| [6] Sony | Proposal 6: C-DAI/T-DAI for multi-PDSCH scheduling should be counted per PDSCH. |
| [7] Lenovo | Proposal 8: For NR operation between 52.6 GHz and 71 GHz, for dynamic (type-2) HARQ-ACK codebook, support C-DAI/T-DAI counting per DCI  Proposal 9: For NR operation between 52.6 GHz and 71 GHz, for dynamic (type-2) HARQ-ACK codebook, if C-DAI/T-DAI counting per DCI is agreed, the one of the following two options should be agreed for HARQ-ACK codebook construction:   * - Option 1: Different sub HARQ-ACK codebook is generated for numerology corresponding to which different number of maximum PDSCHs can be scheduled. For example, if up to 1 PDSCH is scheduled for 120 kHz, then first sub HARQ-ACK codebook is constructed for 120 kHz, if up to 4 PDSCHs are scheduled for 480 kHz, then second sub HARQ-ACK codebook is constructed for 480 kHz, and if up to 8 PDSCHs are scheduled for 960 kHz, then third sub HARQ-ACK codebook is constructed for 960 kHz * - Option 2: Same HARQ-ACK codebook is applied for multi-PDSCH scheduling DCI, even if the maximum allowed PDSCH scheduling is different and codebook size alignment can be done by time-domain bundling. For example, if up to PDSCHs can be scheduled with 480 kHz and up to 8 PDSCHs can be scheduled with 960 kHz, then 4 HARQ-ACK bits are expected to be generated per DCI for both cases, where time-domain bundling for every 2 PDSCHs is applied for 960 kHz in order to limit the size to 4, similar to 480 kHz |
| [8] Samsung | Proposal 11: If HARQ-ACK bundling is supported, bundling is performed within 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 PDSCHs per HARQ-ACK bundling groups (Npb) * Alt c: gNB configures time duration of one HARQ-ACK bundling group (Tb).   Proposal 13: For Type-2/enhanced type-2 HARQ-ACK codebook, when a UE supports >1 DCIs in the same Mos which scheduling PDSCHs to the same serving cell, and these DCIs are configured to be able to schedule multiple PDSCHs.   * For Alt-1 (C-DAI/T-DAI is counted per PDCCH): The counting order for the PDCCHs scheduling the PDSCHs is determined by the reception time of the first PDSCH scheduled by each PDCCH. * For Alt-2 (C-DAI/T-DAI is counted per PDSCH): The counting procedure for the PDSCHs scheduled by these DCIs is:   + PDSCHs are separated into different sets by the scheduling 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.   Proposal 14: For Type-2/enhanced type-2 HARQ-ACK codebook, Alt -1 (DAI is counted per DCI) should be supported:   * 1st sub-codebook for single PDSCH reception, and PDCCHs requiring HARQ-ACK feedback. * 2nd sub-codebook for multi-PDSCHs reception and CBG-based reception. |
| [9] CATT | Proposal 12: Simultaneous configuration for both CBG-based scheduling and multi-PDSCH scheduling shall be avoided.  Proposal 13: The HARQ-ACK bits for 2 PDSCHs scheduled by one DCI is included in the second sub-codebook.  Proposal 14: Time bundling of HARQ-ACK feedback is low priority.  Proposal 15: If alt-2 is supported, for counting of PDSCH(s) scheduled by a single DCI, counting the DAI on the last PDSCH is preferred. |
| [10] ZTE | Proposal 5: Considering the specification impact, Alt 1 (C-DAI/T-DAI is counted per DCI) is preferred. |
| [11] Fujitsu | Proposal 4: To generate the type-2 HARQ-ACK codebook for DCI scheduling multiple PDSCHs, Alt. 1 should be supported where C-DAI/T-DAI is counted per DCI. For Alt. 1, it should be supported that the Type-2 HARQ-ACK codebook includes 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. |
| [13] Ericsson | Observation 8: Alt-1 reuses the same DAI counting mechanism as in Rel-15/16 NR. It requires neither re-definition of DAI counting mechanism nor extension of the bit-width of DAI values. Hence, Alt-1 has the minimum impact on the current NR specs and implementations among the three identified alternatives for dynamic HARQ-ACK codebook enhancement.  Observation 9: In the case of carrier aggregation, the size of HARQ-ACK bits (NA/N) corresponding to different DCIs detected on different component carriers that schedule multiple PDSCHs can be set to the maximum configured number of PDSCHs among all component carriers in the same PUCCH cell group on which multi-PDSCH scheduling is configured.  Observation 10: For Alt-1, presence of NACK padding bits in HARQ-ACK codebook shouldn’t affect PUCCH link performance and coverage, compared to Alt-2.  Observation 11: Fundamental redefinition of DAI can have a large impact on the current NR specs, and also affects DAI counting related to DCIs not used for multi-PDSCH scheduling. This can cause conceptual chaos among different 3GPP releases, hence should definitely be avoided.  Observation 12: Alt-2 requires DAI bit-extension at least for at least for DL DCI format 1\_1 and UL DCI formats 0\_1 and 0\_2 which increases DCI and reduces PDCCH coverage compared to Alt-1.  Observation 13: The latest agreement on Alt-2 implies bit-width extension of DAI counter at least for DL DCI format 1\_1 and UL DCI format 0\_1/0\_2. The extension of DAI bit-widths applies to all relevant DL and UL DCI formats (at least including DCI Format 1\_1, 0\_1 and 0\_2).  Observation 14: The latest agreement on Alt-2 implies separate HARQ-ACK sub-codebook for single and multiple PDSCH scheduling.  Observation 15: Analysis shows that Alt-2 is expected to have much larger impact on the specs due to re-definition of DAI counting, and suffer from reduced PDCCH coverage due to increased DCI size as the consequence of DAI bit-extension.  Observation 16: In terms of number of HARQ-ACK sub-codebook and PUCCH coverage aspect, both Alt-1 and Alt-2 are on an equal footing.  Proposal 23: For dynamic HARQ-ACK codebook enhancement, support Alt-1 in combination with separate HARQ-ACK codebook for single/multi-PDSCH scheduling,  Observation 17: Applying configurable time domain HARQ-ACK bundling on top of Alt-1 can reduce the HARQ-ACK codebook size, thus achieving a configurable balance with retransmission efficiency depending on the deployment scenario.  Observation 18: 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. The legacy dynamic HARQ-ACK codebook mechanism in Rel-15/16 can be directly reused.  Proposal 25: Time domain HARQ-ACK bundling with configurable number of time bundling groups can be considered for Alt-1 dynamic codebook enhancement. |
| [14] Futurewei | Proposal 10. Alt 3 (C-DAI/T-DAI is counted per M scheduled PDSCH(s), where M is configurable) will no longer be considered despite the decisions on Alts 1 and 2 for HARQ-ACK codebook generation for multi-PDSCH.  Proposal 11. If Alt 2 is down-selected, support using two sub-codebooks for the HARQ-ACK codebook generation to ensure that at most 3 consecutive missed DCIs can be resolved.  Observation7. For technical consideration on the short slot duration in comparison with the channel coherence time, the 3rd sub-codebook is at least not applicable for SCS 480kHz/960kHz. For SCS 120kHz, if the final decision is that CBG is supported, one may have to face a consequential issue of HARQ-ACK codebook size growth for the CBG + multi-PDSCH option.  Proposal 13. The 3rd sub-codebook is not supported for the type-2 HARQ-ACK codebook.  Observation 8. Time-domain bundling is applicable to both Alt 1 and Alt 2. Time-domain bundling is compatible with the two sub-codebooks design.  Proposal 14. Support time-domain bundling for at least Alt 1 to further reduce HARQ-ACK codebook size. The number of HARQ-ACK bits per DCI for 2nd sub-codebook is the maximum number of PDSCH bundles per DCI.  Proposal 15. If down-selection between Alt 1 and Alt 2 is preferred, Alt 1 with two sub-codebooks and configurable time-domain bundling requires substantially less standard effort than Alt 2 and is thus the recommended alternative. Alt 2 that requires a change of DAI counting can be deprioritized.  Observation 9. The codebook sizes need to be aligned for different SCSs if the maximally allowed PDSCHs in a multi-PDSCH are different.  Proposal 16. For SCS 120kHz, in case the maximum allowable number of PDSCHs is 1, i.e., only single PDSCH is allowed, it can be merged into the first sub-codebook. |
