**3GPP TSG RAN WG1 #107bis-e R1-220XXXX**

**e-Meeting, January 17th – 25th, 2022**

**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:

[107bis-e-R17-52-71GHz-06] Email discussion/approval on scheduling particularly w.r.t. multi-PDSCH/PUSCH with a single DCI, HARQ – Seonwook (LGE)

* 1st check point: January 20
* Final check point: January 25

Among text proposals in the contributions, the ones that seem to be able to be directly discussed without agreeing on the related functionality are listed up in Section 4 while the other text proposals can be further discussed after more generic agreement is made in this meeting. Please see TP#A to TP#I in Section 4 and provide your views if they are acceptable or not.

# Multi-PDSCH/PUSCH scheduling

## 2-TB transmission

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| Company | Views |
| [1] Futurewei | Proposal 1. Prefer that TB-disabling (if supported) applies to all scheduled TBs, and the need of further optimization over the Rel-15 mechanism can be discussed. |
| [4] vivo | Proposal 6: Regarding TB disabling for multi-PDSCH scheduling, when two codeword transmission is configured, for a DCI format scheduling more than one PDSCH, a given TB can be disabled for each scheduled PDSCH individually, by setting *IMCS* = 26 and the 1-bit RV for a scheduled PDSCH to a predefined value, e.g. ‘1’, to indicated the given TB for the scheduled PDSCH is disabled. |
| [6] CATT | Proposal 7: Both All-PDSCHs based and per-PDSCH based TB disable/enable mechanisms are supported, it depends on gNB configuration.  Proposal 8: For the scheme 1 on TB disable, to enable flexible gNB scheduling, the following points can be considered:   * Only all M of RV bit(s) are set to 1 (e.g. 11111111) represent the TB disable, even if the number of scheduled PDSCH is less than M. M is maximum number of PDSCHs can be scheduled configured by TDRA parameter. * If M PDSCH(s) are scheduled, and two TBs are set as MCS=26/RV=all “1”, UE assume that only TB1 is disabled. M is maximum number of PDSCHs can be scheduled configured by TDRA parameter. |
| [7] Nokia | Proposal 1: The combination MCS=26 and ‘1’ for RV bit fields for all PDSCHs associated with the TB is used to indicate the second TB is disabled. |
| [9] NTT DOCOMO | Proposal 2: When multiple PDSCHs are scheduled, dynamic 2-TB disabling/enabling is determined for each PDSCH separately. For each PDSCH, the corresponding 1 bit RV field is used. If IMCS=26 and rvid=2, 2-TB transmission is disabled for the PDSCH. Otherwise, 2-TB transmission is enabled for the PDSCH. Otherwise, 2-TB transmission is enabled for the PDSCH.  Proposal 3: For antenna port field indication by multi-PDSCH scheduling DCI, two antenna port(s) fields are included in multi-PDSCH scheduling DCI. One antenna port field is applied to PDSCHs with only one codeword enabled, while the other antenna port field is applied to PDSCHs with two codeword enabled. |
| [12] Qualcomm | Proposal 8: To indicate that the second TB is disabled for a certain DCI that schedules multiple PDSCHs, use a combination of MCS and rv­id such that rvid bit of PDCSH i-1 is the complement of the one of PDSCH i for i=1 : number of maximum PDSCHs -1. |
| [16] Apple | Proposal 9: RAN1 should update the RV design to support the TB-disabling mechanism for multi-PDSCH with a single scheduling DCI |
| [20] LG Electronics | Proposal #8: Consider one of the following methods to disable one of 2 TBs if 2-TB is enabled and more than one PDSCH is scheduled by multi-PDSCH scheduling DCI.   * Method 1: Set all ‘1’s for RV bits corresponding to the TB of all scheduled PDSCHs and set MCS=26. * Method 2: Set ‘1’ for RV bit corresponding to the TB of a PDSCH and set MCS=26 (e.g., by reinterpreting value ‘1’ for RV field as RV index #1 when multiple PDSCHs are scheduled and MCS=26). |

### Issue 2.1) TB-disabling mechanism:

Motivation:

* In Rel-16, if 2-TB transmission is enabled, a TB signalled with MCS=26 and rvid =1 is disabled.
* In Rel-17, if DCI format 1\_1 schedules more than one PDSCH, one-bit RV field can indicate rvid =0 or 2 and cannot indicate rvid =1, which disallows TB-disabling mechanism.

Company views on TB-disabling mechanism:

* Alt 1: TB-disabling for all of PDSCHs scheduled by a single DCI
  + Supported by Futurewei, CATT, Nokia, Qualcomm, LG Electronics
  + Alt 1-1: Set all ‘1’s to RV bits
    - Supported by CATT, Nokia, LG Electronics
  + Alt 1-2: rvid bit of PDCSH i-1 is the complement of the one of PDSCH i for i=1 : number of maximum PDSCHs -1 (e.g., 101010…)
    - Supported by Qualcomm
* Alt 2: TB-disabling individually for each of PDSCHs scheduled by a single DCI
  + Supported by vivo, NTT DOCOMO, Apple, LG Electronics
  + NTT DOCOMO: If Alt 2 is adopted, two DCI fields for antenna port(s) indication can be needed such that one is for 2-TB PDSCH and the other is for 1-TB PDSCH.

Companies are encouraged to provide views on the above alternatives (or any other alternatives) to disable a TB.

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| Company | Views |
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## Out-of-order handling

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| Company | Views |
| [2] Huawei | Proposal 6: UE does not expect any of the scheduled/SPS PDSCHs and the resource for the HARQ-ACK transmission to lead to out-of-order scheduling. |
| [3] InterDigital | Proposal 2: For the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, UE doesn’t expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCI lead to out-of-order scheduling.  Observation 1: For the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, any further specification is not needed. As per Rel-16, it is considered as an out-of-order scheduling and not supported.  Proposal 3: A UE doesn’t expect the case of two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans where span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV. |
| [4] vivo | Observation 1: The case where two DCIs, each of which schedules a multi-slot PDSCH (or multi-slot PUSCH), end in the same symbol but the two scheduled multi-slot PDSCHs (or multi-slot PUSCHs) have overlapping spans, where the span is defined from the beginning of the first repetition till the end of the last repetition for a PDSCH/PUSCH, is allowed in Rel-15/16.  Proposal 4: For multi-PDSCH/PUSCH scheduling, DCI-to-PDSCH/PUSCH out-of-order scheduling is defined as NR Rel-15/16 without any exception.  Proposal 5: For multi-PDSCH scheduling, UE does not expect any of the scheduled PDSCH(s)/SPS PDSCH and the PUCCH resource for the HARQ-ACK transmission to lead to out-of-order HARQ-ACK reporting. |
| [8] Samsung | Proposal 8: For single PDSCH (or PUSCH) scheduling DCIs and multi-PDSCH (or multi-PUSCH) scheduling DCIs, UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCIs to lead to out-of-order scheduling.  Observation 1: SPS PDSCH reception has large scheduling restriction on multi-PDSCH scheduling.  Proposal 9: UE is not expected to receive a SPS PDSCH if the SPS PDSCH is configured to be received between a PDCCH with a DCI scheduling multiple PDSCHs and the last PDSCH scheduled by the DCI. |
| [9] NTT DOCOMO | Proposal 1: The following two cases are OoO scheduling, and should not be allowed:   * the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH). * the case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV. |
| [10] ZTE | Proposal 1: It is not recommended to introduce additional specification impact to handle the two cases listed in FFS except existing OOO rule. |
| [11] Panasonic | Proposal 3: For the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, UE does not expect any of the scheduled PDSCHs (or PUSCHs) to lead to out-of-order scheduling.  Proposal 4: For the case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol, but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, UE does not expect any of the scheduled PDSCHs (or PUSCHs) to lead to out-of-order scheduling.  Proposal 5: For multi-PDSCH scheduling, UE does not expect any of the scheduled/SPS PDSCHs and the resource for the HARQ-ACK transmission lead to out-of-order scheduling. |
| [12] Qualcomm | Proposal 10: The UE does not expect to be scheduled with two DCIs that schedule DL (UL) data allocations with overlapping spans, where the span of the allocations scheduled by one DCI is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV by the same DCI. |
| [13] OPPO | Proposal 1: Support scheduling of the following case:   * One multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH), and the single-PDSCH (or single-PUSCH) is transmitted at least later than the first PDSCH (or PUSCH) of the multi-PDSCH (or multi-PUSCH).   Proposal 2: Do not specify the following case:   * Two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV. |
| [14] Intel | Proposal 4  For two PDCCHs and the associated PDSCH(s) and PUSCH(s), if at least one PDCCH is scheduling multiple PDSCHs/PUSCHs, referring to Figure 1,   * Case A/B/C/D are invalid; * The existing specification should be updated to reflect that Case A/C are invalid * Agree on the TP 2 on OOO handling between two PDCCHs and the associated PDSCH(s) and PUSCH(s)   For two sets of PDSCHs and associated PUCCH, if at least one set of PDSCHs is of multiple PDSCHs/PUSCHs, referring to Figure 2,   * Case E/F are valid, and Case G/H is invalid. * The existing specification is sufficient for cases E/F/G/H. * No TP is needed on OOO handling between two sets of PDSCHs and associated PUCCH.  |  | | --- | | **------------------------------ TP#2: TS 38.214 -----------------------------------**  \*\*\* Unchanged text is omitted \*\*\* 5.1 UE procedure for receiving the physical downlink shared channel \*\*\* Unchanged text is omitted \*\*\*  For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start receiving a first PDSCH starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to receive a PDSCH starting earlier than the end of the first PDSCH with a PDCCH that ends later than symbol *i*. In a given scheduled cell, if the UE is scheduled to receive multiple PDSCHs, with the first PDSCH starting in symbol *j* and the last PDSCH ending in symbol *k,* by a first PDCCH ending in symbol *i*, the UE is not expected to be scheduled to receive a PDSCH starting no earlier than symbol *j* and no later than symbol *k* with a second PDCCH.  \*\*\* Unchanged text is omitted \*\*\* 6.1 UE procedure for transmitting the physical uplink shared channel \*\*\* Unchanged text is omitted \*\*\*  Except for the case when a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet* for the active BWP of a serving cell and PDCCHs that schedule two non-overlapping in time domain PUSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex,*   * for any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH that ends later than symbol *i*. * in a given scheduled cell, if the UE is scheduled to transmit multiple PUSCHs, with the first PUSCH starting in symbol *j* and the last PUSCH ending in symbol *k,* by a first PDCCH ending in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting no earlier than symbol *j* and no later than symbol *k* with a second PDCCH.   \*\*\* Unchanged text is omitted \*\*\* | |
| [15] Ericsson | Proposal 2 Out-of-Order scheduling is allowed for the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH).  Proposal 3 Out-of-Order scheduling is NOT allowed for the case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV. |
| [16] Apple | Proposal 3: To simplify UE implementation, we propose that for the DCI-to-data out of order issue, the UE does not expect any out-of-order scheduling for the following cases:   * for the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH). * for the case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV. This applies also when one of two DCIs is single-PDSCH (or single-PUSCH) scheduling DCI   Proposal 4: For the PDSCH-to-HARQ-ACK out-of-order issue,   * for multi-PDSCH scheduling, the UE does not expect any of the scheduled/SPS PDSCHs and the resource for the HARQ-ACK transmission to lead to out-of-order scheduling in the case of a PDSCH scheduled by multi-PDSCH scheduling DCI and other unicast PDSCH scheduled by single-PDSCH scheduling DCI |
| [19] MediaTek | Proposal 4: For the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, UE doesn’t expect any of the scheduled PDSCHs(or PUSCHs) and the scheduling DCI lead to out-of-order scheduling.  Proposal 5: For multi-PDSCH scheduling, UE doesn’t expect any of the scheduled PDSCHs and the resource for the HARQ-ACK transmission lead to out-of-order scheduling. |
| [20] LG Electronics | Proposal #4: For one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCI to lead to out-of-order scheduling.  Proposal #5: For the case where two DCIs end at the same symbol but two DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV, UE drops the PDSCHs scheduled by one of the two DCIs in the overlapping duration. |
| [22] WILUS | Proposal 1: We propose to support the followings:   * A UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCI to lead to out-of-order scheduling, also for the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH) * The case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV, is considered as out-of-order scheduling and is not expected by UE.   + This applies also when one of two DCIs is single-PDSCH (or single-PUSCH) scheduling DCI. |

### Issue 2.2-1) DCI-to-data out-of-order issue:

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

Agreement: (RAN1#106bis-e)

For two multi-PDSCH (or two multi-PUSCH) scheduling DCIs, UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCI to lead to out-of-order scheduling.

* FFS: whether to allow OOO scheduling for the following two cases:
  + for the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH)
  + for the case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV
* Note: The above FFS aspect applies only to multi-PDSCH and multi-PUSCH scheduling with single DCI

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

* For the first case of above highlighted FFS,
  + Considered as OOO scheduling: Huawei, InterDigital, vivo, Samsung, NTT DOCOMO, ZTE, Panasonic, Apple, MediaTek, LG Electronics, WILUS
  + Can be allowed: OPPO (if single PXSCH DCI is transmitted later than the first PXSCH scheduled by multi-PXSCH DCI), Ericsson
* For the second case of above highlighted FFS,
  + Considered as OOO scheduling: InterDigital, NTT DOCOMO, Intel, Ericsson, Apple, WILUS
  + Can be allowed: vivo, ZTE, vivo

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

### Proposal #2.2-1 (DCI-to-data OOO):

* UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCI to lead to out-of-order scheduling, also for the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH).
  + This may not have specification impact.
* The case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV, is considered as out-of-order scheduling and is not expected by UE.
  + This applies also when one of two DCIs is single-PDSCH (or single-PUSCH) scheduling DCI.

