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

**Document for:** Discussion and decision

# Introduction

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

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

[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. |

## 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. |

## 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 |

## TDRA enhancement

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| 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
* 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. |

## 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 |
| 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. |

## 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

[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 in FR2-2, 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. |

## 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 |

## 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.

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| 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 |

## 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 |
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## 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 |
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## 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 |

## 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 |

## 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. |
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# 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
  + 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 |

## 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
* 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.

|  |  |
| --- | --- |
| 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. |

## 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 |

## 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 |

## 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

[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 |

## Others

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| 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