| [15] Nokia | Proposal 8: Alt.3 is supported, that is, C-DAI/T-DAI is counted per M scheduled PDSCH(s), where M is configurable. In case Alt. 3 is not supported, Alt. 1 is supported.  Proposal 9: In case of Alt. 3, number of DAI bits is determined based on the configured M value and the maximum number of schedulable PDSCHs.  Observation 1: In case of Alt. 2, separate sub-codebooks are needed for multi-PDSCH scheduling and single-PDSCH scheduling to maintain Rel-15/16 resilience against missed DCIs with 2-bit DAI field in fallback DCIs without gNB scheduling restrictions.  Proposal 10: HARQ-ACK reporting for CBG-based scheduling and multi-PDSCH scheduling is not supported simultaneously by UE on the serving cells in the same PUCCH cell group.  Proposal 11: Configurable time domain bundling of HARQ-ACK feedback over M consecutive 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. |
| [16] 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. |
| [17] OPPO | Proposal 7: If alt 1 is supported for Type-2 HARQ-ACK codebook construction,   * The two sub-codebooks corresponding to schedules of one PDSCH and multi-PDSCH respectively. * The CBG-based feedback may be included in the sub-codebook of multi-PDSCH scheduling if supported. * Time-domain bundling can be considered to reduce the feedback overhead.   Proposal 8: If alt 2 is supported for Type-2 HARQ-ACK codebook construction, a single codebook should be considered. |
| [18] Qualcomm | Proposal 13: With Alt 1, 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.  Proposal 14: 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.   Proposal 15:   * Support increasing the field size of the DAI based on RRC configuration to increase the reliability against the missed DCIs. However, the field size increase should be subject to gNB configuration. * Allow adjusting the resolution of the DAI counter based on the greatest common divisor of the number of the SLIVs, among the rows of the TDRA, i.e., each increment of the DAI indicates that a number of PDSCHs equal to the greatest common divisor has been sent. |
| [19] LG Electronics | Proposal #13: For (enhanced) type-2 HARQ-ACK codebook,   * If Alt 1 (C-DAI/T-DAI is counted per DCI) is adopted, two sub-codebooks where one is for single PDSCH scheduling case and the other is for multi-PDSCH scheduling case are introduced. If CBG is additionally configured, the number of sub-codebooks is kept as two and HARQ-ACK corresponding to CBG-based PDSCH scheduling and multi-PDSCH scheduling cases is merged into the same sub-codebook. * If Alt 2 (C-DAI/T-DAI is counted per PDSCH) is adopted, two sub-codebooks where one is for single PDSCH scheduling case and the other is for multi-PDSCH scheduling case are introduced to prevent from increasing C-DAI size in DCI format 1\_0. If CBG is additionally configured, the number of sub-codebooks is increased to three where first sub-codebook is for TB-based single-PDSCH scheduling case, second sub-codebook is for CBG-based PDSCH scheduling case, and third sub-codebook is for multi-PDSCH scheduling case.   Proposal #14: Consider the following methods if time bundling operation is introduced:   * Method 1: Time domain HARQ-ACK bundling operation per M PDSCHs * Method 2: Time domain HARQ-ACK bundling operation per N slots |
| [20] MediaTek | Proposal 2: 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   Proposal 3: For Type-2 codebook construction based on the principle of DAI per PDSCH, consider the scheduling restriction such that at most PDSCHs can be scheduled by any 3 consecutive DCIs.   * + The corresponding bit filed length of DAI will be .   Proposal 4: For Type-2 codebook construction, consider the principle of DAI per HARQ-ACK bit and consider the restriction on the number of HARQ-ACK bits such that at most HARQ-ACKs are corresponding to a DCI   * + When the number of PDSCHs scheduled by a DCI is less than , UE only needs to report HARQ-ACK bits instead of HARQ-ACK bits.   + When the number of PDSCHs scheduled by a DCI is greater or equal to , UE only needs to report HARQ-ACK bits instead of HARQ-ACK bits     - The HARQ-ACK bits can be generated based on Rel-16 CBG-like grouping among the scheduled PDSCH.   + DAI bit field length is   + can be configured by gNB |
| [21] Intel | Proposal 9  Type-2 HARQ-ACK codebook is generated with Alt 1 ‘C-DAI/T-DAI counted per DCI’   * Two sub-codebooks are generated for a PUCCH cell group   + If time bundling is configured, a single HARQ-ACK codebook may be adopted. * If 2 HARQ-ACK bits are generated for a multi-PDSCH DCI, it is included in the first sub-codebook if 2 HARQ-ACK bits per DCI is reported in the first sub-codebooks * Same number of HARQ-ACK bits is associated with each DCI in a sub-codebook   + 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 * 1 HARQ-ACK bit is included in the first sub-codebook for the DCI indicating SPS PDSCH release, Scell dormancy indication without scheduled PDSCH   Proposal 10   * Time domain bundling can be supported in Type-2 HARQ-ACK codebook.   + FFS how to determine the number of sub-codebooks   + The same grouping of the two sub-codebooks by the number of bundled HARQ-ACK bits as the case that time bundling is not configured. * Time domain bundling can be supported in Type-1 HARQ-ACK codebook.   + A bundled occasion corresponds to multiple HARQ-ACK bits that are associated with same multi-PDSCH DCI. |
| [22] Apple | Proposal 19: Reusing the existing C-DAI and T-DAI definition in Rel-15/6, i.e., counting per DCI.  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.  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. |
| [23] Panasonic | Proposal 8: For generating type-2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, C-DAI/T-DAI is counted per PDSCH, i.e., Alt. 2.  Proposal 9: For C-DAI/T-DAI is counted per PDSCH in Alt. 2, 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, and   + ) bits, where is maximum number of the non-scheduled PDSCH group. |
| [24] NTT DOCOMO | Proposal 7: Support time domain HARQ-ACK bundling in case of Alt 1.  Proposal 8: For HARQ-ACK feedback for multiple PDSCHs scheduled by one DCI if HARQ-ACK bundling among different PDSCHs is not applied,   * Support Alt. 2 (C-DAI/T-DAI is counted per PDSCH) for type 2 HARQ-ACK CB construction. |
| [25] Xiaomi | Proposal 1: Support Alt.1 for Type 2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs. |
| [28] WILUS | Proposal 1: We propose to support Alt 1, which is C-DAI/T-DAI is counted per DCI for generating Type-2 HARQ-ACK codebook corresponding to a DCI that can schedule multiple PDSCHs. |