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

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| Company | Views |
| Xiaomi | Agree with the proposal in general. |
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### Issue 2.2-2) PDSCH-to-HARQ-ACK out-of-order issue:

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

Company views on PDSCH -to-HARQ-ACK out-of-order issue:

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

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

### Proposed Conclusion #2.2-2 (PDSCH-to-HARQ-ACK OOO):

* UE does not expect any of the scheduled/SPS PDSCHs and the resource for the HARQ-ACK transmission to lead to out-of-order scheduling, for any scheduling DCIs (including multi-PDSCH scheduling DCI).

Companies are encouraged to provide views on Proposed Conclusion #2.2-2.

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| Company | Views |
| Xiaomi | Agree with the proposal in general. |
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## Maximum gap between PDSCHs/PUSCHs

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| Company | Views |
| [1] Futurewei | Proposal 4. It is recommended to specify the maximum value of the gap between the first scheduled PxSCH and the last scheduled PxSCH for simpler UE implementation. |
| [2] Huawei | Proposal 1: Support proposed conclusion#2.7 in RAN1#107-e that for multi-PDSCH or multi-PUSCH scheduling DCI, the following maximum gap values are not specified and are up to the gNB implementation.   * The maximum value of the gap between two consecutively scheduled PDSCHs or between two consecutively scheduled PUSCHs * 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. |
| [3] InterDigital | Proposal 1: The maximum value of the gap between the first scheduled PDSCH and the last scheduled PDSCH and the gap between the first scheduled PUSCH and the last scheduled PUSCH should be 8 X,X∈{2,3}. |
| [11] Panasonic | Proposal 1: For multi-PDSCH or multi-PUSCH scheduling DCI, not to specify the following maximum value of a gap other than the values of the scheduling offset K0 (or K2)   * A maximum value of the gap between two consecutively scheduled PDSCHs or between two consecutively scheduled PUSCHs * A 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. |
| [15] Ericsson | Proposal 1 Do not introduce constraints on maximum value of the gap between two consecutively scheduled PDSCHs/PUSCHs or maximum value of the gap between the first and the last scheduled PDSCH/PUSCH other than that inherently provided by the range of K0/K2 value. |
| [16] Apple | Proposal 2: On the maximum gap for PxSCH transmission:   * The maximum gap between the first and last PxSCH transmissions should be selected based on the maximum values of k0 and k2 i.e., 128 slots. * The maximum gap between two consecutive transmissions, can be set to the maximum value between the first and the last transmission in a 2 PDSCH/PUSCH transmission i.e., 128 slots. |
| [19] MediaTek | Proposal 3: For multi-PDSCH scheduling, if M PDSCHs are scheduled by a DCI, the M PDSCHs should be contained within at most M consecutive slots |
| [20] 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. |

### 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, Panasonic, Ericsson, LG Electronics
  + To be specified: Apple
* 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, Panasonic, Ericsson, LG Electronics
  + To be specified: Futurewei, InterDigital, Apple, MediaTek (M PDSCHs are confined within at most M consecutive slots)

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

### Proposed Conclusion #2.3 (Max gap):

* For multi-PDSCH or multi-PUSCH scheduling DCI, the following maximum value of a gap is not specified in Rel-17 and up to gNB scheduler.
  + The maximum value of the gap between two consecutively scheduled PDSCHs or between two consecutively scheduled PUSCHs
  + 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

Companies are encouraged to provide views on Proposed Conclusion #2.3.

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| Company | Views |
| Xiaomi | Agree with the proposal. |
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## Handling of collision with semi-static DL/UL/flexible symbols

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| Company | Views |
| [1] Futurewei | Proposal 2. For multiple PDSCH/PUSCH, the NDI/RV fields are based the maximum number of schedulable SLIVs; for RV the bit-width between 1 bit and 2 bits is based on the maximum number of schedulable PUSCH; for the CSI-request, the number M needs to be determined based on the number a valid SLIVs; whether CBG field is determined based on number of configured SLIVs or valid SLIVs is not relevant; valid SLIVs should be used for OOO scheduling.  Proposal 5. On handling of collision between PUSCH and CORESET#0 for Rel-17 multiple PUSCHs scheduled by a single DCI, update the agreement by removing [or symbol(s) indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set]. |
| [5] Fujitsu | Proposal 3: For a first DCI scheduling multiple PDSCHs and providing an inapplicable value of k1 in its PDSCH-to-HARQ\_feedback timing indicator filed, to multiplex the corresponding HARQ-ACK information in a PUCCH or PUSCH in a slot indicated by the PDSCH-to-HARQ\_feedback timing indicator filed in a second DCI, only the valid PDSCHs scheduled by the first DCI are considered for definition of the corresponding timeline requirements. |
| [6] CATT | Proposal 5: NDI/RV fields for both valid and invalid PXSCHs are present in multi-PXSCH scheduling DCI.  Proposal 6: For out-of-order scheduling, the rule for OOO case is determined based on valid SLIV(s) |
| [9] NTT DOCOMO | Proposal 4: If multiple PUSCHs are scheduled by single DCI, and there is at least one PUSCH collides with semi-static DL symbol, and/or symbol configured for SSB or CORESET#0 reception,   * OoO scheduling limitation is based on valid PUSCHs. * If CBG based transmission is configured, CBGTI field is present in DCI for the case when multiple PUSCHs are scheduled but only one PUSCH is valid. * A-CSI reporting triggered by multi-PUSCH scheduling DCI is based on valid PUSCHs. When the A-CSI triggering DCI schedules N valid PUSCHs, the PUSCH that carries the aperiodic CSI feedback is N-th valid PUSCH for N <= 2, or (N-1)-th valid PUSCH for N > 2. * When timeline is satisfied, the CG PUSCH overlapping with the cancelled DG PUSCH can be transmitted. * When timeline is satisfied, the CG PUSCH with same HARQ process ID as the cancelled DG PUSCH can be transmitted.   Proposal 5: If multiple PDSCHs are scheduled by single DCI, and there is at least one PDSCH collides with semi-static UL symbol,   * OoO scheduling limitation is based on valid PDSCHs. * If CBG based transmission is configured, CBGTI/CBGFI fields are present in DCI for the case when multiple PDSCHs are scheduled but only one PDSCH is valid. * DCI scheduling multiple PDSCHs but with only one valid PDSCH is included in the first sub-codebook. * When timeline is satisfied, the SPS PDSCH overlapping with the cancelled DG PDSCH can be received. |
| [10] ZTE | Proposal 2: Unnecessary optimization should not be introduced for “scheduled PXSCH”.   * NDI/RV/CBGTI field is determine based on the number of configured SLIVs. * gNB should guarantee the assigned PUSCH carrying the A-CSI is valid. * Only valid PXSCH should be considered in out-of-order scheduling. |
| [12] Qualcomm | Proposal 7: In the case of multi-PDSCH scheduling via a single DCI with 'tdmSchemeA', consider one of the following options to handle the overlap with semi-static UL symbols   * Option 1: If one of the repetitions of the PDSCH collides with semi-static UL symbols, the corresponding PDSCH is considered as not valid * Option 2: If the first repetition of the PDSCH collides with semi-static UL symbols, the corresponding PDSCH is considered as not valid   + On the other hand, if only the second repetition of the PDSCH collides with semi-static UL symbol, the PDSCH is still considered valid   Proposal 9: For a single DCI that schedules multi-PDSCH/PUSCH, the NDI/ RV should be signaled per SLIV, i.e., a single bit will be assumed for each SLIV in NDI or RV vector even if the corresponding PDSCH/PUSCH is not valid. |
| [13] OPPO | Proposal 6: Clarify whether one PDSCH/PUSCH of the multi-PDSCH/PUSCH scheduled by a single DCI can be cancelled by a dynamic indication. |
| [14] Intel | Proposal 1   * If a PUSCH is collided with symbol(s) indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set, the HARQ process number increment is not skipped for the PUSCH. * No TP is needed for HARQ process number increment for invalid PUSCH.   Proposal 5: The following behavior should be defined based on the configured SLIVs of a TDRA row,   * NDI/RV field in the DCI format * A-CSI multiplexing on the multiple PUSCHs scheduled by a DCI * OOO handling * No TP is needed as operation based on configured SLIVs is the default behavior |
| [20] LG Electronics | Proposal #1: If a PDSCH among multiple PDSCHs that are scheduled by a single DCI is collided with uplink symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, NDI/RV fields corresponding to the PDSCH are absent in the DCI.  Proposal #2: 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* or collided with SSB symbols indicated by *ssb-PositionsInBurst*, NDI/RV fields corresponding to the PUSCH are absent in the DCI.  Proposal #3: Considering that M-th or (M-1)-th scheduled PDSCH (which would carry aperiodic CSI report as per previous agreement) can be cancelled due to the collision with semi-static DL symbols or SSB, when the DCI schedules M PUSCHs and K (<=M) PUSCHs are actually transmitted, the PUSCH that carries the aperiodic CSI feedback is K-th transmitted PUSCH for K <= 2, or (K-1)-th transmitted PUSCH for K > 2.  Proposal #6: Do not consider any invalid PDSCH (which is collided with semi-static UL symbol(s)) to check out-of-order scheduling. |
| [22] WILUS | Proposal 2: If one of multiple PUSCHs is collided with symbol(s) indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set, the HARQ process number increment is skipped for the PUSCH. |

### Issue 2.4-1) How to handle collision between PUSCH and CORESET#0:

Agreement: (RAN1#106bis-e)

For multiple PDSCHs (or PUSCHs) scheduled by a single DCI,

* Rel-15/16 behavior that is described in TS 38.213 Clauses 11 and 11.1 for a PDSCH (or PUSCH) indicated by DCI also applies for multiple PDSCHs (or PUSCHs) schedule by a single DCI.
* If one of multiple PDSCHs (or PUSCHs) scheduled by the DCI collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*),
  + If that PUSCH is collided with SSB symbols indicated by *ssb-PositionsInBurst* [or symbol(s) indicated by *pdcch-ConfigSIB1* in *MIB* for a CORESET for Type0-PDCCH CSS set], the HARQ process number increment is skipped for the PUSCH.
  + Otherwise, the HARQ process number increment is not skipped for that PDSCH (or PUSCH).

Company views on highlighted part above:

* If that PUSCH is collided with SSB symbols indicated by *ssb-PositionsInBurst* or symbol(s) indicated by *pdcch-ConfigSIB1* in *MIB* for a CORESET for Type0-PDCCH CSS set, the HARQ process number increment is skipped for the PUSCH.
  + Supported by NTT DOCOMO, WILUS
  + Objected by Futurewei, Intel

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

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| Company | Views |
| Xiaomi | Agree with the highlighted part |
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### Issue 2.4-2) Clarification on whether “scheduled PXSCH” in previous agreements implies valid PXSCH or not:

Agreement: (RAN1#104-bis)

For a DCI that can schedule multiple PDSCHs,

* 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

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)

* 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.

Agreement: (RAN1#106bis-e)

For two multi-PDSCH (or two multi-PUSCH) scheduling DCIs, UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCI to lead to out-of-order scheduling.

Agreement: (RAN1#106bis-e)

For a DCI that can schedule multiple PDSCHs, and if RRC parameter configures that two codeword transmission is enabled,

* NDI for the 2nd TB: This is signaled per PDSCH and applies to the 2nd 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 2nd TB of each PDSCH

Company views on whether “scheduled PXSCH” in previous agreements implies valid PXSCH or not:

* Case 1: For NDI/RV, are NDI/RV fields for invalid PXSCHs present in multi-PXSCH scheduling DCI?
  + Based on configured SLIVs: Futurewei, CATT, ZTE, Qualcomm, Intel
  + Based on valid SLIVs: LG Electronics
* Case 2: For RV field, is the bit-width between 1 bit and 2 bits determined based on the number of configured SLIVs or valid SLIVs?
  + Based on configured SLIVs: Futurewei, ZTE, Qualcomm, Intel
  + Based on valid SLIVs
* Case 3: For CSI-request, is the number M determined based on the number of configured SLIVs or valid SLIVs?
  + Based on configured SLIVs: ZTE, Intel
  + Based on valid SLIVs: Futurewei, NTT DOCOMO, LG Electronics
* Case 4: For CBGTI field, is the presence of CBGTI field determined based on the number of configured SLIVs or valid SLIVs?
  + Based on configured SLIVs: ZTE
  + Based on valid SLIVs: NTT DOCOMO
* Case 5: For out-of-order scheduling, is the rule for OOO scheduling determined based on configured SLIVs or valid SLIVs?
  + Based on configured SLIVs: Intel
  + Based on valid SLIVs: Futurewei, CATT, NTT DOCOMO, ZTE, LG Electronics
* Case 6: For a first DCI scheduling multiple PDSCHs and providing an inapplicable value of k1 in its PDSCH-to-HARQ\_feedback timing indicator filed, to multiplex the corresponding HARQ-ACK information in a PUCCH or PUSCH in a slot indicated by the PDSCH-to-HARQ\_feedback timing indicator filed in a second DCI, only the valid PDSCHs scheduled by the first DCI are considered for definition of the corresponding timeline requirements.
  + Supported by Fujitsu
* Case 7: In the case of multi-PDSCH scheduling via a single DCI with 'tdmSchemeA', cancel both of two repeated PDSCHs if at least one of repeated PDSCHs collides with semi-static UL symbols or determine the validity rule for each of repeated PDSCHs
  + Supported by Qualcomm

Companies are encouraged to provide views on the above cases.

