**3GPP TSG RAN WG1 #108-e R1-220XXXX**

**e-Meeting, February 21st – March 3rd, 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:

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

* 1st check point: February 25
* Final check point: March 3

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#J in Section 4 and provide your views if they are acceptable or not.

# Multi-PDSCH/PUSCH scheduling

## Out-of-order handling

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| Company | Views |
| [1] Huawei | Proposal 5: UE is not expected to be scheduled with two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol and these 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. |
| [2] Futurewei | Proposal 1. Prefer not to allow OOO for the second case under ‘DCI-to-data OOO’, i.e., UE does not expect any of the scheduled PxSCHs and the scheduling DCIs to lead to OOO scheduling for the case where two multi-PxSCH scheduling DCIs end in the same symbol but these two multi-PxSCH scheduling DCIs have overlapping spans. |
| [3] InterDigital | Proposal 1: UE does not expect to receive two multi-PDSCH (or multi-PUSCH) scheduling DCIs ending in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs having overlapping spans.  Proposal 2: UE does not expect the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI end in the same symbol, and the single-PDSCH (or single-PUSCH) is scheduled during the span of multi-PDSCH (or multi-PUSCH) scheduling DCI. |
| [4] vivo | Observation 1: The case where two DCIs, each of which schedules a multi-slot PDSCH (or a multi-slot PUSCH), end in the same symbol but the two scheduled multi-slot PDSCHs (or the two scheduled 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 2: For multi-PDSCH/PUSCH scheduling, DCI-to-data out-of-order scheduling is defined as NR Rel-15/16 without any exception. |
| [7] ZTE | Proposal 1: It is recommended that the case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but these two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans is considered as out-of-order scheduling and is not expected by UE. |
| [10] NTT DOCOMO | Proposal 1: The following case is defined as OoO scheduling, and should not be allowed:   * 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. |
| [12] Intel | Proposal 4   * The case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but these 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, including the case that one DCI schedules multi-slot PDSCH (or multi-slot PUSCH). * Agree on the TP 2 on OOO handling between two PDCCHs and the associated PDSCH(s) and PUSCH(s) |
| [13] Ericsson | Proposal 1 For two scheduling DCIs both scheduling DL or both scheduling UL end in the same OFDM symbol, the following cases are considered as out-of-order scheduling and are not expected by the UE:   * Both DCIs schedule multiple PxSCHs where the time span of the two multi-PxSCH schedulings overlap at least partially * One DCI schedules multiple PxSCHs and the other DCI schedules a multi-slot PxSCH where the time span of the multi-PxSCH scheduling and the multi-slot PxSCH scheduling overlap at least partially   Note: "time span" is the time interval between the first OFDM symbol of the first PxSCH and the last OFDM symbol of the last PxSCH |
| [14] Apple | Proposal 1: 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] Qualcomm | Proposal 5: 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. |
| [21] LG Electronics | Proposal #2: 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. |

### Issue 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

**Conclusion** (RAN1#107bis-e)

* UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCIs 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.
* Note: It is separately discussed whether the scheduled PDSCHs (or PUSCHs or SLIV) is based on configured SLIV or valid SLIV.

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

* For the first case of above highlighted FFS,
  + This FFS point was resolved in RAN1#107bis-e
* For the second case of above highlighted FFS,
  + Considered as OOO scheduling: Huawei, Futurewei, InterDigital, ZTE, NTT DOCOMO, Intel, Ericsson, Apple, Qualcomm
  + Can be allowed: vivo

[Moderator’s note] Considering the majority view, the following proposal can be made. It is noted that the case where one DCI schedules slot-aggregated PXSCH and the other DCI schedules multiple PXSCHs, is added. It is also noted that this issue is indicated as HIGH since it has been discussed during several meetings and needs to be finalized in this meeting.

### [HIGH] Proposal #2.1 (DCI-to-data OOO):

* 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, including the case that one DCI schedules multi-slot PDSCH (or multi-slot PUSCH).
* Note: It is separately discussed whether the scheduled SLIV is based on configured SLIV or valid SLIV.

Companies are encouraged to provide views on Proposal #2.1.