### Summary on Type-2 HARQ-ACK codebook generation:

Company views on Type-2 HARQ-ACK codebook (CB) generation:

* Alt 1 (C-DAI/T-DAI is counted per DCI)
  + Supported by Lenovo (SCS-dependent sub-CB), Samsung (2 sub-CBs w/ CBG), ZTE, Fujitsu (2 sub-CBs w/ CBG), Ericsson, Futurewei, Nokia (2nd preference), NEC (3 sub-CBs w/ CBG), OPPO (2 sub-CBs w/ CBG), LG Electronics (2 sub-CBs w/ CBG), Intel (2 sub-CBs w/ CBG, 2 HARQ-ACK bits in the first sub-CB), Apple (up to M HARQ-ACK bits in the first sub-CB), NTT DOCOMO (if time domain bundling is supported), Xiaomi, WILUS
  + Ericsson, Qualcomm, Intel: Single codebook if time domain bundling is configured to generate 1 bit per DCI
* Alt 2 (C-DAI/T-DAI is counted per PDSCH)
  + Supported by Huawei (separate 3? Sub-CBs), vivo (N\_max based DCI bit increase, 2 sub-CBs), Spreadtrum, Sony, OPPO (single CB), Qualcomm (single CB?, gNB-configurable DCI bit), LG Electronics (2 sub-CBs), Panasonic (N\_max based DCI bit increase), NTT DOCOMO
  + CATT: C-DAI corresponding to the last PDSCH
* Alt 3 (C-DAI/T-DAI is counted per M scheduled PDSCH(s), where M is configurable)
  + Supported by Nokia (1st preference)
* Other aspects
  + Time domain bundling: Huawei, vivo, Lenovo, Samsung, CATT (low priority), Ericsson, Futurewei, Nokia, Qualcomm, LG Electronics, Intel, Apple, NTT DOCOMO
  + Avoidance of simultaneous configuration of CBG and multi-PDSCH scheduling: CATT, Ericsson, Futurewei, Nokia
  + For the UE indicating by *type2-HARQ-ACK-Codebook* support: Huawei, Samsung

[Moderator’s note] It is observed that companies have split view between 2 alternatives but understanding for each alternative is aligned thanks to extensive discussions in previous meetings. Based on detailed company views, it would be better to focus on alt 1 and alt 2 (excluding alt 3) and the followings can be summarized for the remaining works for each alternative:

* For Alt 1 (C-DAI/T-DAI is counted per DCI)
  + The number of sub-codebooks when CBG is configured
  + Whether or not up to M (>1) HARQ-ACK bits corresponding to a DCI can be included in the first sub-codebook (but seems optimization)
* For Alt 2 (C-DAI/T-DAI is counted per PDSCH)
  + The number of sub-codebooks when CBG is not configured, among 1, 2, and 3
  + How to determine bit-width of DAI fields (e.g., based on N\_max or gNB configuration)
  + C-DAI corresponding to the first or last PDSCH
* For both alternatives
  + Behaviour if time domain bundling is introduced and configured
  + Whether to allow simultaneous configuration of CBG and multi-PDSCH scheduling

Considering that Alt 1 is supported by slightly more companies than Alt 2 and Alt 2 has more fundamental issues to be resolved than Alt 1, it is proposed to adopt Alt 1, as shown in the following Proposal #9. It should be noted that this issue is indicated as “HIGH” since this decision is critical to complete HARQ operation for multi-PDSCH scheduling.

**[HIGH] Proposal #9 (Type-2 HARQ-ACK CB):**

* 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.

Companies are encouraged to provide views on Proposal #9. In case a company has a strong concern for this proposal, please provide alternative proposal that can be acceptable to more companies than this proposal.

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| --- | --- |
| Company | Views |
| Lenovo, Motorola Mobility | Support the proposal#9 |
| Ericsson | Support Proposal #9  We agree with the moderator that it is dangerous to be making fundamental changes to the DAI counting mechanism at this stage in the WI, and we see that Alt-1 is the most straight forward and low-risk option. |
| Nokia, NSB | We support the proposal to adopt Alt 1, i.e., C-DAI/T-DAI counting per DCI |
| Qualcomm | We do not support excluding Alt 2 from the discussion as the specs can support both alternatives |
| Huawei, HiSilicon | We think it might be better to start with further clarifying the two alternatives in case CBG is not configured (or not supported for 480/960) and in case CBG is configured, to have a more complete comparison, which depends on other decisions (proposal #5). Moreover, in a typical case, we expect that all carriers in the same PUCCH group in the band above 52.6 GHz will be configured with multi-PDSCH scheduling, while sometimes the use of fallback DCI may be necessary. Therefore, both Alt1 and Alt2 may only need to be designed based on two sub-codebooks.\  For supporting all combinations of single PDSCH with CBG transmission, multi-PDSCH scheduling without CBG transmission, and fallback DCI in the same HARQ codebook, both Alt1 and Alt2 would need 3 sub-codebooks for achieving the smallest overhead, and the overhead of Alt1 would still be larger than the feedback overhead of Alt2. |
| Apple | Support the proposal |
| Convida Wireless | We are fine with proposal #9. |
| Intel | We support the FL proposal. |
| Fujitsu | Support Proposal #9 |
| Futurewei | Support Proposal #9. |

On 8/17 GTW session, the following agreement was made:

### Agreement:

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.

[Moderator’s note] The next step to move forward is how to construct type-2 HARQ-ACK codebook when CBG is configured for a cell within the same PUCCH cell group. Based on Tdoc review, the following three options can be considered.

* 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

### [HIGH] Proposal #10 (CBG+multi-PDSCH):

* Consider the following options to construct type-2 HARQ-ACK codebook when CBG operation is configured.
  + 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.

Companies are encouraged to provide views on Proposal #10.