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| Company | Views |
| Example | Case 1 (NDI/RV): Based on configured or valid SLIVs  Case 2 (RV bit-width): Based on configured or valid SLIVs  Case 3 (CSI-request): Based on configured or valid SLIVs  Case 4 (CBGTI): Based on configured or valid SLIVs  Case 5 (OOO): Based on configured or valid SLIVs  Case 6 (NN-K1): Any views?  Case 7 (tdmSchemeA): Any views? |
| Xiaomi | Case 1 (NDI/RV): Based on configured SLIVs  Case 2 (RV bit-width): Based on configured SLIVs  Case 3 (CSI-request): Based on configured SLIVs  Case 4 (CBGTI): Based on configured SLIVs  Case 5 (OOO): Based on valid SLIVs  Case 6: based on valid SLIVs |

## SPS/CG-related issues

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| Company | Views |
| [1] Futurewei | Proposal 6. For multi-PxSCH, the Rel-15/16 rule to handle collision with SPS/CG HPN can be reused. The corresponding Proposal #2.9-1 can be agreed with a note on it is up to the gNB implementation to avoid unfavorable cases that end up with data retransmission.  Proposal 7. For multi-PxSCH, the Option 1 that allows only single SLIV-based activation for SPS/CG should be adopted, with a note to clarify that activation of SPS/CG is not supported if there is no row containing a single SLIV in the configured multi-PxSCH TDRA table. |
| [4] vivo | Proposal 3: For activation/de-activation of SPS/CG by using multi-PDSCH/PUSCH scheduling DCI, the first (valid) SLIV in the row indicated by an activation/de-activation DCI is used for determining SPS/CG occasions. |
| [5] Fujitsu | Proposal 2: For SPS activation/retransmission via DCI format 1\_1 when multi-PDSCH scheduling is supported, the following 3 options can be considered, and Option 2 is slightly preferred for a well trade-off between flexibility and standardization effort.   * Option 1: Allow only single SLIV-based (de)activation * Option 2: Based on the last configured SLIV * Option 3: Based on the first (valid) SLIV |
| [6] CATT | Proposal 1: When Activation of DL SPS is indicated by DCI format 1\_1, if the time domain resource assignment indicates a multiple SLIV(s) entry, the first (valid) SLIV is used to compute PDSCH time domain resource allocation and slot of PUCCH carrying HARQ-ACK.  Proposal 2: When Activation of UL CG is indicated by DCI format 0\_1, if the time domain resource assignment indicates a multiple SLIV(s) entry, the first (valid) SLIV is used to compute PUSCH time domain resource allocation  Proposal 3: At least for PUSCH transmission, for special HARQ process ID(s) that are assigned to GC PUSCH by RRC, UE shall skip these HARQ process IDs if the dynamic scheduling signaling indicates the same ID(s). |
| [8] Samsung | Proposal 4: If a CG PUSCH is configured to be transmitted between the first scheduled PUSCH and the last scheduled PUSCH by a single DCI scheduling multiple PUSCHs, HARQ process number increment is skipped for the HARQ ID used for the CG PUSCH when determining the HARQ ID of the multiple scheduled PUSCHs.  Proposal 5: For a DCI capable of scheduling multi-PDSCH/PUSCHs, gNB can only indicate a row with single SLIV for SPS PDSCH/CG PUSCH activation and retransmission. |
| [11] Panasonic | Proposal 2: For an activation of SPS (or CG) by using multi-PDSCH (or multi-PUCH) scheduling DCI, support to use a solution based on the last or first (valid) SLIV in order to reuse SLIV entry for multi-PDSCH/PUSCH scheduling. |
| [14] Intel | Proposal 2   * A HARQ process number configured for SPS PDSCH/CG PUSCH can be allocated to a PDSCH/PUSCH of multi-PDSCH/PUSCH scheduling, as long as the timeline is met. * No TP is needed for HARQ process number collision handling between SPS PDSCH/CG PUSCH and DG PDSCH/PUSCH.   Proposal 3   * For activation of SPS-PDSCH or Type-2 CG-PUSCH by using multi-PDSCH or multi-PUSCH scheduling mechanism, respectively, only single SLIV-based activation is allowed. * Agree on TP1 for activation of SPS-PDSCH or Type-2 CG-PUSCH by using multi-PDSCH or multi-PUSCH scheduling mechanism, respectively. |
| [15] Ericsson | Proposal 4 Support the FL proposal #2.9-1 (SPS/CG HPN) on how to handle HARQ process number when it collides with that assigned for SPS or CG. I.e., HARQ process number configured for SPS PDSCH (or CG PUSCH) can be allocated to a PDSCH (or PUSCH) of multi-PDSCH (or multi-PUSCH) scheduling, as long as the timeline condition defined in Rel-15/16 is met.  Observation 1 With the current specification regarding PDCCH validation for DL SPS and UL grant Type 2, it is not possible that a multiple scheduling DCI indicates SPS/CG activation/release while schedules normal PDSCH/PUSCH transmission at the same time.  Proposal 5 For SPS/CG activation/release by using multi-PDSCH/PUSCH scheduling DCI, support Option 1. I.e., SPS/CG activation/release is indicated by a DCI that indicates a single SLIV. |
| [20] LG Electronics | Proposal #7: If a DCI that indicates a row index of the TDRA table associated with multiple SLIVs can be used for SPS PDSCH (or CG PUSCH) (de)activation, determine TDRA or PUCCH resource corresponding to SPS (or CG) based on the last SLIV value in the indicated TDRA row index. |
| [22] WILUS | Proposal 3: We propose to support that   * If the timeline condition defined in Rel-15/16 is met, HARQ process number configured for SPS PDSCH (or CG PUSCH) can be allocated to a PDSCH (or PUSCH) of multi-PDSCH (or multi-PUSCH) scheduling. * Otherwise, HARQ process number increment for a PDSCH(or PUSCH) of multi-PDSCH (or multi-PUSCH) scheduling is skipped for the HARQ process number configured for SPS PDSCH (or CG PUSCH). |

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

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

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

Timeline for PDSCH:

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| TS 38.214  5.1 UE procedure for receiving the physical downlink shared channel  ……………………………………..<omitted>………………………………………  The UE is not expected to decode a PDSCH in a serving cell scheduled by a PDCCH with C-RNTI, CS-RNTI or MCS-C-RNTI and one or multiple PDSCH(s) required to be received according to this Clause in the same serving cell without a corresponding PDCCH transmission if the PDSCHs partially or fully overlap in time except if the PDCCH scheduling the PDSCH ends at least 14 symbols before the earliest starting symbol of the PDSCH(s) without the corresponding PDCCH transmission, where the symbol duration is based on the smallest numerology between the scheduling PDCCH and the PDSCH, in which case the UE shall decode the PDSCH scheduled by the PDCCH. |

Timeline for PUSCH:

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| TS 38.214  6.1 UE procedure for transmitting the physical uplink shared channel  ……………………………………..<omitted>………………………………………  A UE is not expected to be scheduled by a PDCCH ending in symbol to transmit a PUSCH on a given serving cell overlapping in time with a transmission occasion, where the UE is allowed to transmit a PUSCH with configured grant according to [10, TS38.321], starting in a symbol on the same serving cell if the end of symbol is not at least symbols before the beginning of symbol . The value in symbols is determined according to the UE processing capability defined in Clause 6.4, and and the symbol duration are based on the minimum of the subcarrier spacing corresponding to the PUSCH with configured grant and the subcarrier spacing of the PDCCH scheduling the PUSCH. |

[Moderator’s note] Although the number of inputs is small, given the wide support of Option 2 in the last meeting, the following proposal can be made with a note (from Futurewei’s proposal) added.

### Proposed Conclusion #2.5-1 (SPS/CG HPN):

* HARQ process number configured for SPS PDSCH (or CG PUSCH) can be allocated to a PDSCH (or PUSCH) of multi-PDSCH (or multi-PUSCH) scheduling, as long as the timeline condition defined in Rel-15/16 is met.
  + Note: It is up to gNB implementation whether/how to avoid UL data retransmission due to HARQ process index collision and flushed HARQ transmit buffer.

Companies are encouraged to provide views on Proposed Conclusion #2.5-1.

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| Company | Views |
| Xiaomi | Agree with proposal |
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### Issue 2.5-2) (De)Activation of SPS (or CG) by using multi-PDSCH (or multi-PUCH) scheduling DCI:

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

* Option 1: Allow only single SLIV-based activation
  + Supported by Futurewei, Samsung, Intel, Ericsson
* Option 2: Based on the last (valid) SLIV
  + Supported by Fujitsu, Panasonic, LG Electronics
* Option 3: Based on the first (valid) SLIV
  + Supported by vivo, CATT, Panasonic

[Moderator’s note] Given diverged view among three options, it is encouraged for companies to provide views on the above options, if any.

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| Company | Views |
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## Other issues

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| Company | Views |
| [8] Samsung | Proposal 6：For single TRP or multi-TRP operation, for 480/960 kHz SCS,   * A UE does not expect to receive more than one unicast PDSCH in a slot on a serving cell from the same TRP. * A UE does not expect to transmit more than one PUSCH in a slot on a serving cell from the same TRP.   Proposal 7: For resolving collision of overlapping PDSCHs and/or PUSCHs and/or PUCCHs in case of M-PDSCH/M-PUSCH scheduling, UE first resolves the collision of PDSCHs/PUSCHs and semi-static UL/DL symbols and then UE resolves the collision among PDSCHs, PUSCHs and PUCCHs.  Proposal 10: Clarify that for Scell dormancy indication, a UE repurposes *Npdsch,max*-bit NDI and *Npdsch,max*-bit RV fields if TDRA indicates multi-PDSCH scheduling or 1-bit NDI and 2-bit RV fields if TDRA indicates single-PDSCH scheduling.   * If *Npdsch,max*-bit NDI and *Npdsch,max*-bit RV fields are repurposed, the sequence order for a bitmap is 5-bit MCS, *Npdsch,max*-bit NDI, *Npdsch,max*-bit RV, HPN, antenna port(s), and DMRS sequence initialization fields |
| [12] Qualcomm | Proposal 6: In the case of multi-PDSCH scheduling via a single DCI with 'tdmSchemeA', consider one of the following options   * Option 1: UE assumes PDSCH mapping Type B for first and second repetitions of each TB regardless of the mapping type for each SLIV of the indicated TDRA row. * Option 2: UE applies the mapping type of each SLIV as indicated by the TDRA assignment field to the first repetition of the corresponding PDSCH and assumes PDSCH mapping Type B for the second repetition of each PDSCH. |
| [17] Xiaomi | Proposal 4: If Type 1 or Type 3 channel access mechanism is indicated, Type 1 or Type 3 channel access can be applied to each transmission burst among the multiple scheduled PUSCHs. If Type 2 channel access mechanism is indicated, Type 2 channel access can be applied to the first transmission burst, and Type 1 channel access can be for the subsequent bursts, if any. |
| [18] NEC | Proposal 4: Consider the impact of minimum applicable scheduling offset when multiple-PXSCH scheduling and cross-slot scheduling are enable simultaneously. |

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

The following issues are brought up by several companies:

* Samsung: Clarification on TDMed PXSCH, collision resolution step, and SCell dormancy indication of multi-PDSCH scheduling DCI
* Qualcomm: Clarification on PDSCH mapping type for TDM scheme A with m-TRP case
* Xiaomi: Interpretation of channel access type indication
* NEC: Clarification on the combination of minK0/minK2 with multi-PXSCH scheduling

[Moderator’s note] Please feel free to express views on above issues, if any.

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| Company | Views |
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# HARQ