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| Company | Views |
| Panasonic | We support the proposal #2.1. This case can be considered as out-of-order scheduling. It means UE is not expected to have this case. |
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## Handling of collision with semi-static DL/UL/flexible symbols

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| Company | Views |
| [1] Huawei | Proposal 2: The “scheduled PUSCH” in case 3 (CSI request) and “scheduled PDSCH” in case 5 (OOO) and case 6 (NNK1) should correspond to valid SLIV.  Proposal 3: In the case of multi-PDSCH scheduled by a single DCI and repetitionScheme is configured with 'tdmSchemeA', if one of the repetitions of a scheduled PDSCH collides with semi-static UL symbols, the corresponding SLIV is considered not valid. |
| [2] Futurewei | Proposal 4. Support Option 2 for handling for the case of tdmSchemeA with a multi-PDSCH grant such that “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 5. For the CSI request case, the number M is determined based on the number of configured PUSCHs.  Proposal 6. Prefer that “scheduled PxSCH” implies “valid PxSCH” for better gNB scheduling flexibility for the OOO case and NN-K1 case. |
| [3] InterDigital | Proposal 3: Out-of-order scheduling determination should be based on valid SLIVs. |
| [4] vivo | Proposal 3: For multi-PUSCH scheduling and A-CSI request, the number M is determined based on the number of configured SLIVs in the TDRA row indicated by the DCI.  Proposal 4: For multi-PDSCH/PUSCH scheduling, OoO scheduling rules are applied only to valid SLIV(s) in the TDRA row indicated by a scheduling DCI.  Proposal 5: For multi-PDSCH scheduling, and for case(s) where Type-2 codebook/enhanced Type-2 codebook is configured and an inapplicable value is provided by a PDSCH-to-HARQ\_feedback timing indicator field included in a first DCI scheduling more than one PDSCH, only valid PDSCH(s) scheduled by the first DCI is considered to decide if an SPS PDSCH reception is received after the PDSCH(s) or not.  Proposal 6: For multi-PDSCH scheduling in conjunction with ‘tdmSchemeA’ of M-TRP, and for a scheduled PDSCH, if the PDSCH transmission occasion corresponding to the configured SLIV, i.e. the first PDSCH transmission occasion, does not collide with any semi-static UL symbol, the scheduled PDSCH is regarded as valid, no matter if the second PDSCH transmission occasion collides with semi-static UL symbol(s) or not. |
| [6] CATT | Proposal 4: NDI/RV fields for both valid and invalid PXSCHs are present in multi-PXSCH scheduling DCI.  Proposal 5: For cases of RV/ M on CSI-request / CBGTI, the parameters are determined based on configured SLIV(s). |
| [7] ZTE | Proposal 2: Unnecessary optimization should not be introduced for “scheduled PXSCH”.   * gNB should guarantee the assigned PUSCH carrying the A-CSI is valid. * Only valid PXSCH should be considered in out-of-order scheduling. |
| [9] Fujitsu | Proposal 8: 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.   * TP#2 can be considered. |
| [10] NTT DOCOMO | Proposal 2: 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. * 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.   Proposal 3: 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. * 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. |
| [11] Nokia | Proposal 1: For CSI-request, is the number M determined based on the number of configured SLIVs  Proposal 2: Determination of OOO scheduling should be based on the valid SLIVs.  Proposal 3: In the case of multi-PDSCH scheduling via a single DCI with ‘tdmSchemeA’, if one of repeated PDSCHs collides with semi-static UL symbols, determine the validity rule for each of repeated PDSCHs. |
| [12] Intel | Proposal 2   * 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 PUSCH carrying the A-CSI report is determined by the configured SLIVs for multi-PUSCH scheduling * Prefer to define OOO handling based on configured SLIVs * If OOO handling is defined by the valid SLIVs, it is preferred to apply valid SLIVs in checking PUSCH preparation time and PDSCH reception preparation time with cross carrier scheduling with different SCSs for PDCCH and PDSCH   + It is necessary to clarify whether configured SLIVs or valid SLIVs are used for multi-slot PUSCH/PDSCH in NR Rel-15/16. * If multi-PDSCH scheduling via a single DCI with ‘tdmSchemeA’ is supported, it is preferred to cancel both of two repeated PDSCHs if at least one of repeated PDSCHs collides with semi-static UL symbols. |
| [13] Ericsson | Proposal 2 For CSI-request in a multi-PUSCH scheduling, the number M is determined based on the number of valid SLIVs.  Proposal 3 For multi-PDSCH scheduling in Rel-17, out-of-order scheduling is determined based on configured SLIVs.  Proposal 4 For multi-PDSCH scheduling in Rel-17, the evaluation of the time-line requirement for application of NN-K1 is based on configured SLIVs.  Proposal 5 In the case of multi-PDSCH scheduling via a single DCI with ‘tdmSchemeA’, a PDSCH is considered invalid if either of the two transmission occasions of the PDSCH collides with semi-static UL symbol(s). |
| [14] Apple | Proposal 2:   |  |  |  |  | | --- | --- | --- | --- | | Case | Issue | Agreement: Configured vs Valid | Apple’s Proposals | | Case 1 | NDI/RV | Configured |  | | Case2 | RV bit-width | Pending | Configured | | Case 3 | CBGTI | Configured |  | | Case 4 | Out-of-order behavior | Pending | Configured | | Case 6 | CSI-Request | Pending | Valid | | Case 6 | NN-K1 | Pending | Valid | |
| [18] MediaTek | Proposal 3: For out-of-order scheduling, the rule for scheduling is determined based on configured SLIVs indicated by the TDRA information field. |
| [19] Qualcomm | Proposal 4: 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 6: The out-of-order rules should be applied on the valid allocations only. |
| [21] LG Electronics | Proposal #1: 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 #3: Do not consider any invalid PDSCH (which is collided with semi-static UL symbol(s)) to check out-of-order scheduling. |