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| --- | --- |
| Company | Views |
| DOCOMO | We are fine with the proposal. We slightly prefer option 3 due to simplicity. |
| Samsung | We support option 1, it is quite simple and achieves similar robustness as Rel-15/Rel-16.  Option 2 leads to 3 sub-codebooks which increases HARQ-ACK codebook size miss-alignment probability and additional DAI bit field in UL grant.  Option 3 does not make sense which deprives the benefit of CBG for FR1/FR2 when CCs in FR1/2 and FR2-2 is within same PUCCH cell group. |
| Fujitsu | We support Option 1, which would result in 2 sub-codebooks when CBG-based PDSCH reception is enabled.  For option 3, we do not quite understand how it works if Proposal #5a is agreed. More details may be needed, or it should be ruled out if Proposal #5a is agreed. |
| ZTE, Sanechips | We prefer Option 1 in order to have the minimized number of sub-codebooks. Option 3 needs more clarification. |
| NEC | We prefer Option 2 to have the minimized number of HARQ-ACK codebook size. |
| Qualcomm | We are fine with the proposal. |
| Intel | We prefer Option 1. In the agreed Type2 codebook design, i.e., Alt 1. In our viewa maximum number of HARQ-ACK bits should be reported per DCI. It doesn’t matter the maximum number of bits is for each CBG of CBG-based feedback or for each TB of the multi-PDSCH scheduling.  Option 2 results in 3 sub-codebooks, which causes large overhead of T-DAI and is not preferred.  Regarding Option 3, it is assumed CA operation of FR2-2 cell with SCS 120kHz and FR2-2 cell with SCS 480/960kHz can be supported. Further, it is up to gNB to configure only single-PDSCH scheduling for SCS 120kHz, which will allow CBG based transmission. Finally, it is possible that both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group. Therefore, Option 3 is not proper. |
| Ericsson | We are okay with the proposal to limit the options that are discussed. However, we have strong concerns about the unnecessary complexity of Option 1. We therefore prefer Option 2, and we can also support Option 3, both from a simplicity standpoint.  Regarding Option 1:  The motivation seems to be reducing the total number of sub-codebooks by merging the sub-codebook corresponding to single-PDSCH + CBG based scheduling with the sub-codebook corresponding to multi-PDSCH scheduling. To be able to merge, the number of HARQ-ACK bits generated by single-PDSCH + CBG-based scheduling and the number of HARQ-ACK bits generated by multi-PDSCH scheduling would need to be aligned. If the numbers are not the same, additional padding bits would be needed for alignment to avoid codebook size ambiguity between gNB and UE. This means that merging sub-codebooks does not save on total codebook size. Furthermore, we see extra specification complexity.  Regarding Option 2:  We understand that because 3 sub-codebooks are needed, that 2 additional bits would be needed for the T-DAI counter in UL DCI if both CBG and multi-PDSCH are simultaneously configured. However, in practice, most of the time these 2 bits would not be configured. As we state below for Option 3, given that FR2-2 operation is likely to be deployed in lower mobility scenarios, we don’t expect a degradation in re-transmission efficiency by relying on TB-based (re)transmissions instead of CBG based (re)transmissions, even for FR1 + FR2-2 based CA. So, in our view, the need for 2 extra bits is not a strong argument against Option 2, especially given the simplicity of this option.  Regarding Option 3:  We understand that this option would preclude configuration of CBGs for an FR1 carrier in the same PUCCH cell group; however, given that FR2-2 operation is likely to be deployed in lower mobility scenarios, we don’t expect a degradation in re-transmission efficiency by relying on TB-based (re)transmissions instead of CBG based (re)transmissions. This solution seems entirely feasible, and of course would greatly minimize spec effort.  Note: As commented by Fujitsu, if Option 3 is agreed, then we think that Proposal #5a is not needed. |
| Samsung | In our understanding, CBG-based transmission is not only beneficial for time variant channel (depends on mobility) but also for interference variant channel, e.g. pre-emption by URLLC, which is also likely to happen in low mobility scenario. Therefore, we think Option 3 is undesirable.  For option 2, if enhanced type-2 codebook is configured, additional 4 bits DAI in UL grant is needed for 1st and 2nd PDSCH group. And, if enhanced type-2 codebook is configured, UCI overhead would be the same as option 1, because there is a single T-DAI for 2nd PDSCH group in DL assignment which is applied to all sub-codebooks for 2nd PDSCH group. Furthermore, for type-2 codebook, because there is only T-DAI/C-DAI in DL assignment for the sub-codebook scheduled by this DL DCI, 3 sub-codebooks is more vulnerable to last DCI miss-detection, if there is no UL grant-scheduled PUSCH, e.g. only PUCCH or CG PUSCH. |
| Apple | We are fine with the proposal |
| CATT | We prefer option 2 or 3 as we don’t see the benefit of introducing complexity. |
| Spreadtrum | We are fine with the proposal. |
| Lenovo, Motorola Mobility | We support the proposal and are fine with option2 or option 3. Option 1 is not preferred as it will introduce unnecessary complexity |
| Xiaomi | We are fine with the proposal#10. |
| OPPO | We are fine with proposal #10. |
| Huawei, HiSilicon | Option 1 is a departure from the principle of Type-2 HARQ-ACK codebook to separate feedback for CBG-based PDSCH transmissions and TB-based PDSCH transmissions. As commented by other companies, option 1 would add a lot of complexity to the codebook design.  Although option 2 could be feasible, it would result in 3 sub-codebooks. It is also not clear how it would work if it is agreed that a multi-slot scheduling DCI scheduling a single PDSCH support CBG-based transmission (e.g. for 120 kHz SCS). Does “multi-PDSCH reception” correspond to reception scheduled by a DCI with a TDRA table configured with one or more rows with multiple SLIVs, only for the case where multiple PDSCHs are actually scheduled (with/without collisions?).  Considering the use cases, we tend to agree with other comments supporting option 3 as a possible alternative. Even if this introduces restrictions for the combination of CBG and multi-slot PDSCH scheduling in FR1, assuming that anyway only one PDSCH could be scheduled with CBG-based transmission by a single DCI, we don’t think that this restriction is an issue. The network has the possibility to not configure multi-slot PDSCH scheduling if conditions for observing gains from CBG-based transmission are met. In this case, we assume that it is beneficial to only schedule one PDSCH at a time with each DCI.  In summary, we support option 3. |
| Moderator | Summary of company views   * Option 1: Samsung, Fujitsu, ZTE, Intel * Option 2: NEC, Ericsson, CATT, Lenovo * Option 3: NTT DOCOMO, Ericsson, CATT, Lenovo, Huawei   Main argument point   * Option 1: Increased HARQ-ACK codebook size * Option 2: Increased UL DCI size * Option 3: Restriction of gNB’s configuration   Based on Huawei’s comment, multi-PDSCH reception is clarified by adding a Note in Proposal #10.  To all,  Now Proposal #10 is indicated as “HIGH” since this discussion is tied with Proposal #5a.  Please make more comments on each option and provide your preference if you have. |
| Qualcomm | We agree with Ericsson on the complexity of Option 1. We are okay with Options 2 and 3, prefer Options 3 because of its simplicity. |
| Futurewei | We do not support Option 2. We are fine with Option 1 and Option 3. |
| Intel | Option 2 is not just adding 2 or 2N additional bits for T-DAI. Even when multiple T-DAIs are indicated by DCI, due to the assumption of no prediction of T-DAI, the received T-DAI may not exactly reflect the HARQ-ACK codebook size if the actual last DCI is missed. Having more sub-codebook makes the issue even worse.  We don’t think Option 3 is right way to go. As commented by other companies and us, in CA between FR1/2-1 and FR2-2, a legacy cell can be configured with CBG based transmission. Further, even for CA of FR2-2 only, a cell with SCS 120kHz may be configured with single PDSCH and CBG based transmission. |
| DOCOMO | We still prefer option 3 for simplicity.  As commented from other companies, HARQ-ACK CB size redundancy will be an issue for option 1, considering that number of bits for single DCI for the 2nd sub-codebook is determined by the maximum of max#CBG and max#PDSCH.  UL DCI size increment by option 2 is not preferred. |
| Nokia/NSB | We are fine with option 2 (first) and Option 3. |
| Samsung | We can not accept option 3.  We don’t think it is reasonable to sacrifice performance for FR1/2-1 for FR2-2, especially considering FR1/2-1 is main band for coverage. |
| Vivo | We support option 2 for simplicity. Option 1 requires more spec efforts and results in larger codebook size. Regarding option 3, it is too restrictive to disallow simultaneous configurations of CBG transmission and multi-PDSCH scheduling in a same PUCCH cell group. |
| Moderator | Updated summary of company views   * Option 1: Samsung, Fujitsu, ZTE, Intel, Futurewei * Option 2: NEC, Ericsson, CATT, Lenovo, Qualcomm, Nokia, vivo * Option 3: NTT DOCOMO, Ericsson, CATT, Lenovo, Huawei, Qualcomm, Futurewei, Nokia   Please continue discussion. |
| ZTE, Sanechips | We can accept Option 3 as a compromise. |
| LG | We are supportive to Option 1 considering DCI overhead, and also OK with Option 2 if UCI overhead is considered as concern of Option 1 by companies.  We don’t see any technical reason to have such restriction as Option 3 since it would enforce not to support URLLC service in lower FR and T-put boosting in higher FR simultaneously, just due to HARQ-ACK codebook construction. For example, if multi-PDSCH scheduling is not configured due to enabling of CBG transmission, DCI overhead/blocking burden would be increased by slot-group based monitoring. It is undesirable to disable a feature just if another feature is enabled, even though those features have different purposes. |
| Apple | We are fine with Option 2 or 3. |
| MediaTek | We prefer option3 for simplicity. |
| Intel | Besides the additional overhead of T-DAI and the impact of missing last PDCCH, Option 2 requires describing the generation of a third sub-codebook, which is even more complicated than Option 1. In option 1, it just includes FR2-2 cells to the group of cells of second sub-codebook.  With Option 3, a UE may not be configured with a cell with CBG based transmission, then the UE is vulnerable to the impact of URLLC preemption. Otherwise, the UE may be configured with FR2-2 cell(s) with single PDSCH scheduling, which cause much DCI overhead. |
| Samsung | We do not agree option 3. We share same view with LG and Intel. |
| Sony | We prefer option 3 for simplicity. |
| Futurewei | We wonder if it is necessary to include the definition of multi-PDSCH reception in the Note as with this proposal, since in other previous agreement/proposal a similar definition does not always appear separately in a Note. |
| Moderator | Summary of company views:   * Option 1: Merged sub-codebook   + Supported by Samsung, Fujitsu, ZTE, Intel, Futurewei, LG Electronics   + Objected by Ericsson, Lenovo, Huawei, Qualcomm, NTT DOCOMO, vivo     - Mainly due to specification complexity and HARQ-ACK payload size increase if # of max. CBG and # of max. PDSCHs are not the same. * Option 2: Separate sub-codebook   + Supported by NEC, Ericsson, CATT, Lenovo, Qualcomm, Nokia, vivo, Apple   + Objected by Samsung, Intel, Futurewei, NTT DOCOMO     - Mainly due to increased DAI bits in UL grant and vulnerability to last DCI miss-detection * Option 3: Support only one configuration between CBG and multi-PDSCH scheduling   + Supported by NTT DOCOMO, Ericsson, CATT, Lenovo, Huawei, Qualcomm, Futurewei, Nokia, ZTE, Apple, MediaTek, Sony   + Objected by Samsung, Fujitsu, Intel, vivo, LG Electronics     - Mainly due to excessive configuration restriction considering FR1 URLLC + FR2-2 multi-slot monitoring CA case   Please continue discussion. If we cannot reach a consensus in this meeting, the best we can do would be just to capture three options. But considering the WI completion schedule, please provide constructive feedback. |