## PUCCH power control

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| Company | Views for type-1 HARQ-ACK codebook |
| [4] vivo | Proposal 9: For multi-PDSCH scheduling and Type-1 codebook, consider the TP2 in TS38.213 for the calculation of .  --------------------------------------------------Start TP2-------------------------------------------------------  **9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel**  ……  If , the UE determines a number of HARQ-ACK information bits for obtaining a transmission power for a PUCCH, as described in clause 7.2.1, as where  - are all DL cells where the UE is configured to receive unicast or multicast PDSCHs  - is the cardinality for the union of all sets of occasions for unicast or multicast PDSCH receptions or SPS PDSCH releases for serving cell  - if *enableTimeDomainHARQ-Bundling* is not provided, is the number of transport blocks the UE receives in PDSCH reception occasion for serving cell if *harq-ACK-SpatialBundlingPUCCH* and *PDSCH-CodeBlockGroupTransmission* are not provided, or the number of transport blocks the UE receives in PDSCH reception occasion for serving cell if *PDSCH-CodeBlockGroupTransmission* is provided and the PDSCH reception is scheduled by a DCI format that does not support CBG-based PDSCH receptions, or the number of PDSCH receptions if *harq-ACK-SpatialBundlingPUCCH* is provided or SPS PDSCH release or TCI state update in PDSCH reception occasion for serving cell and the UE reports corresponding HARQ-ACK information in the PUCCH.  - if *enableTimeDomainHARQ-Bundling* is provided, is the number of enabled transport blocks in a DCI format scheduling a PDSCH associated with PDSCH reception occasion for serving cell if *harq-ACK-SpatialBundlingPUCCH* is not provided, or the number of DCI formats scheduling a PDSCH associated with PDSCH reception occasion for serving cell if *harq-ACK-SpatialBundlingPUCCH* is provided or SPS PDSCH release or TCI state update in PDSCH reception occasion for serving cell and the UE reports corresponding HARQ-ACK information in the PUCCH.  - is the number of CBGs the UE receives in a PDSCH reception occasion for serving cell if *PDSCH-CodeBlockGroupTransmission* is provided and the PDSCH reception is scheduled by a DCI format that supports CBG-based PDSCH receptions and the UE reports corresponding HARQ-ACK information in the PUCCH.  ---------------------------------------------------End TP2------------------------------------------------------- |
| [8] Samsung | Proposal 16: Adopt TP#6 in Appendix for TS38.213  ====================== Start of TP #6 for TS 38.213 ========================  9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel  ====================== Unchanged Text Omitted ==========================  If , the UE determines a number of HARQ-ACK information bits for obtaining a transmission power for a PUCCH, as described in clause 7.2.1, as where  - are all DL cells where the UE is configured to receive unicast or multicast PDSCHs  - is the cardinality for the union of all sets of occasions for unicast or multicast PDSCH receptions or SPS PDSCH releases for serving cell  - is the number of transport blocks the UE receives in PDSCH reception occasion for serving cell if *harq-ACK-SpatialBundlingPUCCH* and *PDSCH-CodeBlockGroupTransmission* are not provided, or the number of transport blocks the UE receives in PDSCH reception occasion for serving cell if *PDSCH-CodeBlockGroupTransmission* is provided and the PDSCH reception is scheduled by a DCI format that does not support CBG-based PDSCH receptions, or the number of PDSCH receptions if *harq-ACK-SpatialBundlingPUCCH* is provided or SPS PDSCH release or TCI state update in PDSCH reception occasion for serving cell and the UE reports corresponding HARQ-ACK information in the PUCCH.  - if *enableTimeDomainHARQ-Bundling* is provided for a serving cell , for a DCI format indicating a TDRA row that includes more than one SLIV entry on the serving cell c, a PDSCH associated with the last SLIV is considered as received, a PDSCH other than the PDSCH associated with the last SLIV is considered as not received  - is the number of CBGs the UE receives in a PDSCH reception occasion for serving cell if *PDSCH-CodeBlockGroupTransmission* is provided and the PDSCH reception is scheduled by a DCI format that supports CBG-based PDSCH receptions and the UE reports corresponding HARQ-ACK information in the PUCCH.  ====================== End of TP #6 for TS 38.213 ========================= |
| [20] LG Electronics | Proposal #9: For type-1 and type-2 HARQ-ACK codebooks, consider multi-PDSCH scheduling and time domain bundling configuration to derive for PUCCH power control when UCI payload size is equal to or less than 11 bits. |
|  | |
| Company | Views for type-2 HARQ-ACK codebook |
| [4] vivo | Proposal 11: For multi-PDSCH scheduling and Type-2 codebook, consider the TP3 in TS38.213 for the calculation of . |
| [20] LG Electronics | Proposal #9: For type-1 and type-2 HARQ-ACK codebooks, consider multi-PDSCH scheduling and time domain bundling configuration to derive for PUCCH power control when UCI payload size is equal to or less than 11 bits. |

### Issue 3.1) How to calculate for PUCCH power control when UCI payload size is equal to or less than 11 bits

[Moderator’s note] Several companies (vivo, Samsung, and LG Electronics) brought up a new issue for PUCCH power control when UCI payload size is equal to or less than 11 bits. Although a few companies raised this issue, it is the moderator’s understanding that the current specification for calculation should be corrected considering at least the followings:

* Type-1 HARQ-ACK codebook: For a serving cell *c* configured with time domain bundling, whether the PDSCH received in PDSCH reception occasion *m* is associated with the last SLIV or not
* Type-2 HARQ-ACK codebook: Whether a serving cell *c* is configured with time domain bundling or not, and whether two sub-codebooks are generated or not

Companies are encouraged to provide views on above moderator’s note. Once we reach a consensus on the necessity of this issue, we can focus on how to figure it out.

|  |  |
| --- | --- |
| Company | Views |
|  |  |
|  |  |

## Time domain bundling

|  |  |
| --- | --- |
| Company | Views for type-1 HARQ-ACK codebook |
| [2] Huawei | Proposal 3: There is no need to further restrict on last SLIV of multi PDSCH scheduling when *enableTimeDomainHARQ-Bundling* is configured for type-1 HARQ codebook. |
| [4] vivo | Proposal 7: For multi-PDSCH scheduling, when configured with Type-1 codebook and time domain bundling is enabled, UE does not expect more than one TDRA rows mapped to a same candidate PDSCH reception occasion is actually scheduled. |
| [5] Fujitsu | Proposal 1: When time domain bundling for Type-1 HARQ-ACK codebook is enabled, it is unnecessary to introduce the restriction that UE does not expect the last scheduled SLIV overlaps with a semi-static UL symbol. |
| [7] Nokia | Proposal 2: Last scheduled SLIV can overlap with a semi-static UL symbol also when parameter *enableTimeDomain-HARQ-Bundling* is configured. |
| [9] NTT DOCOMO | Proposal 6: The restriction “UE does not expect the last scheduled SLIV overlaps with a semi-static UL symbol when parameter *enableTimeDomainHARQ-Bundling* is configured” is not needed. |
| [10] ZTE | Proposal 3: In order not to introduce scheduling flexibility restrictions, the pruning procedure can be optimized when time domain bundling for Type 1 HARQ-ACK codebook is enabled.   * The last configured invalid SLIV can be remove from the set of SLIVs used to determine the set of candidate PDSCH reception occasion and each of the removed last configured invalid SLIV corresponds one candidate PDSCH reception occasion. * After removing the last configured invalid SLIV, pruning procedure of Rel-16 can be reused to determine the remaining candidate PDSCH reception occasion. |
| [13] OPPO | Proposal 3: Remove the last bullet in the agreement, i.e., “FFS: UE does not expect the last scheduled SLIV overlaps with a semi-static UL symbol when parameter *enableTimeDomainHARQ-Bundling* is configured.” |
| [14] Intel | Proposal 6: If time bundling is configured,   * For Type1 HARQ-ACK codebook, it is allowed that the last scheduled SLIV overlaps with a semi-static UL symbol. * For Type2 HARQ-ACK codebook, the bundling groups are allocated based on the configured SLIVs of the indicated TDRA row. * Agree on the TP 3 to handle the HARQ-ACK bundling when Type-2 HARQ-ACK codebook is configured. |
| [15] Ericsson | Proposal 6 Remove the entire FFS bullet in the agreement for Type-1 HARQ-ACK codebook enhancement for multi-PDSCH scheduling with a single DCI. |
| [16] Apple | Proposal 5: The following FFS is not needed in the agreement in RAN1 #107-e: UE does not expect the last scheduled SLIV overlaps with a semi-static UL symbol when parameter *enableTimeDomainHARQ-Bundling* is configured. |
|  | |
| Company | Views for type-2 HARQ-ACK codebook |
| [2] Huawei | Proposal 4: Support to allocate PDSCHs corresponding to configured SLIVs in a TDRA row index indicated by multi-PDSCH scheduling DCI to the bundling groups. |
| [4] vivo | Proposal 10: For multi-PDSCH scheduling, when configured with Type-2 codebook and time domain bundling is enabled, division of bundling groups is based on valid SLIVs of the indicated TDRA row index. |
| [7] Nokia | Proposal 4: In HARQ-ACK time domain bundling for type-2 codebook, allocation of PDSCHs corresponding to the configured SLIVs in a TDRA row indicated by the scheduling DCI to the transport block groups is slightly preferred. |
| [8] Samsung | Proposal 17: Support to use valid PDSCH-based grouping for Type-2 HARQ-ACK CB with time-domain bundling |
| [12] Qualcomm | Proposal 3: For generating type-2 HARQ-ACK codebook, the formation of the bundling groups should be based on the valid SLIVs  Proposal 4: 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. |
| [14] Intel | Proposal 6: If time bundling is configured,   * For Type1 HARQ-ACK codebook, it is allowed that the last scheduled SLIV overlaps with a semi-static UL symbol. * For Type2 HARQ-ACK codebook, the bundling groups are allocated based on the configured SLIVs of the indicated TDRA row. * Agree on the TP 3 to handle the HARQ-ACK bundling when Type-2 HARQ-ACK codebook is configured. |
| [15] Ericsson | Proposal 7 For configurable time domain bundling for Type-2 HARQ-ACK codebook, where the number of HARQ bundling groups is indicated by a RRC parameter, grouping of PDSCHs is based on valid SLIVs. |
| [16] Apple | Proposal 6: For multi-PDSCH scheduling with a single DCI and Type 2 HARQ-ACK codebook, bundling is based on the number of configured PDSCHs and not valid PDSCHs. |
| [18] NEC | Proposal 3: The PDSCHs corresponding to valid SLIVs in a TDRA row index indicated by multi-PDSCH scheduling DCI are allocated to the bundling groups |
| [19] MediaTek | Proposal 1: For Type-2 codebook construction with bundling groups, the PDSCHs corresponding to configured SLIVs in a TDRA row index indicated by multi-PDSCH scheduling DCI are allocated to the bundling groups by reusing CBG grouping method. |
| [20] LG Electronics | Proposal #10: The PDSCHs corresponding to “configured” SLIVs in a TDRA row index indicated by multi-PDSCH scheduling DCI are allocated to the bundling groups. |
|  | |
| Company | Views for type-3 HARQ-ACK codebook |
| [14] Intel | Proposal 8  Time domain bundling can be applied to Type-3 HARQ-ACK codebook.   * HARQ-ACK bits of two or more consecutive HARQ processes that are scheduled by the same DCI can be bundled. |

### Issue 3.2-1) Remaining issue on type-1 HARQ-ACK codebook with time domain bundling

Company views on remaining issue of type-1 HARQ-ACK codebook with time domain bundling:

**Agreement** (RAN1#107-e)

For multi-PDSCH scheduling with a single DCI

* Introduce a new RRC parameter, e.g., *enableTimeDomainHARQ-Bundling*, to enable time domain bundling operation for type-1 HARQ-ACK codebook per serving cell.
  + If the RRC parameter enables time domain bundling operation,
    - To determine the set of candidate PDSCH reception occasions,
      * A row index is removed if at least one symbol of every PDSCH associated with the row index is configured as semi-static UL. (NOTE: This is similar to the case of slot aggregated PDSCH in Rel-16)
      * Pruning procedure in Rel-16 is performed based on the last configured SLIV of each row index.
    - Logical AND operation is applied across all valid PDSCHs associated with a determined candidate PDSCH reception occasion, at least for 1-TB case.
    - FFS: UE does not expect the last scheduled SLIV overlaps with a semi-static UL symbol when parameter *enableTimeDomainHARQ-Bundling* is configured
* Remove the entire bullet “FFS: UE does not expect the last scheduled SLIV overlaps with a semi-static UL symbol when parameter *enableTimeDomainHARQ-Bundling* is configured” in the above previous agreement
  + Supported by Huawei, vivo, Fujitsu, Nokia, NTT DOCOMO, OPPO, Intel, Ericsson, Apple

Based on the large number of supports to remove the whole FFS bullet in previous agreement, the following proposal can be made.

### Proposal #3.2-1 (Time domain bundling for type-1 codebook):

* Update the previous agreement made in RAN1#107-e, as follows:

**Agreement** (RAN1#107-e)

For multi-PDSCH scheduling with a single DCI

* Introduce a new RRC parameter, e.g., *enableTimeDomainHARQ-Bundling*, to enable time domain bundling operation for type-1 HARQ-ACK codebook per serving cell.
  + If the RRC parameter enables time domain bundling operation,
    - To determine the set of candidate PDSCH reception occasions,
      * A row index is removed if at least one symbol of every PDSCH associated with the row index is configured as semi-static UL. (NOTE: This is similar to the case of slot aggregated PDSCH in Rel-16)
      * Pruning procedure in Rel-16 is performed based on the last configured SLIV of each row index.
    - Logical AND operation is applied across all valid PDSCHs associated with a determined candidate PDSCH reception occasion, at least for 1-TB case.
    - ~~FFS: UE does not expect the last scheduled SLIV overlaps with a semi-static UL symbol when parameter~~ *~~enableTimeDomainHARQ-Bundling~~* ~~is configured~~

Companies are encouraged to provide views on Proposal #3.2-1.

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| --- | --- |
| Company | Views |
| Xiaomi | Agree with the proposal |
|  |  |

### Issue 3.2-2) Remaining issue on type-2 HARQ-ACK codebook with time domain bundling

**Agreement** (RAN1#107-e)

For multi-PDSCH scheduling with a single DCI

* Introduce a new RRC parameter, e.g., *numberOfHARQ-BundlingGroups*, to configure the number of HARQ bundling groups with value range {1, 2, 4} for type-2 HARQ-ACK codebook per serving cell.
  + If the RRC parameter is not configured for a serving cell, time domain bundling for type-2 HARQ-ACK codebook is not enabled for the serving cell.
  + The maximum number of PDSCHs allocated to each bundling group is ceil(NPDSCH,MAX/NHBG) where NHBG is the number of bundling groups configured by *numberOfHARQ-BundlingGroups* for a serving cell and NPDSCH,MAX is the maximum configured number of PDSCHs for the serving cell.
  + The PDSCHs corresponding to [configured or valid] SLIVs in a TDRA row index indicated by multi-PDSCH scheduling DCI are allocated to the bundling groups, e.g., if NHBG =4, NPDSCH,MAX =8, and 5 PDSCHs are scheduled, then 2/1/1/1 PDSCHs are assigned to each group, by reusing CBG grouping method.
    - For a group that is empty or is filled with only invalid PDSCH(s), HARQ-ACK bits for the bundling group is set to NACK (same principle as when no time bundling configured)
    - Logical AND operation is applied to across all valid PDSCHs within the same bundling group to generate 1 HARQ-ACK bit per group, at least for 1-TB case
  + If the number of HARQ bundling groups is configured as 1 for a serving cell, HARQ-ACK bits corresponding to any DCI for the serving cell belong to the first sub-codebook.
  + At least for 1-TB case, if the number of HARQ bundling groups is configured as larger than 1 for a serving cell, HARQ-ACK bits corresponding to multi-PDSCH scheduling case (which implies a multi-PDSCH DCI schedules more than one PDSCH) for the serving cell belong to the second sub-codebook,
    - Where the number of HARQ-ACK bits corresponding to a multi-PDSCH DCI is determined based on the maximum of Q value across all serving cells within the same PUCCH cell group, and Q=maximum configured number of PDSCHs for a cell without *numberOfHARQ-BundlingGroups* configured or Q=number of configured HARQ bundling groups for a cell with *numberOfHARQ-BundlingGroups* configured

Company views on between configured and valid in the above agreement:

* Construction of bundling group based on “configured” SLIVs
  + Supported by Huawei, Nokia, Intel, Apple, MediaTek, LG Electronics
* Construction of bundling group based on “valid” SLIVs
  + Supported by vivo, Samsung, Qualcomm, Ericsson, NEC

[Moderator’s note] The following points can be observed from Moderator’s point of view:

* “Based on **configured** SLIVs” is supported by 6 companies while “Based on **valid** SLIVs” is supported by 5 companies
* Proponents of “Based on **configured** SLIVs” prefer the common rule with HARQ-ACK bit ordering (which is also based on configured SLIV position) for simple UE implementation.
* Proponents of “Based on **valid** SLIVs” point out that it takes advantage of reducing the number of unnecessary retransmissions.