### [HIGH] Proposal #10a (CBG+multi-PDSCH):

* 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.

Companies are encouraged to provide views on Proposal #10a.

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| Company | Views |
| Moderator | Seems that it’s hard to make a consensus in this meeting. We can list all of three options on the table, discuss further, and down-select to one in the next meeting.  On the NOTE, even though it can be redundant, it helps to avoid potential misunderstanding so we can keep it. |
| Lenovo, Motorola Mobility | We agree to do further downselection in the next meeting. So we can support this proposal |
| Huawei, HiSilicon | We think that option 1 could be removed already since it fundamentally changes the principle of separate sub-codebooks for CBG-based and non-CBG-based HARQ information, and option 1 is the only option that has more companies objecting than supporting. Why should option 1 remain? |
| Apple | We are fine with the proposal to down-select next meeting. We see value in this proposal as it identifies the options under discussion. |
| Ericsson | Agree with Huawei that we should try to make further progress in this meeting by limiting the number of options to Option 2 and 3 due to the strong concerns on complexity raised by several companies. At this stage of the WI, the goal should be on simple solutions to solve a problem, and both Option 2 and 3 are simple and an avoid quite long follow on discussions. We think that it would be preferrable to try and narrow down to only one option between Option 2 and 3 already in this meeting, but if this is impossible, deciding between Option 2 and 3 no later than next meeting is the next best thing. |
| Qualcomm | Generally, we are fine with the proposal, and agree with Ericsson and Huawei, it would be better to remove option 1 |
| Intel | We support the FL proposal to do down-selection in the next meeting |
| DOCOMO | Generally we are fine with the proposal. We share similar view as Ericsson/Huawei/Qualcomm on option 1. |
| Futurewei | Agree with deprioritizing this issue, discuss further and decide by the next meeting. |
| OPPO | We support the FL proposal to do down-selection in the next meeting |
| Fujitsu | We are fine with the proposal. |
| NEC | We support this proposal to decide in the next meeting |
| Nokia/NSB | We are fine with the proposal, and also fine to remove option 1. |
| vivo | We support proposal #10a, and we are also fine to remove option 1 as proposed by other companies. |
| ZTE, Sanechips | We are fine with the proposal. |
| Moderator | Summary of companies’ views:   * OK: Lenovo, Apple, Intel, Futurewei, OPPO, Fujitsu, NEC, ZTE * OK, but prefer to remove Option 1 in this meeting: Huawei, Ericsson, Qualcomm, NTT DOCOMO, Nokia, vivo   For efficient discussion in the next meeting, the less options are, the better. Option 1 is removed from the list in Proposal #10b. But in case there are several companies that have strong concerns to remove it, there is no way but to go back to Proposal #10a. |

### [HIGH] Proposal #10b (CBG+multi-PDSCH):

* 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 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.

Please provide comments if there is a strong concern for Proposal #10b.