Given diverged view between two options, it is encouraged for companies to provide views on the above options, if any.

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| --- | --- |
| Company | Views |
| Xiaomi | Prefer “Based on **configured** SLIVs”. And can go with majority |
|  |  |

## Remaining issues of Type-2 (dynamic) HARQ-ACK codebook

|  |  |
| --- | --- |
| Company | Views |
| [4] vivo | Proposal 12: For multi-PDSCH scheduling and Type-2 codebook, consider the TP4 in TS38.213 for the case when spatial bundling is configured. |
| [8] Samsung | Observation 3: Including HARQ-ACK bits for 2 PDSCHs scheduled by a DCI in the first HARQ-ACK sub-codebook complicates the specification with marginal gain.  Proposal 19: when a UE supports UE capability type2-HARQ-ACK-Codebook (FG 18-9), and there are >1 DCIs belonging to the same MOs and scheduling PDSCHs to the same serving cell. And these DCIs are configured to be able to schedule multiple PDSCHs. The counting procedure for the PDSCHs scheduled by these DCIs are:   * PDSCHs are separated into different sets and each set of PDSCHs are scheduled by the same DCI. PDSCHs are counted separately for different sets. * The counting order between different sets of PDSCHs are based on the reception time of the first PDSCH in each set. |
| [9] NTT DOCOMO | Proposal 5: If multiple PDSCHs are scheduled by single DCI, and there is at least one PDSCH collides with semi-static UL symbol,   * OoO scheduling limitation is based on valid PDSCHs. * If CBG based transmission is configured, CBGTI/CBGFI fields are present in DCI for the case when multiple PDSCHs are scheduled but only one PDSCH is valid. * DCI scheduling multiple PDSCHs but with only one valid PDSCH is included in the first sub-codebook. * When timeline is satisfied, the SPS PDSCH overlapping with the cancelled DG PDSCH can be received. |
| [12] Qualcomm | Proposal 5: If all PDSCHs scheduled by a DCI that schedules multi-PDSCHs (TDRA row has multiple SLIVs) except one PDSCH will not be transmitted due to overlap with semi-static UL symbols, then A/N bit of the valid PDSCH will be carried in the codebook of fallback and single-PDSCH grants. |
| [13] OPPO | Proposal 4: Spatial domain bundling operation should be applied before time domain bundling operation for 2-TB case.  Proposal 5: HARQ-ACK bits corresponding to multi-PDSCH belong to the second sub-codebook only if the number of HARQ bundling groups is configured as larger than 2 for 2-TB case. |
| [14] Intel | Proposal 7: In HARQ-ACK codebook generation,   * Spatial bundling and time bundling can be independently configured and enabled/disabled in HARQ-ACK transmission. * The agreement on Type-2 HARQ-ACK codebook generation with single TB per PDSCH applies per TB for a serving cell configured with two TBs per PDSCH. * Agree on the TP 4 to generate the Type-2 HARQ-ACK codebook depending on the configuration of spatial bundling. |
| [18] NEC | Proposal 1:   * Handling of spatial bundling is an open question to be discussed for multiple-PDSCH transmission. * Only one function is applied for *harq-ACK-SpatialBundling* and *enableTimeDomainHARQ-Bundling*. |
| [20] LG Electronics | Proposal #11: If a UE is provided with *numberOfHARQ-BundlingGroups*, the UE can be also configured with *harq-ACK-SpatialBundlingPUCCH* or *harq-ACK-SpatialBundlingPUSCH*. |

### Issue 3-4) Remaining issues of Type-2 (dynamic) HARQ-ACK codebook

Company views on remaining issues of Type-2 (dynamic) HARQ-ACK codebook:

* Issue 1: Allow separate configuration of spatial bundling from time domain bundling configuration
  + Supported by vivo, Intel, LG Electronics
  + Objected by NEC, OPPO?
* Issue 2: Include HARQ-ACK bits for 2 PDSCHs scheduled by a DCI in the first HARQ-ACK sub-codebook
  + Supported by NTT DOCOMO, Qualcomm
  + Objected by Samsung

[Moderator’s note] Issue 2 had been discussed in previous meetings but majority view was that previous agreement was clear enough to contain HARQ-ACK bits for 2 PDSCHs into the second HARQ-ACK sub-codebook. So, it is proposed to deprioritize Issue 2 in Rel-17.

On the other hand, for Issue 1, RAN1 decision seems necessary. It is observed that current specification already supports separate configuration of time domain bundling and spatial bundling for type-1 HARQ-ACK codebook. Thus, similar to type-1 HARQ-ACK codebook design and considering time domain bundling and spatial bundling can provide two independent functionalities, the following proposal can be made.

### Proposal #3.4 (Spatial bundling):

* For multi-PDSCH scheduling with a single DCI and for type-2 HARQ-ACK codebook generation,
  + Time domain bundling and spatial bundling can be independently configured.

Companies are encouraged to provide views on Proposal #3.4.

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| Company | Views |
| Xiaomi | Agree with proposal. |
|  |  |

## HARQ process

|  |  |
| --- | --- |
| Company | Views |
| [1] Futurwei | Observation 1. Though introduction of 32 HARQ processes with UE capability does not hurt, it is recommended that more discussion on whether ‘uniform design’ alone is a strong enough reason to spend effort on introducing such feature, even if it is subject to UE capability. |
| [2] Huawei | Proposal 2: Support 32 as the maximum number of HARQ processes for DL and UL for 120 kHz SCS, subject to UE capability. |
| [8] Samsung | Observation 4. *nrofHARQ-ProcessesForPDSCH* (or *nrofHARQ-ProcessesForPUSCH*) are applied to all UE’s DL BWPs (or UL BWPs) of a serving cell  Proposal 21: If *nrofHARQ-ProcessesForPDSCH* (or *nrofHARQ-ProcessesForPUSCH*) is configured for a cell, RAN1 decides one of two options:  Option 1.   * For a DL BWP (or UL BWP) with in a cell, the number of HARQ processes the UE may assume is 16 if the value of *nrofHARQ-ProcessesForPDSCH (*or *nrofHARQ-ProcessesForPUSCH)* is larger than 16. * For a DL BWP (or UL BWP) with or in a cell, the number of HARQ processes the UE may assume is provided *nrofHARQ-ProcessesForPDSCH (*or *nrofHARQ-ProcessesForPUSCH)*.   Option 2.   * For all DL BWPs (or UL BWPs) in a cell, the number of HARQ processes the UE may assume is provided *nrofHARQ-ProcessesForPDSCH (*or *nrofHARQ-ProcessesForPUSCH)*   Proposal 22: If option 1 is supported, adopt TP#9 in Appendix for TS38.214. If option 2 is supported, adopt TP#10 in Appendix for TS38.214  Proposal 23: When (enhanced) Type-3 HARQ-ACK is generated, the number of HARQ processes is determined by the number of HARQ processes configured in the active BWP of a serving cell. |
| [11] Panasonic | Proposal 6: For NR FR2-2 for 120 kHz SCS (in addition to 480/960 kHz), support 32 as the maximum number of HARQ processes for DL and UL, subject to UE capability. |
| [12] Qualcomm | Proposal 1: In case of BWP switching between SCS 120kHz, and 480/960kHz and when different numbers of HARQ processes are configured, consider one of the following options:   * Option 1: No retransmission can be allowed over different SCSs. * Option 2: No soft combining is assumed between retransmissions over different SCSs.   Proposal 2: To define different numbers of HARQ processes for 480/960kHz SCS and 120kHz SCS, consider one of the following options:   * Option 1: Reuse the same parameter in PDSCH-ServingCellConfig and add more values, e.g., 24 and 32.   + If UE is configured with more than 16 HARQs and the operating SCS is 120kHz or less, it will assume that number of HARQ processes is 16. * Option 2: Introduce new parameter(s) for SCSs 480kHz/960kHz. |
| [14] Intel | Proposal 10   * Up to 32 HARQ processes can be configured for SCS 120kHz. * The same configured number of HARQ processes applies to all possible SCSs for a FR2-2 cell. * No TP is needed since same number of HARQ processes for BWPs with different numerologies can be configured. |
| [15] Ericsson | Proposal 8 For Type-1 and Type-2 HARQ-ACK codebook generation for multi-PDSCH scheduling, if time domain HARQ bundling is not configured, the UE should report NACK for the feedback-disabled HARQ processes regardless of the decoding results of the corresponding PDSCHs.  Proposal 9 For Type-1 and Type-2 HARQ-ACK codebook generation for multi-PDSCH scheduling, if time domain HARQ bundling is configured,   * For a group with only feedback-disabled PDSCH(s), HARQ-ACK bits for the bundling group is set to NACK * Logical AND operation is applied across all valid feedback-enabled PDSCHs within the same bundling group, if any, to generate 1 HARQ-ACK bit per group   Note: For Type-1 HARQ-ACK codebook, all PDSCHs scheduled by a DCI belong to a single bundling group.  Proposal 10 For Type-2 HARQ-ACK codebook, the DAI counters in a DCI that schedule multiple PDSCHs still need to be incremented if any of the PDSCHs scheduled by the DCI are not feedback-disabled.  Proposal 11 For Type-2 HARQ-ACK codebook generation for multi-PDSCH scheduling, if all PDSCHs scheduled by a DCI are feedback-disabled, HARQ-ACK feedback for the scheduling should be skipped, regardless of whether time domain bundling is configured or not. |
| [20] LG Electronics | Proposal #12: For 120 kHz SCS (in addition to 480/960 kHz), support 32 as the maximum number of HARQ processes for DL and UL, subject to UE capability. |

### Issue 3-5-1) Increased maximum number of HARQ processes for 120 kHz SCS

Agreement: (RAN1#106bis-e)

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

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

Company views on supporting 32 as the maximum number of HARQ processes for 120 kHz SCS:

* Supported by Huawei, Panasonic, Intel, LG Electronics
* Objected by Samsung, Qualcomm

If 32 maximum HARQ processes are not supported for 120 kHz SCS, at least the following issues seems to be resolved, in case a BWP in a serving cell is configured with 120 kHz SCS and another BWP in the serving cell is configured with 480/960 kHz SCS:

* Issue 1: Whether the number of HARQ processes is configured per cell (as in Rel-16) or per BWP/SCS
* Issue 2: Whether to perform data soft combining after BWP switching
* Issue 3: The number of HARQ processes for the serving cell to generate type-3 HARQ-ACK codebook

[Moderator’s note] In order not to create new issues in maintenance phase, and considering a UE capable of 32 HARQ processes for 480/960 kHz SCS would be capable of 32 HARQ processes for 120 kHz SCS as well in FR2-2, it is proposed to support 32 as the maximum number of HARQ processes for 120 kHz SCS. This proposal is indicated as “HIGH” since it might have an impact on RRC parameter.

### [HIGH] Proposal #3.5-1 (HARQ process):

* For NR FR2-2 for 120 kHz SCS (in addition to 480/960 kHz), support 32 as the maximum number of HARQ processes for DL and UL, subject to UE capability.

Companies are encouraged to provide views on Proposal #3.5-1.

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| Company | Views |
| Xiaomi | Agree with the proposal. |
|  |  |

### Issue 3-5-2) Whether to combine HARQ-disabling feature introduced in Rel-17 NTN with multi-PDSCH scheduling

[Moderator’s note] Ericsson brought up several issues when HARQ-disabling feature introduced in Rel-17 is also applicable to the serving cell configured with multi-PDSCH scheduling. From the moderator’s perspective, it should be first discussed whether this combination can be allowed or not. In that sense, it is encouraged for companies to provide views on this issue, if any.