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| Company | Views |
| Intel | We cannot agree with proposal 10b. As commented by some companies including us, both Option 2 and 3 have clear drawbacks. It is not clear to us the concern on complexity. In fact, Option 1 is even simpler than Option 2. There is no need to add a 3rd sub-codebook. The DCI format 0\_1 and 1\_1 can be reused directly (regarding C-DAI/T-DAI, and NFI if eType2 codebook is considered) |
| Lenovo, Motorola Mobility | Support the proposal#10b |

## HARQ timing

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| Company | Views |
| [3] vivo | Proposal 21: For multi-PDSCH scheduling, support reporting HARQ-ACK information corresponding to different PDSCHs scheduled by a DCI on different PUCCH(s).  Proposal 22: For reporting HARQ-ACK feedback on different PUCCHs, further study how to divide the PDSCHs scheduled by a single DL DCI, as well as indicate or determine more than one PUCCH carrying HARQ-ACK feedback. |
| [5] InterDigital | Proposal 3: 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 4: 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. |
| [6] Sony | Proposal 5: If PDSCH processing time is long, at least one of the following solutions should be considered   1. Multiple HARQ feedback timing indication by one DCI 2. Multiple DCI in a slot 3. Increasing the number of HARQ process |
| [7] Lenovo | Proposal 7: 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 |
| [8] Samsung | Proposal 10: HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI carried by different PUCCH(s) is not supported in Rel-17. |
| [10] ZTE | Proposal 6: HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s) considering HARQ-ACK feedback delay. |
| [13] Ericsson | Proposal 26: Do not support HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI to be carried by different PUCCH occasions. |
| [15] Nokia | Proposal 7: If up to 32 DL HARQ processes are supported for 960 kHz SCSs, it is enough to support single transmission of HARQ feedback per multi-PDSCH DCI.  If only 16 DL HARQ processes are supported for 960 kHz SCS, HARQ information for multi-PDSCH DCI can be carried by up to two PUCCHs to reduce HARQ process starvation   * When DCI schedules more than N PDSCHs, where N is configurable, the HARQ-ACK feedback for the scheduled PDSCHs is transmitted over two slots. |
| [16] 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. |
| [17] OPPO | Proposal 9: 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. |
| [18] Qualcomm | Proposal 11: All HARQ-ACK information corresponding to different PDSCHs scheduled by the same DCI to be carried by the same PUCCH. |
| [19] LG Electronics | Proposal #15: Further discuss whether or not HARQ-ACK information corresponding to different PDSCHs scheduled by a single DCI can be carried by two different PUCCHs, at least considering the follows:   * How to separately allocate resource for two PUCCHs (e.g., K1, PRI, etc) * How to signal individual DAI values corresponding to two PUCCHs * Under which condition(s) two PUCCHs are indicated by the DCI (e.g., in case more than N PDSCHs are scheduled) |
| [20] MediaTek | Proposal 5: The HARQ-ACK information corresponding to different PDSCHs scheduled by a DCI should only be carried by single PUCCH to simplify Type-2 codebook design. |
| [22] Apple | Observation 2: 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. |
| [23] Panasonic | Proposal 7: 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. |
| [24] NTT DOCOMO | Proposal 9: Support transmitting HARQ-ACKs for multiple PDSCHs scheduled by one DCI on different PUCCHs. |
| [25] Xiaomi | Proposal 2: For latency sensitive service, separate HARQ-ACK PUCCH resources for multiple PDSCHs scheduled by single DCI can be considered. |

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

[Moderator’s note] 10 companies suggest to support that HARQ-ACK information corresponding to different PDSCHs scheduled by a DCI is carried by different PUCCHs while 5 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 |
| Lenovo, Motorola Mobility | We see that majority of companies want to support that HARQ-ACK information corresponding to different PDSCHs scheduled by a DCI is carried by different PUCCHs  Also, there are 5 opposing companies.  Based on considerable interest from several companies, we suggest to continue discussing this in this meeting with medium priority. |
| Ericsson | Agree with the moderator’s assessment to de-prioritize. |
| Qualcomm | We are okay with the moderator suggestion |
| Huawei, HiSilicon | Even though we think there may be scenarios where allowing reporting in 2 PUCCHs could be beneficial, for the sake of progress we are ok to focus on a single PUCCH in this release. |
| Apple | We are fine with the moderator’s position |
| Intel | We are fine to deprioritize it in this meeting |
| Futurewei | Since multiple PUCCH and HARQ processing increment are different approaches to solve the HARQ process starvation. It is more reasonable not to only deprioritize one of these approaches.  We are fine if no solution is provided for this issue, since multiple PUCCH has disadvantage of high standard effort and increment of HARQ processing number from 16 to 32 would result in increased buffer size. |
| Panasonic | Agree to deprioritize this issue in this meeting |
| Samsung | We support to deprioritize this issue. |
| ZTE, Sanechips | Agree with moderator’s assessment. |
| NEC | We are okay to deprioritize this issue. |
| Sony | We support to deprioritize this issue |
| InterDigital | Considering that 10 companies support carrying HARQ-ACK information corresponding to different PDSCHs by different PUCCHs, and 15 companies have indicated their preference, we would like to continue this discussion if time permits. |
| CATT | We are okay to deprioritize this issue. |
| Spreadtrum | We agree to deprioritize this issue. |
| Xiaomi | We are fine to deprioritize this issue. |

## HARQ process

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| Company | Views |
| [3] vivo | Proposal 16: There is no need to increase the maximum number of HARQ processes due to multi-PDSCH/PUSCH scheduling. |
| [5] InterDigital | Proposal 5: The maximum number of HARQ processes does not change to support multi-PDSCH/PUSCH scheduling. |
| [6] Sony | Proposal 5: If PDSCH processing time is long, at least one of the following solutions should be considered   1. Multiple HARQ feedback timing indication by one DCI 2. Multiple DCI in a slot 3. Increasing the number of HARQ process |
| [13] Ericsson | Proposal 4: Increase maximum number of DL and UL HARQ processes in Rel-17 from 16 to 32. |
| [15] Nokia | Proposal 7: If up to 32 DL HARQ processes are supported for 960 kHz SCSs, it is enough to support single transmission of HARQ feedback per multi-PDSCH DCI.  If only 16 DL HARQ processes are supported for 960 kHz SCS, HARQ information for multi-PDSCH DCI can be carried by up to two PUCCHs to reduce HARQ process starvation  • When DCI schedules more than N PDSCHs, where N is configurable, the HARQ-ACK feedback for the scheduled PDSCHs is transmitted over two slots. |
| [18] Qualcomm | Proposal 10: In the case of increasing the HARQ processes to 32 for SCSs 480kHz and 960kHz, a UE capability should be defined such that X HARQ processes can be supported, and Y of them can do soft combining where X and Y ≥ 16. |
| [25] Xiaomi | Proposal 3: Tx/Rx HARQ buffer capacity will need to be enhanced if HARQ process number increases for SCS 480/960 kHz. |

### Summary (on the number of HARQ processes):

Company views on increasing the number of HARQ processes:

* Supported by Sony, Ericsson, Nokia, Qualcomm
* Objected by vivo, InterDigital, Samsung

[Moderator’s note] Given a small number of inputs, this issue can be deprioritized in this meeting.