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| Company | Views |
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## Other issues

|  |  |
| --- | --- |
| Company | Views |
| [14] Intel | Proposal 9   * For Type-1 HARQ-ACK codebook, if time bundling is not configured, a PDSCH can be scheduled by DCI format 1\_0 if the indicated K1 belongs to the intersection of the extended set of K1 values for DCI format 1\_1/1\_2 and the predefined set of K1 values for DCI format 1\_0. * Agree on the TP 5 to determine the allowed K1 values for DCI format 1\_0 |
| [16] Apple | Proposal 7: RAN1 should support a single HARQ-ACK feedback for multi-PDSCH transmissions within a single COT only.  Proposal 8: In the case of BWP switching during multi-PxSCH transmission 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. |
| [17] Xiaomi | Proposal 2: For multi-slot PDSCH scheduling, the PDSCH(s) exceeding the COT are regarded as valid PDSCH(s) and the HARQ process is/are still reserved for those PDSCH(s).  Proposal 3: For multi-slot PDSCH scheduling, the HARQ-ACK PUCCH resource for the scheduled multi-slot PDSCH is determined by the last PDSCH among the multiple PDSCHs scheduled by a single DCI, even if the last PDSCH exceeds the COT. |
| [19] MediaTek | Proposal 2: The UCI information bits including HARQ-ACK information bits should reuse the existing PUCCH payload size limit 1706. |

### Summary on other aspects for HARQ operation:

The following issues are brought up by several companies:

* Intel: To apply extended K1 set values also to DCI format 1\_0.
* Xiaomi and Apple: Relationship between HARQ-ACK transmission and COT
* Apple: Clarification on BWP switching during multi-PDSCH reception (or multi-PUSCH transmission)
* MediaTek: Reuse the existing PUCCH payload size limit 1706.

[Moderator’s note] Please feel free to express views on above issues, if any.

|  |  |
| --- | --- |
| Company | Views |
| Xiaomi | Multi-PDSCH scheduling exceeding COT should be considered |
|  |  |

# TPs

## TP#A (was TP#1 from [4] vivo)

--------------------------------------------Start of TP#A for TS 38.213 Clause 9.1.2.1 ------------------------------------------------

If a UE is not provided *ca-SlotOffset* for any serving cell of PDSCH receptions and for the serving cell of corresponding PUCCH transmission with HARQ-ACK information

while

if or *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook

Set – index of a DL slot overlapping with an UL slot

Set to a number of DL slots overlapping with UL slot if *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook; otherwise,

while

……

if slot starts at a same time as or after a slot for an active DL BWP change on serving cell or an active UL BWP change on the PCell and slot is before the slot for the active DL BWP change on serving cell or the active UL BWP change on the PCell, or *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook and slot overlaps with UL slot , , where is a DL slot with a smallest index among DL slots overlapping with UL slot ,

;

else

while

if the UE is not provided *enableTimeDomainHARQ-Bundling* and is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot to slot , at least one symbol of the PDSCH time resource derived by row is configured as ULwhere is the *k*-th slot timing value in set , where is a DL slot with a smallest index among DL slots overlapping with UL slot , or *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook and the end of the PDSCH time resource for row is not within any UL slot , or if HARQ-ACK information for PDSCH time resource derived by row in slot cannot be provided in slot

;

elseif the UE is provided *enableTimeDomainHARQ-Bundling* and *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot , at least one symbol of each of the one or more PDSCH time resources derived by row of set is configured as UL, where = 0,1,…,, , and is the cardinality of .

;

;

else

;

end if

end while

……

;

end if

end while

end if

;

end while

else

……

end if

------------------------------------------------------------End of TP#A----------------------------------------------------------------

[Moderator’s note] TP#A is to consider the case when more than one PDSCH time resource can be configured within one DL slot based on a TDRA row for 120 kHz SCS.

Companies are encouraged to provide views on TP#A. It is noted that if it is agreeable, the same change is also needed for the case when UE is provided with ca-offset.

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| Company | Views |
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## TP#B (was from [7] Nokia)

--------------------------------------------Start of TP#B for TS 38.213 Clause 9.1.2.1 ------------------------------------------------

9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel

For a serving cell , an active DL BWP, and an active UL BWP, as described in clause 12, the UE determines a set of occasions for candidate PDSCH receptions for which the UE can transmit corresponding HARQ-ACK information in a PUCCH in slot . If serving cell is deactivated, the UE uses as the active DL BWP for determining the set of occasions for candidate PDSCH receptions a DL BWP provided by *firstActiveDownlinkBWP-Id*. The determination is based:

a) on a set of slot timing values associated with the active UL BWP

- If the UE is configured to monitor PDCCH for DCI format 1\_0 and is not configured to monitor PDCCH for either DCI format 1\_1 or DCI format 1\_2 for serving cell , is provided by the slot timing values {1, 2, 3, 4, 5, 6, 7, 8} for SCS configuration of PUCCH transmission , {7, 8, 12, 16, 20, 24, 28, 32} for , and {13, 16, 24, 32, 40, 48, 56, 64} for .

- If the UE is configured to monitor PDCCH for DCI format 1\_1 and is not configured to monitor PDCCH for DCI format 1\_2 for serving cell , is provided by *dl-DataToUL-ACK*

- If the UE is configured to monitor PDCCH for DCI format 1\_2 and is not configured to monitor PDCCH for DCI format 1\_1 for serving cell , is provided by *dl-DataToUL-ACK-DCI-1-2*

- If the UE is configured to monitor PDCCH for DCI format 1\_1 and DCI format 1\_2 for serving cell , is provided by the union of *dl-DataToUL-ACK* and *dl-DataToUL-ACK-DCI-1-2*

- If the UE is configured to monitor PDCCH for multicast DCI formats for serving cell

- if the UE is not provided *type1-Codebook-Generation-Mode =* 'mode1', is additionally provided by the union of *dl-DataToUL-ACK-ForDCI Format4\_1*

- if the UE is not provided *dl-DataToUL-ACK-ForDCI Format4\_1*, is provided by the slot timing values {1, 2, 3, 4, 5, 6, 7, 8}

- if the UE is provided *type1-Codebook-Generation-Mode =* 'mode1', the UE

- determines a first set as , where is a set of slot timing values for the multicast DCI formats, a second set as , and a third set as

b) on a set of row indexes of a table that is associated with the active DL BWP and defining respective sets of slot offsets , start and length indicators *SLIV*, and PDSCH mapping types for PDSCH reception as described in [6, TS 38.214], where the row indexes of the table are provided by

- the union of row indexes of time domain resource allocation tables for DCI formats the UE is configured to monitor PDCCH for serving cell if the UE is not configured to monitor PDCCH for multicast DCI formats for serving cell , or is not provided *type1-Codebook-Generation-Mode =* 'mode1', or, if any, for the first set

- the union of row indexes of time domain resource allocation tables for DCI format 1\_0 and/or DCI format 1\_1 and/or DCI format 1\_2 for serving cell for the second set, if any

- the union of row indexes of time domain resource allocation tables for multicast DCI formats the UE is configured to monitor PDCCH for serving cell for the third set, if any

- if the UE is provided *referenceOfSLIVDCI-1-2*, for each row index with slot offset and PDSCH mapping Type B in a set of row indexes of a table for DCI format 1\_2 [6, TS 38.214], for any PDCCH monitoring occasion in any slot where the UE monitors PDCCH for DCI format 1\_2 and with starting symbol , if for normal cyclic prefix and for extended cyclic prefix, add a new row index in the set of row indexes of the table by replacing the starting symbol of the row index by

c) on the ratio between the downlink SCS configuration and the uplink SCS configuration provided by *subcarrierSpacing* in *BWP-Downlink* and *BWP-Uplink* for the active DL BWP and the active UL BWP, respectively

d) if provided, on *tdd-UL-DL-ConfigurationCommon* and *tdd-UL-DL-ConfigurationDedicated* as described in clause 11.1

e) if *ca-SlotOffset* is provided, on and provided by *ca-SlotOffset* for serving cell , or on and provided by *ca-SlotOffset* for the primary cell, as described in [4, TS 38.211].

If a UE

- is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with a value of 0 for first CORESETs on active DL BWPs of serving cells, and

- is provided *coresetPoolIndex* with a value of 1 for second CORESETs on active DL BWPs of the serving cells, and

- is provided *ackNackFeedbackMode* = *joint*

where

- a serving cell is placed in a first set of serving cells if the serving cell includes a first CORESET, and

- a serving cell is placed in a second set of serving cells if the serving cell includes a second CORESET, and

- serving cells are placed in a set according to an ascending order of a serving cell index

the UE generates a Type-1 HARQ-ACK codebook for the set and the set of serving cells separately by setting and in the following pseudo-code. The UE concatenates the HARQ-ACK codebook generated for the set followed by the HARQ-ACK codebook generated for the set to obtain a total number of HARQ-ACK information bits.

If a UE is provided *fdmed-Reception-Multicast* and the UE is configured to monitor PDCCH for detection of unicast DCI formats and to monitor PDCCH for detection of multicast DCI formats

- a serving cell is placed in a first set of serving cells if the UE is configured to monitor PDCCH for DCI formats 1\_0/1\_1/1\_2 for scheduling on serving cell , and

- a serving cell is placed in a second set of serving cells if the UE is configured to monitor PDCCH for detection of DCI format 4\_1/4\_2 for scheduling on serving cell , and

- serving cells are placed in a set according to an ascending order of a serving cell index

the UE generates a Type-1 HARQ-ACK codebook for the set and the set of serving cells separately by setting and in the following pseudo-code. The UE concatenates the HARQ-ACK codebook generated for the set followed by the HARQ-ACK codebook generated for the set to obtain a total number of HARQ-ACK information bits.

If the UE is configured to monitor PDCCH for DCI formats with CRC scrambled by G-RNTI or G-CS-RNTI and is provided *type1-Codebook-Generation-Mode* ='mode1', the UE separately applies the following pseudo-code for each of the first set, the second set, and third set as the set of slot timing values , and for the corresponding sets of row indexes as to obtain first, second, and third Type-1 HARQ-ACK sub-codebooks, and concatenates the first, second, and third, Type-1 HARQ-ACK sub-codebooks to obtain the Type-1 HARQ-ACK codebook.

If *enableTimeDomainHARQ-Bundling* is provided

- set

- set to the set of rows that include the last SLIV of each row of set

------------------------------------------------------------End of TP#B----------------------------------------------------------------

[Moderator’s note] TP#B is to clarify the definition of as “set of rows that include the last SLIV of each row of set ”.

Companies are encouraged to provide views on TP#B.

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| Company | Views |
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## TP#C (was TP#2 from [8] Samsung)

---------------------------------------------Start TP#C for TS 38.214 Clause 5.1.2.1.1 ------------------------------------------------

Table 5.1.2.1.1-1: Applicable PDSCH time domain resource allocation for DCI formats 1\_0, 1\_1, 4\_0, 4\_1 and 4\_2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| RNTI | PDCCH search space | SS/PBCH block and CORESET multiplexing pattern | *PDSCH-ConfigCommon* includes *pdsch-TimeDomainAllocationList* | *PDSCH-Config* includes *pdsch-TimeDomainAllocationList* | *PDSCH-Config-MCCH* includes *pdsch-TimeDomainAllocationList or PDSCH-Config-MTCH* includes *pdsch-TimeDomainAllocationList* or *pdsch-Config-Multicast* includes *pdsch-TimeDomainAllocationList* | *PDSCH-Config* includes *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* | PDSCH time domain resource allocation to apply |
| SI-RNTI | Type0 common | 1 | - | - | - | - | Default A for normal CP |
| 2 | - | - | - | - | Default B |
| 3 | - | - | - | - | Default C |
| SI-RNTI | Type0A common | 1 | No | - | - | - | Default A |
| 2 | No | - | - | - | Default B |
| 3 | No | - | - | - | Default C |
| 1,2,3 | Yes | - | *-* | - | *pdsch-TimeDomainAllocationList provided in PDSCH-ConfigCommon* |
| RA-RNTI, MSGB-RNTI, TC-RNTI | Type1 common | 1, 2, 3 | No | - | - | - | Default A |
| 1, 2, 3 | Yes | - | *-* | - | *pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon* |
| P-RNTI | Type2 common | 1 | No | - | - | - | Default A |
| 2 | No | - | - | - | Default B |
| 3 | No | - | - | - | Default C |
| 1,2,3 | Yes | - | *-* | - | *pdsch-TimeDomainAllocationList provided in PDSCH-ConfigCommon* |
| MCCH-RNTI | Type 0/0B common for broadcast | 1 | No | - | No | *-* | Default A |
| 2 | No | - | No | *-* | Default B |
| 3 | No | - | No | *-* | Default C |
| 1,2,3 | Yes | - | No | *-* | *pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon* |
| 1,2,3 | No/Yes | - | Yes | *-* | *pdsch-TimeDomainAllocationList provided in pdsch-Config-MCCH* |
| G-RNTI for broadcast | Type 0/0B common for broadcast | 1 | No | - | No | *-* | Default A |
| 2 | No | - | No | *-* | Default B |
| 3 | No | - | No | *-* | Default C |
| 1,2,3 | Yes | - | No | *-* | *pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon* |
| 1,2,3 | No/Yes | - | Yes | *-* | *TimeDomainAllocationList* provided in *PDSCH-Config-MCCH* |
| 1,2,3 | No/Yes | - | Yes | *-* | *pdsch-TimeDomainAllocationList* provided in *PDSCH-Config-MTCH* |
| C-RNTI, MCS-C-RNTI, CS-RNTI | Any common search space associated with CORESET 0 | 1, 2, 3 | No | - | - | - | Default A |
| 1, 2, 3 | Yes | - | - | *-* | *pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon* |
| C-RNTI, MCS-C-RNTI, CS-RNTI | Any common search space not associated with CORESET 0  UE specific search space | 1,2,3 | No | No | - | - | Default A |
| 1,2,3 | Yes | No | - | *-* | *pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon* |
| 1,2,3 | No/Yes | Yes | - | *-* | *pdsch-TimeDomainAllocationList* provided in *PDSCH-Config* |
| 1,2,3 | No/Yes | - | - | Yes | *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* provided in *PDSCH-Config (Note 2)* |
| G-RNTI, G-CS-RNTI (for multicast) | Type-X common search space for multiast | 1,2,3 | No | - | No | - | *Default A* |
| 1,2,3 | Yes | - | No | - | *pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon (Note 1)* |
| 1,2,3 | No/Yes | - | Yes | - | *pdsch-TimeDomainAllocationList* provided in *pdsch-Config-Multicast*  *(Note 1)* |
| Note 1: For a UE that supports multicast, the same TDRA table applies to all G-RNTIs (configured for multicast) if configured on a given serving cell.  Note 2: If *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* is provided, it is applicable to DCI format 1\_1 only. | | | | | | | |

------------------------------------------------------------End TP#C----------------------------------------------------------------

[Moderator’s note] TP#C is 1) to restore some rows which seem to be accidently lost in Rel-17 specification (compared to Rel-16 specification), and 2) to clarify that multi-PDSCH scheduling is not applicable to DCI format 1\_0 by adding a Note 2.

Companies are encouraged to provide views on TP#C.

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| Company | Views |
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## TP#D (was TP#3 from [8] Samsung)

-----------------------------------------------------Start of TP#D for TS 38.214 ---------------------------------------------------------

5.1.2.1 Resource allocation in time domain

=============================== Unchanged Text Omitted ===================================

If a UE is configured with *pdsch-TimeDomainAllocationListForMultiPDSCH-r17*, the UE does not expect to be configured with higher layer parameter *repetitionNumber* in *pdsch-TimeDomainAllocationListForMultiPDSCH-r17*.

If a UE is configured with *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* on a DL BWP of a serving cell, the UE does not apply *pdsch-AggregationFactor* in *PDSCH-config*, if configured, to DCI format 1\_1 on the DL BWP of the serving cell.

=============================== Unchanged Text Omitted ===================================

6.1.2.1 Resource allocation in time domain

If a UE is configured with *pusch-TimeDomainAllocationListForMultiPUSCH-r17* on a UL BWP of a serving cell, the UE does not apply *pusch-AggregationFactor,* if configured, to DCI format 0\_1 on the UL BWP of the serving cell and the UE does not expect to be configured with *numberOfRepetitions* in *pusch-TimeDomainAllocationListForMultiPUSCH-r17*.

------------------------------------------------------------End of TP#D----------------------------------------------------------------

[Moderator’s note] TP#D is mainly to remove “in which one of more rows contain multiple SLIVs for PDSCH (PUSCH)” which seems redundant.

Companies are encouraged to provide views on TP#D.

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| Company | Views |
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## TP#E (was TP#4 from [8] Samsung)

--------------------------------------------Start of TP#E for TS 38.213 Clause 9.1.2.1 ------------------------------------------------

9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel

=============================== Unchanged Text Omitted ===================================

while

if the UE is not provided *enableTimeDomainHARQ-Bundling* and is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot to slot , at least one symbol of the PDSCH time resource derived by row is configured as ULwhere is the *k*-th slot timing value in set , where is a DL slot with a smallest index among DL slots overlapping with UL slot , or *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook and the end of the PDSCH time resource for row is not within any UL slot , or if HARQ-ACK information for PDSCH time resource derived by row in slot cannot be provided in slot

;

elseif the UE is provided *enableTimeDomainHARQ-Bundling* and *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot , at least one symbol of the PDSCH time resource derived by row of set is configured as UL, where = 0,1,…,, , and is the cardinality of and for each slot from to slot , at least one symbol of the PDSCH time resource derived by row of set *R* is configured as UL

;

;

else

;

end if

end while

------------------------------------------------------------End of TP#E----------------------------------------------------------------

[Moderator’s note] As shown below excerpt from [8], TP#E is to allow the case when time domain bundling from DCI format 1\_1 and PDSCH repetition from DCI format 1\_2.

|  |  |
| --- | --- |
| If time domain bundling is not configured (see the green highlight below), PDSCH occasions are generated by taking into account multi-PDSCH scheduling and PDSCH repetition. Note that for multi-PDSCH scheduling, the row r of the set R contains single SLIVs decomposing multiple SLIVs in a TDRA table (i.e., SLIV decomposition) and for PDSCH repetition, the single SLIV is assumed to be repeated over slots. Therefore, some of rows associated with DCI format 1\_1 does not need to be repeated but all of rows are assumed to be repeated over slots, which make some overhead in type-1 HARQ-ACK CB. However, it can be acceptable since it does not bring any scheduling restrictions.  If time domain bundling is configured (see the yellow highlight below), PDSCH occasions are generated by taking into account multi-PDSCH scheduling only, but not PDSCH repetition. As a results, the type-1 HARQ-ACK CB with time domain bundling does not includes PDSCH occasions for PDSCH repetition. Therefore, gNB may not schedule PDSCH repetitions by using DCI format 1\_2.   |  | | --- | | while  if the UE is not provided *enableTimeDomainHARQ-Bundling* and is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot to slot , at least one symbol of the PDSCH time resource derived by row is configured as ULwhere is the *k*-th slot timing value in set , where is a DL slot with a smallest index among DL slots overlapping with UL slot , or *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook and the end of the PDSCH time resource for row is not within any UL slot , or if HARQ-ACK information for PDSCH time resource derived by row in slot cannot be provided in slot  ;  elseif the UE is provided *enableTimeDomainHARQ-Bundling* and *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot , at least one symbol of the PDSCH time resource derived by row of set is configured as UL, where = 0,1,…,, , and is the cardinality of .  ;  ;  else  ;  end if  end while |   **Observation 2: If time domain bundling is configured, Type-1 HARQ-ACK CB does not cover PDSCH repetitions scheduled by DCI format 1\_2.**  To address this issue, we suggest to consider the following two options.   * Option 1. A row *r* is removed when two conditions are met   + Condition 1 for multi-PDSCH scheduling: each SLIVs of the TDRA row *r* overlapped with a semi-static UL symbol   + Condition 2 for PDSCH repetition: the last SLIV of the TDRA row *r* over *K* slots overlapped with a semi-static UL symbol.     - Note that the last SLIV is used for PDSCH repetition since the TDRA row *r* may include more than one SLIVs. Note that this may result in some overhead because the TDRA rows only for multi-PDSCH scheduling are also used for PDSCH repetition. * Option 2. Treat it as an error case. i.e., a UE does not expect to be configured with multi-PDSCH scheduling with time domain bundling and *pdsch-AggregationFactor* at the same time.   Since type-1 HARQ-ACK CB is mainly used for a coverage limited scenario where a PDCCH scheduling PDSCH may be missed often, support of PDSCH repetitions scheduled by a DCI format 1\_2 would be beneficial. Therefore, we prefer to support that type-1 HARQ-ACK CB covers both multi-PDSCH scheduling and PDSCH repetition.  **Proposal 13: To support multi-PDSCH scheduling by DCI format 1\_1 and PDSCH repetition by DCI format 1\_2 in type-1 HARQ-ACK CB, a row *r* in the set *R’* and the set *R* is removed when the both conditions are met**   * + **Condition 1 for multi-PDSCH scheduling) each SLIVs of the TDRA row *r* overlapped with a semi-static UL symbol**   + **Condition 2 for PDSCH repetition) the last SLIV of the TDRA row *r* over *K* slots overlapped with a semi-static UL symbol.**   **Proposal 14: Adopt TP#4 in Appendix for TS38.213** |

Companies are encouraged to provide views on TP#E.

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| Company | Views |
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## TP#F (was TP#5 from [8] Samsung)

--------------------------------------------Start of TP#F for TS 38.213 Clause 9.1.2.1 ------------------------------------------------

9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel

=============================== Unchanged Text Omitted ===================================

while

if the UE is not provided *enableTimeDomainHARQ-Bundling* and is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot to slot , at least one symbol of the PDSCH time resource derived by row is configured as ULwhere is the *k*-th slot timing value in set , where is a DL slot with a smallest index among DL slots overlapping with UL slot , or *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook and the end of the PDSCH time resource for row is not within any UL slot , or if *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* is provided and HARQ-ACK information for PDSCH time resource derived by row in slot cannot be provided in slot

;

elseif the UE is provided *enableTimeDomainHARQ-Bundling* and *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot , at least one symbol of the PDSCH time resource derived by row of set is configured as UL, where = 0,1,…,, , and is the cardinality of .

;

;

else

;

end if

end while

------------------------------------------------------------End of TP#F----------------------------------------------------------------

[Moderator’s note] TP#F is to clarity that K1 set extension is only for the case when multi-PDSCH scheduling is configured.

Companies are encouraged to provide views on TP#F.

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| Company | Views |
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## TP#G (was TP#8 from [8] Samsung)

----------------------------------------------Start of TP#G for TS 38.214 Clause 6.1 --------------------------------------------------

6.1 UE procedure for transmitting the physical uplink shared channel

=============================== Unchanged Text Omitted ===================================

For uplink, 16 HARQ processes per cell are supported by the UE, or subject to UE capability, a maximum of 32 HARQ processes per cell for the cases of = 5 or = 6. The number of processes the UE may assume will at most be used for the uplink is configured to the UE for each cell separately by higher layer parameter *nrofHARQ-ProcessesForPUSCH*, and when no configuration is provided the UE may assume a default number of 16 processes.

------------------------------------------------------------End of TP#G----------------------------------------------------------------

[Moderator’s note] TP#G is to capture that the maximum number of HARQ processes for UL is configurable by *nrofHARQ-ProcessesForPUSCH* and its default value is 16.

Companies are encouraged to provide views on TP#G.

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| Company | Views |
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## TP#H (was TP#1 from [18] NEC)

------------------------------------------Start of TP#H for TS 38.212 Clause 7.3.1.2.2 ----------------------------------------------

7.3.1.2.2 Format 1\_1

=============================== Unchanged Text Omitted ===================================

- CBG transmission information (CBGTI) – 0 bit if higher layer parameter *codeBlockGroupTransmission* for PDSCH is not configured or if the number of scheduled PDSCH indicated by the Time domain resource assignment field is larger than 1; otherwise, 2, 4, 6, or 8 bits as defined in Clause 5.1.7 of [6, TS38.214], determined by the higher layer parameters *maxCodeBlockGroupsPerTransportBlock* and *maxNrofCodeWordsScheduledByDCI* for the PDSCH.

If higher layer parameter *priorityIndicatorDCI-1-1* is configured, if the bit width of the CBG transmission information in DCI format 1\_1 for one HARQ-ACK codebook is not equal to that of the CBG transmission information in DCI format 1\_1 for the other HARQ-ACK codebook, a number of most significant bits with value set to '0' are inserted to smaller CBG transmission information until the bit width of the CBG transmission information in DCI format 1\_1 for the two HARQ-ACK codebooks are the same.

- CBG flushing out information (CBGFI) – 1 bit if higher layer parameter *codeBlockGroupFlushIndicator* is configured as "TRUE" and if the number of scheduled PDSCH indicated by the Time domain resource assignment field is 1, 0 bit otherwise.

If higher layer parameter *priorityIndicatorDCI-1-1* is configured, if the bit width of the CBG flushing out information in DCI format 1\_1 for one HARQ-ACK codebook is not equal to that of the CBG flushing out information in DCI format 1\_1 for the other HARQ-ACK codebook, a number of most significant bits with value set to '0' are inserted to smaller CBG flushing out information until the bit width of the CBG flushing out information in DCI format 1\_1 for the two HARQ-ACK codebooks are the same.

------------------------------------------------------------End of TP#H----------------------------------------------------------------

[Moderator’s note] TP#H is to capture the previous agreement on configuration of CBG operation and multi-PDSCH scheduling.

Companies are encouraged to provide views on TP#H.

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| Company | Views |
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## TP#I (was from [21] ASUSTeK)

--------------------------------------------Start of TP#I for TS 38.214 Clause 6.1.2.1 ------------------------------------------------

6.1.2.1 Resource allocation in time domain

=============================== Unchanged Text Omitted ===================================

For PUSCH repetition Type A, when transmitting PUSCH scheduled by DCI format 0\_1 or 0\_2 in PDCCH with CRC scrambled with C-RNTI, MCS-C-RNTI, or CS-RNTI with NDI=1, the number of repetitions *K* is determined as

- if *numberOfRepetitions* is present in the resource allocation table, the number of repetitions K is equal to *numberOfRepetitions*;

- elseif the UE is configured with *pusch-AggregationFactor* and the transmitting PUSCH is scheduled by DCI format 0\_2, the number of repetitions *K* is equal to *pusch-AggregationFactor*;

- elseif the UE is configured with *pusch-AggregationFacto*r, (and the transmitting PUSCH is scheduled by DCI format 0\_1) and not configured with *pusch-TimeDomainAllocationListForMultiPUSCH-r17*, the number of repetitions *K* is equal to *puschAggregationFactor*;

- otherwise *K=1*.

- the number of slots used for TBS determination *N* is equal to 1.

For PUSCH repetition type A, when transmitting PUSCH scheduled by RAR UL grant, the 2 MSBs of the MCS information field of the RAR UL grant provide a codepoint to determine the number of repetitions *K* according to Table 6.1.2.1-1A, based on whether or not the higher layer parameter *numberOfMsg3Repetitions* is configured.

For PUSCH repetition type A, when transmitting PUSCH scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI, the 2 MSBs of the MCS information field of the DCI format 0\_0 with CRC scrambled by TC-RNTI provide a codepoint to determine the number of repetitions *K* according to Table 6.1.2.1-1A, based on whether or not the higher layer parameter *numberOfMsg3Repetitions* is configured.