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

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| Company | Views |
| Lenovo, Motorola Mobility | We agree to deprioritize this discussion |
| Nokia/NSB | We disagree with Moderator’s proposal. The number of HARQ processes is a critical system parameter impacting e.g. processing times. Hence, we should discuss this topic already in this meeting. |
| Qualcomm | We are okay with the moderator suggestion |
| Huawei, HiSilicon | If the support of 32 HARQ processes (agreed under NR NTN) can be directly reused without additional specification impact then it should be straightforward to support it generally in NR (with a UE capability). This could be discussed later. |
| Apple | Agree with Nokia that this may be necessary to decide on some of the UE processing times and should be discussed. |
| Intel | We are in principle OK to increase the number of HARQ processes, but fine to deprioritize it in this meeting |
| Futurewei | As mentioned in the above response, we are fine if no solution is provided for this issue, since multiple PUCCH has disadvantage of high standard effort and increment of HARQ processing number from 16 to 32 would result in increased buffer size. |
| Panasonic | Our view is to support to increase HARQ processes in Rel-17 from 16 to 32. We agree to deprioritize this discussion in this meeting |
| Samsung | We support to deprioritize the discussion for this issue. |
| ZTE, Sanechips | Agree with moderator’s assessment. |
| InterDigital | We are fine with deprioritizing |
| CATT | We are okay to deprioritize this issue. |
| Spreadtrum | We agree to deprioritize this issue. |
| Xiaomi | We are fine to deprioritize this issue. |
| Nokia/NSB | Based on discussion in processing timeline, if we agree the scale up value for 480/960kHz, HARQ ID starvation will happen. Ask companies to take this aspect into account. |
| Ericsson | We very much agree with the comment from Nokia,  In fact, it would be preferrable to discuss the N1, N2, N3 timelines + # of HARQ processes jointly, i.e., move this discussion point to the other part of 8.2.5. |
| Futurewei | Agree with Nokia. It seems that 8.2.5(1) also realized that part of the discussion relating to timeline for multi-PxSCH is being covered by 8.2.5(2) and has now focused only on single-PxSCH timeline-related definition. If moving the discussion point to 8.2.5(1) is seen as necessary, it can be beneficial to notify them sooner during this meeting about what is not to be covered here such that they can embrace more topics into their ongoing discussion. |
| Moderator | Based on the company view that the decision on the number of HARQ processes may affect the discussion on UE processing timeline, it would be better to open the discussion on whether or not to increase HARQ process number in this meeting.  **To Futurewei,**  Please let me know which aspect that is now being discussed here is related to timeline. For K0/K1/K2 for multi-PXSCH scheduling DCI, we are dealing with their definition itself and not discussing the value range for them. |
| Futurewei | To Moderator:  Thanks, moderator, for the follow-up question. Yes, here we are dealing with the definitions of K0/K1/K2 for multi-PxSCH and the other thread is dealing with the definitions of K0/K1/K2 for single PxSCH. We were just thinking that it might be better that the two parts of the definitions can be merged in this meeting and further progresses that may relate to timeline based upon the definitions are handled jointly as well. |

### [HIGH] Proposal #11 (# HARQ process):

* For NR FR2-2, support 32 as the maximum number of HARQ processes, subject to UE capability.
  + Note: Up to 32 maximal supported HARQ process number is already agreed in Rel-17 NTN WI.

Companies are encouraged to provide views on Proposal #11.

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| Company | Views |
| vivo | We may need more clarification on this proposal.   * + - 1. Does this proposal apply to both DL and UL?       2. What’s the motivation of this proposal?   If the motivation is due to long timeline for single PXSCH scheduling, we may need joint discussion with the following two alternatives to solve HARQ process starvation problem:  Alt. 1: Adopt reduced timeline and no increase of HARQ process number  Alt. 2: Reuse timeline value for 120KHza and increase of HARQ process number  If the motivation is multi-PXSCH scheduling, we think increase of HARQ process number is not necessary since there is other solution with less UE complexity. |
| Huawei, HiSilicon | Support proposal #11  We are not sure we understand vivo’s last sentence. Alt 1 obviously increases UE complexity since it requires a short processing timeline. So which solution (other than Alt 1 and Alt 2) is being suggested, which doesn’t increase UE complexity? |
| Qualcomm | We support the proposal |
| DOCOMO | Fine with Proposal #11. |
| Intel | We are fine with the proposal. |
| ZTE, Sanechips | We are fine with the proposal. |
| Futurewei | OK with Proposal #11. It seems a better option to increase the HARQ processes up to 32, subject to UE capability than other options for solving the HARQ process starvation. |
| Ericsson | We support Proposal #11, since we have agreed that N1 for 480/960 kHz is based on a scaling of the value for 120 kHz. This leads to a large number of slots at 480/960 kHz, and thus to HARQ process starvation as we show in our contribution. |
| Nokia/NSB | Support the proposal #11. Due to relaxed processing timeline, increase the number of HARQ process ID is necessary.  To vivo, even with the smaller value (half of the existing proposal), 16 is still not enough. |
| Samsung | Before agree to increase the number of HARQ processes, we’d like to have some discussion for the following issues:  1. Latency, if additional smaller values of N1/N2/N3 can be agreed.  2. The impact on UE implementation. Larger number of HARQ processes requires larger buffer, and also more complexity at UE side.  3. Signaling mechanism for larger number of HARQ processes. For example, increase 1 bit HPN, or other mechanisms, e.g. as discussed in NTN (whether it is applicable for terrestrial network), or new mechanism. How much standard effort it requires.  4. In Rel-15, number of HARQ processes is fixed for UL, while it can be configured for DL. Do we assume same or different handle for DL and UL here? |
| Moderator | Proposal #11 is supported by most companies except for vivo and Samsung.  **To vivo,**  From my understanding, this proposal applies to both DL and UL and the motivation is to overcome HARQ starvation problem, regardless of single or multi PXSCH scheduling. Do you think 32 HARQ processes for single PXSCH scheduling DCI and 16 HARQ processes for multi-PXSCH scheduling DCI? Hope this is not the case…  **To Samsung,**  1. Latency, Even though smaller N1/N2/N3 will be introduced, UE implementation can have the flexibility to handle HARQ starvation issue: One is with 32 HARQ processes but relaxed (i.e., already agreed) N1/N2/N3, and the other is with 16 HARQ processes but smaller N1/N2/N3 values.  2. UE complexity, it can be further discussed. However, if large buffer is the issue for a UE capable of 32 HARQ processes, it also should be handled for NTN UE.  3. Signaling mechanism, We don’t need to make the system unnecessarily complicated. Whatever signaling is made in NTN, we can just borrow that signaling mechanism, as is.  4. Configurability, it can be further discussed. However, again, we can just follow the decision in NTN.  With the clarification that HARQ process number is increased both for DL and UL, Proposal #11 can be slightly updated as follows. |

### [HIGH] Proposal #11a (# HARQ process):

* For NR FR2-2, 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.