------------------------------------------------------------End of TP#I----------------------------------------------------------------

[Moderator’s note] TP#I is to clarify that UE does not apply *pusch-AggregationFactor* to DCI format 0\_1 (can scheduling more than one PDSCH) and the number of repetitions *K* is 1.

Companies are encouraged to provide views on TP#I.

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| Company | Views |
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# Reference

1. R1-2200025 On several study points for PDSCH/PUSCH enhancements for Beyond 52.6GHz FUTUREWEI
2. R1-2200048 Remaining issues of PDSCH/PUSCH enhancement for 52-71GHz spectrum Huawei, HiSilicon
3. R1-2200064 Remaining issues for PDSCH/PUSCH enhancements to supporting 52.6-71 GHz band in NR InterDigital, Inc.
4. R1-2200078 Remaining issues on PDSCH/PUSCH enhancements for NR operation from 52.6GHz to 71GHz vivo
5. R1-2200124 Remaining issues of multi-PDSCH scheduling via a single DCI Fujitsu
6. R1-2200145 Remaining issues on PDSCH/PUSCH enhancements for up to 71GHz operation CATT
7. R1-2200187 PDSCH/PUSCH enhancements Nokia, Nokia Shanghai Bell
8. R1-2200196 Maintenance on PDSCH/PUSCH enhancements for NR from 52.6 GHz to 71 GHz Samsung
9. R1-2200230 Remaining issues on PDSCH/PUSCH enhancements for NR in FR2-2 NTT DOCOMO, INC.
10. R1-2200263 Remaining issues on the data channel enhancements for 52.6 to 71GHz ZTE, Sanechips
11. R1-2200267 Discussion on PDSCH/PUSCH enhancements for NR 52.6-71 GHz Panasonic Corporation
12. R1-2200292 PDSCH/PUSCH enhancements for NR in 52.6 to 71GHz band Qualcomm Incorporated
13. R1-2200328 Discussion on remaining issue for PDSCH/PUSCH enhancements OPPO
14. R1-2200370 Discussion on PDSCH/PUSCH enhancements for extending NR up to 71 GHz Intel Corporation
15. R1-2200405 PDSCH-PUSCH Enhancements Ericsson
16. R1-2200412 On remaining issues for PDSCH/PUSCH Enhancements Apple
17. R1-2200461 Remaining issues on PDSCH and PUSCH enhancements for NR 52.6-71GHz xiaomi
18. R1-2200508 Remaining issues on PDSCH/PUSCH enhancement for NR operation from 52.6GHz to 71GHz NEC
19. R1-2200542 Remaining discussion on multi-PDSCH scheduling design for 52.6-71 GHz NR operation MediaTek Inc.
20. R1-2200568 PDSCH/PUSCH enhancements to support NR above 52.6 GHz LG Electronics
21. R1-2200631 Discussion on multi-PUSCH scheduling ASUSTeK
22. R1-2200632 Remaining issues on PDSCH/PUSCH enhancement for NR from 52.6GHz to 71GHz WILUS Inc.

# Appendix: Previous agreements

### RAN1#104-e

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.

Agreement:

* 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:

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:

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:

* 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.

### RAN1#104bis-e

Agreement:

* 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:

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:

* 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:

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:

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:

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:

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

### RAN1#105-e

Agreement:

* 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:

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:

* 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:

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:

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:

* 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:

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:

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

### RAN1#106-e

Working assumption:

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

* FFS: Further limitations on maximum number of PDSCHs

Agreement:

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

Agreement:

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

Agreement:

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

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

Agreement:

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

Agreement:

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

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

Agreement:

For a DCI that can schedule multiple PDSCHs,

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

Working assumption:

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

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

Agreement:

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

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

Agreement:

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

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

Agreement:

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

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

### RAN1#106bis-e

Agreement:

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

Working assumption: (RAN1#106-e)

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

* ~~FFS: Further limitations on maximum number of PDSCHs~~
* Note: Further limitations (in addition to what was agreed earlier) on the maximum number of PDSCHs or PUSCHs can be separately discussed for all SCSs.

Working assumption:

UE does not expect to be configured with both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group with a Type 2 codebook.

* If time bundling operation is supported, this working assumption can be revisited

Agreement:

For a PDSCH that is scheduled by multi-PDSCH scheduling DCI and is skipped due to collision with semi-static UL symbol(s),

* For Type-1 HARQ-ACK codebook generation, the PDSCH is not considered and the HARQ-ACK bit corresponding to the PDSCH is not reported by UE.
  + Note: Rel-16 procedure can be reused to handle this case.
* For Type-2 HARQ-ACK codebook generation, UE reports NACK for the PDSCH.
  + FFS on HARQ-ACK bit ordering
* Note: Codebook generation in case time domain bundling is enabled can be separately discussed if time domain bundling is supported.

Agreement:

For generating type-2 HARQ-ACK codebook corresponding to a DCI that can schedule multiple PDSCHs,

* HARQ-ACK bit corresponding to SPS PDSCH release or SCell dormancy indication without scheduled PDSCH, belongs to the first sub-codebook (which is defined in the previous agreement made in RAN1#105-e)

Agreement:

For two multi-PDSCH (or two multi-PUSCH) scheduling DCIs, UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCI to lead to out-of-order scheduling.

* FFS: whether to allow OOO scheduling for the following two cases:
  + for the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH)
  + for the case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV
* Note: The above FFS aspect applies only to multi-PDSCH and multi-PUSCH scheduling with single DCI

Agreement:

For multiple PDSCHs (or PUSCHs) scheduled by a single DCI,

* Rel-15/16 behavior that is described in TS 38.213 Clauses 11 and 11.1 for a PDSCH (or PUSCH) indicated by DCI also applies for multiple PDSCHs (or PUSCHs) schedule by a single DCI.
* If one of multiple PDSCHs (or PUSCHs) scheduled by the DCI collides with a flexible symbol (indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*),
  + If that PUSCH is collided with SSB symbols indicated by *ssb-PositionsInBurst* [or symbol(s) indicated by *pdcch-ConfigSIB1* in *MIB* for a CORESET for Type0-PDCCH CSS set], the HARQ process number increment is skipped for the PUSCH.
  + Otherwise, the HARQ process number increment is not skipped for that PDSCH (or PUSCH).

Conclusion:

For a DCI that can scheduled multiple PDSCHs (or PUSCHs), HARQ process number indicated in the DCI is applied to the first valid PDSCH (or PUSCH).

* Note: This is the consequence of previous agreements.

Agreement:

For single TRP operation, for 480/960 kHz SCS,

* A UE does not expect to be scheduled with more than one unicast 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.

Agreement:

For a DCI that can schedule multiple PDSCHs, and if RRC parameter configures that two codeword transmission is enabled,

* MCS for the 2nd TB: This appears only once in the DCI and applies commonly to the 2nd TB of each PDSCH
* NDI for the 2nd TB: This is signaled per PDSCH and applies to the 2nd 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 2nd TB of each PDSCH
* FFS: the maximum number of PDSCHs when 2 TB is enabled or when 2 TB is scheduled

### RAN1#107-e

**Agreement**

* For multi-PDSCH or multi-PUSCH scheduling DCI, FDRA enhancement is deprioritized in Rel-17.

**Agreement**

* For multi-TRP operation, for 480/960 kHz SCS,
  + A UE does not expect to be scheduled with more than one unicast PDSCH in a slot, by a single DCI or multiple DCIs, from the same TRP.
  + A UE does not expect to be scheduled with more than one PUSCH in a slot, by a single DCI or multiple DCIs, from the same TRP.
  + Note: This does not preclude a UE being scheduled with two PDSCHs (or two PUSCHs) in the same slot from two different TRPs for multi-DCI based multi-TRP mechanism.

**Agreement**

* For a DCI that can schedule multiple PDSCHs, CBGTI and CBGFI fields are not present in the DCI.
* UE does not expect to be configured with both of CBG operation and multi-PDSCH scheduling in the serving cell with a Type 1 codebook.
* Confirm the working assumption from RAN1#106bis-e with the following modification.

Working assumption: (RAN1#106bis-e)

* UE does not expect to be configured with both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group with a Type 2 codebook.
  + ~~If time bundling operation is supported, this working assumption can be revisited~~

**Agreement**

For 480/960 kHz SCS, CBG-based HARQ cannot be configured for uplink and downlink.

**Agreement**

* The maximum number of PDSCHs that can be scheduled with a single DCI in Rel-17 is also 8 when 2 TB is enabled or when 2 TB is scheduled, for SCS of 120, 480 and 960 kHz.
  + Note: This is to handle FFS (the maximum number of PDSCHs when 2 TB is enabled or when 2 TB is scheduled) in previous agreement in RAN1#106bis-e.

**Agreement**

For multi-PUSCH scheduling DCI in Rel-17, support intra-slot frequency hopping which is applicable to each of multiple PUSCH transmissions scheduled by the DCI, and do not support inter-slot frequency hopping.

**Agreement**

For multi-PDSCH scheduling with a single DCI

* Introduce a new RRC parameter, e.g., *enableTimeDomainHARQ-Bundling*, to enable time domain bundling operation for type-1 HARQ-ACK codebook per serving cell.
  + If the RRC parameter enables time domain bundling operation,
    - To determine the set of candidate PDSCH reception occasions,
      * A row index is removed if at least one symbol of every PDSCH associated with the row index is configured as semi-static UL. (NOTE: This is similar to the case of slot aggregated PDSCH in Rel-16)
      * Pruning procedure in Rel-16 is performed based on the last configured SLIV of each row index.
    - Logical AND operation is applied across all valid PDSCHs associated with a determined candidate PDSCH reception occasion, at least for 1-TB case.
    - FFS: UE does not expect the last scheduled SLIV overlaps with a semi-static UL symbol when parameter *enableTimeDomainHARQ-Bundling* is configured

**Agreement**

* If a UE is configured with a TDRA table in which one or more rows contain multiple SLIVs for PDSCH for DCI format 1\_1, the UE does not expect to be configured with *repetitionNumber* for the TDRA table, and if *pdsch-AggregationFactor* is configued in *PDSCH-config*, it does not apply to DCI format 1\_1.
  + Note: *repetitionNumber* cannot be configured with *pdsch-TimeDomainAllocationListDCI-1-2* as in Rel-16.
  + Note: Under agenda item 8.2.4, in RAN1#106-bis, it was already agreed that within the TDRA table for multi-PDSCH scheduling, the UE does not expect to be configured with the higher layer parameter *repetitionNumber*.
  + Note: These does not preclude *pdsch-AggregationFactor* can be configured and applies to DCI format 1\_2
* If a UE is configured with a TDRA table in which one or more rows contain multiple SLIVs for PUSCH for DCI format 0\_1, the UE does not expect to be configured with *numberOfRepetitions* for the TDRA table, and if *pusch-AggregationFactor* is configued in *PUSCH-config*, it does not apply to DCI format 0\_1.
  + Note: These does not preclude *numberOfRepetitions* is configured for TDRA table corresponding to DCI format 0\_2
  + Note: These does not preclude *pusch-AggregationFactor* can be configured and applies to DCI format 0\_2

**Agreement**

* For type-2 HARQ-ACK codebook generation, HARQ-ACK bit ordering is based on configured SLIV position in the indicated TDRA row index, regardless of the validity of each scheduled PDSCH.

**Agreement**

* There is no consensus in RAN1 to support that HARQ-ACK information corresponding to different PDSCHs scheduled by a single DCI is carried over multiple PUCCHs in Rel-17.

**Agreement**

For multi-PDSCH scheduling with a single DCI

* Introduce a new RRC parameter, e.g., *numberOfHARQ-BundlingGroups*, to configure the number of HARQ bundling groups with value range {1, 2, 4} for type-2 HARQ-ACK codebook per serving cell.
  + If the RRC parameter is not configured for a serving cell, time domain bundling for type-2 HARQ-ACK codebook is not enabled for the serving cell.
  + The maximum number of PDSCHs allocated to each bundling group is ceil(NPDSCH,MAX/NHBG) where NHBG is the number of bundling groups configured by *numberOfHARQ-BundlingGroups* for a serving cell and NPDSCH,MAX is the maximum configured number of PDSCHs for the serving cell.
  + The PDSCHs corresponding to [configured or valid] SLIVs in a TDRA row index indicated by multi-PDSCH scheduling DCI are allocated to the bundling groups, e.g., if NHBG =4, NPDSCH,MAX =8, and 5 PDSCHs are scheduled, then 2/1/1/1 PDSCHs are assigned to each group, by reusing CBG grouping method.
    - For a group that is empty or is filled with only invalid PDSCH(s), HARQ-ACK bits for the bundling group is set to NACK (same principle as when no time bundling configured)
    - Logical AND operation is applied to across all valid PDSCHs within the same bundling group to generate 1 HARQ-ACK bit per group, at least for 1-TB case
  + If the number of HARQ bundling groups is configured as 1 for a serving cell, HARQ-ACK bits corresponding to any DCI for the serving cell belong to the first sub-codebook.
  + At least for 1-TB case, if the number of HARQ bundling groups is configured as larger than 1 for a serving cell, HARQ-ACK bits corresponding to multi-PDSCH scheduling case (which implies a multi-PDSCH DCI schedules more than one PDSCH) for the serving cell belong to the second sub-codebook,
    - Where the number of HARQ-ACK bits corresponding to a multi-PDSCH DCI is determined based on the maximum of Q value across all serving cells within the same PUCCH cell group, and Q=maximum configured number of PDSCHs for a cell without *numberOfHARQ-BundlingGroups* configured or Q=number of configured HARQ bundling groups for a cell with *numberOfHARQ-BundlingGroups* configured