Companies are encouraged to provide views on Proposal #11a.

|  |  |
| --- | --- |
| Company | Views |
| Lenovo, Motorola Mobility | Considering that maximum 32 HARQ process number if agreed for another WI, we are okay to support the proposal |
| Huawei, HiSilicon | We support the proposal |
| InterDigital | As well as Samsung and vivo, we also prefer to have further discussion on this issue. Especially, we sympathize that larger number of HARQ processes require larger UE buffer. Due to the complex implementation, if most of UE does not support the larger number of HARQ process, then HARQ process starvation issue will still exist. |
| Apple | We are fine with the proposal as it is subject to UE capability. If there is a concern on HARQ starvation, one option to resolve this is that NTN has a mechanism that allows enabling/disabling HARQ feedback on specific HARQ processes.  Agreement:  Enabling/disabling on HARQ feedback for downlink transmission should be at least configurable per HARQ process via UE specific RRC signaling |
| Samsung | Thanks for the explanation provided by FL.  Considering probably different UE requirement for NTN and non-NTN UE, we don’t think it is that natural to reuse same NTN design for non-NTN UE. Also, based on the feedback from other companies, we are not sure whether the design details of increased number of HARQ processes in NTN can be directly applied to FR2-2, since the motivation to have the increased number is essentially different (e.g. trying to address the propagation delay issue in NTN).  Also, we would like to clarify that the proposal of increasing HARQ number should be only motivated for 480 and 960 kHz, and we didn’t see a reasoning to support it for 120 kHz. |
| Ericsson | We support Proposal #11a. |
| Qualcomm | We support the proposal as it is subject to UE capability |
| DOCOMO | We are generally fine with the proposal.  We also think clarification is needed whether the number of HARQ processes is increased only for 480/960kHz, or for all SCSs. |
| Futurewei | Support Proposal #11a and agree with SCS clarification. |
| OPPO | How to indicate the HARQ process number up to 32 is still pending in Rel-17 NTN WI, so we prefer to postpone the proposal until the corresponding solution in NTN is clear, and then we can inherit the whole solution to avoid redundant discussion. |
| Fujitsu | We are fine with the proposal. |
| Nokia/NSB | We support Proposal #11a. |
| vivo | Thanks moderator on the clarification on DL and UL.  Corresponding to moderator’s question: there is no intention to have different HARQ process number for single-PXSCH and multi-PXSCH scheduling. We just want to clarify the motivation of this proposal: to solve HARQ process starvation for single or multi-PXSCH scheduling. If smaller N1/N2/N3 value is introduced, HARQ process starvation may not be a problem for single-PXSCH scheduling. We are not against the proposal and just make sure that the increase of HARQ process number is useful with a proper reason. Considering the current agreed baseline N1/N2/N3 value is large, we can accept the proposal here. Besides, agree that further clarification of supported SCS is needed. |
| ZTE, Sanechips | We are fine with the proposal. |
| Moderator | Summary of companies’ views:   * OK: Lenovo, Huawei, Apple, Ericsson, Qualcomm, Fujitsu, Nokia, ZTE * Need further discussion: InterDigital, Samsung, OPPO * Need clarification on SCS: Samsung, DOCOMO, Futurewei, vivo   Overall, it seems that most companies are willing to agree on increasing HARQ process number as a UE capability.  Regarding SCS issue, what I thought was if a UE capability on 32 HARQ processes is defined, it is not relevant with SCS and the UE capability applies to all SCSs (i.e., 120/480/960 kHz). However, I’d like to hear companies’ views on that issue. |

### [HIGH] Proposal #11b (# HARQ process):

* For NR FR2-2 [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.

Companies are encouraged to provide views on Proposal #11b, especially on the applicable SCS.

|  |  |
| --- | --- |
| Company | Views |
| Intel | We are generally ok with the proposal. However we would like to leave out SCS specific component (480/960kHz in brackets) from the agreement. We just made a working assumption to support multiple PDSCH for 120kHz as well for FR2-2. Our preference would be not to introduce too many SCS specific features but have a feature that could be applied to all applicable SCS.  Given that the increased HARQ process number of subject to UE capability, we can further discuss whether there will be a single capability for all supported SCS or whether it can be for each SCS. This would leave door open for potentially issues with 120kHz HARQ process number increase. |
| Lenovo, Motorola Mobility | Fine to support the proposal |

## Others

|  |  |
| --- | --- |
| Company | Views |
| [20] MediaTek | Proposal 7: The UCI information bits including HARQ-ACK information bits should reuse the existing PUCCH payload size limit 1706. |
| [25] 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. |

# Reference

1. R1-2106446 PDSCH/PUSCH enhancements for 52-71GHz spectrum Huawei, HiSilicon
2. R1-2106569 PT-RS enhancements for NR from 52.6GHz to 71GHz Mitsubishi Electric RCE
3. R1-2106583 Discussions on PDSCH/PUSCH enhancements for NR operation from 52.6GHz to 71GHz vivo
4. R1-2106695 Discussion on PDSCH and PUSCH enhancements for above 52.6GHz Spreadtrum Communications
5. R1-2106770 PDSCH/PUSCH enhancements for supporting NR from 52.6GHz to 71 GHz InterDigital, Inc.
6. R1-2106799 PDSCH/PUSCH enhancements for NR from 52.6 GHz to 71 GHz Sony
7. R1-2106835 PDSCH/PUSCH scheduling enhancements for NR from 52.6 GHz to 71GHz Lenovo, Motorola Mobility
8. R1-2106877 PDSCH/PUSCH enhancements for NR from 52.6 GHz to 71 GHz Samsung
9. R1-2106960 PDSCH/PUSCH enhancements for up to 71GHz operation CATT
10. R1-2107004 Discussion on the data channel enhancements for 52.6 to 71GHz ZTE, Sanechips
11. R1-2107033 Considerations on multi-PDSCH/PUSCH with a single DCI and HARQ for NR from 52.6GHz to 71 GHz Fujitsu
12. R1-2107039 Enhancements of PDSCH/PUSCH Scheduling for 52.6 GHz to 71 GHz Band CEWiT
13. R1-2107054 PDSCH-PUSCH Enhancements Ericsson
14. R1-2107100 Enhancements of PDSCH/PUSCH and scheduling for 52.6GHz to 71GHz FUTUREWEI
15. R1-2107108 PDSCH/PUSCH enhancements Nokia, Nokia Shanghai Bell
16. R1-2107154 Discussion on PDSCH enhancements supporting NR from 52.6GHz to 71 GHz NEC
17. R1-2107241 Discussion on PDSCH/PUSCH enhancements OPPO
18. R1-2107334 PDSCH/PUSCH enhancements for NR in 52.6 to 71GHz band Qualcomm Incorporated
19. R1-2107439 PDSCH/PUSCH enhancements to support NR above 52.6 GHz LG Electronics
20. R1-2107512 Multi-PDSCH scheduling design for 52.6-71 GHz NR operation MediaTek Inc.
21. R1-2107581 Discussion on PDSCH/PUSCH enhancements for extending NR up to 71 GHz Intel Corporation
22. R1-2107730 Discussion on PDSCH and PUSCH Enhancements for NR above 52.6 GHz Apple
23. R1-2107829 Discussion on PDSCH/PUSCH enhancements for NR 52.6-71 GHz Panasonic Corporation
24. R1-2107849 PDSCH/PUSCH enhancements for NR from 52.6 to 71 GHz NTT DOCOMO, INC.
25. R1-2107915 PDSCH and PUSCH enhancements for NR 52.6-71GHz Xiaomi
26. R1-2108010 Discussion on multiple PDSCHs scheduled by a DCI ITRI
27. R1-2108017 NR PDSCH design consideration from 52.6 GHz to 71 GHz Convida Wireless
28. R1-2108150 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