### [LOW] Issue 2.2-1) 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
  + Objected by Intel

[Moderator’s note] Considering a small number of inputs and that this issue had been discussed during previous meetings without consensus, it is suggested to deprioritize this issue in this meeting.

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

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| Company | Views |
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### [HIGH] Issue 2.2-2) Clarification on whether “scheduled PXSCH” in previous agreements/conclusion implies valid PXSCH or not:

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#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.

**Conclusion** (RAN1#107bis-e)

* UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCIs 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.
* Note: It is separately discussed whether the scheduled PDSCHs (or PUSCHs or SLIV) is based on configured SLIV or valid SLIV.

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?
  + Resolved in RAN1#107bis-e
* 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?
  + Resolved in RAN1#107bis-e
* Case 3: For CSI-request, is the number M determined based on the number of configured SLIVs or valid SLIVs?
  + Based on configured SLIVs: Futurewei, vivo, CATT, ZTE, Nokia, Intel, Apple?
  + Based on valid SLIVs: Huawei, NTT DOCOMO, Ericsson, LG Electronics
* Case 4: For CBGTI field, is the presence of CBGTI field determined based on the number of configured SLIVs or valid SLIVs?
  + Resolved in RAN1#107bis-e
* 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 (concern on PUSCH preparation time and PDSCH reception preparation time), Ericsson, MediaTek (concern on type-1 HARQ-ACK codebook generation with time domain bundling)
  + Based on valid SLIVs: Huawei, Futurewei, InterDigital, vivo, ZTE, NTT DOCOMO, Nokia, Apple?, Qualcomm, 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.
  + Based on configured SLIVs: Ericsson
  + Based on valid SLIVs: Huawei, Futurewei, vivo, Fujitsu, Apple
* Case 7: In the case of multi-PDSCH scheduling via a single DCI with 'tdmSchemeA', **Option 1)** cancel both of two repeated PDSCHs if at least one of repeated PDSCHs collides with semi-static UL symbols or **Option 2)** determine the validity rule for each of repeated PDSCHs
  + Option 1: Huawei, Intel, Ericsson, Qualcomm
  + Option 2: Futurewei, vivo, Nokia, Qualcomm

Companies are encouraged to provide views on the above cases.

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| Company | Views |
| Example | Case 3 (CSI-request): Based on configured or valid SLIVs  Case 5 (OOO): Based on configured or valid SLIVs  Case 6 (NN-K1): Based on configured or valid SLIVs  Case 7 (tdmSchemeA): Option 1 or Option 2, any else? |
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## [MID] TDRA indication for a DCI format with CS-RNTI or without scheduling PDSCH

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| Company | Views |
| [6] CATT | Proposal 1: When re-transmission of DL SPS is indicated by DCI format 1\_1, the PDCCH indicates a TDRA row index including only one SLIV.  Proposal 2: When re-transmission of UL CG is indicated by DCI format 0\_1, the PDCCH indicates a TDRA row index including only one SLIV.  Proposal 3: If *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* is provided, it is applicable to DCI format 1\_1 scrambled by C-RNTI or MCS-RNTI only. |
| [9] Fujitsu | Proposal 1: In order to avoid ambiguity, clarify whether *pdsch-AggregationFactor* in *pdsch-Config* would be applicable for SPS PDSCH activated by DCI format 1\_1 or not when DCI format 1\_1 is provided with a TDRA table in which one or more TDRA rows include multiple SLIVs.  Proposal 2: *pdsch-AggregationFactor* in *pdsch-Config* should be applicable for SPS PDSCH activated by DCI format 1\_1 when DCI format 1\_1 is provided with a TDRA table in which one or more TDRA rows include multiple SLIVs.  Proposal 3: In case of PDSCH/PUSCH scheduling for SPS/CG retransmission, DCI format 1\_1/0\_1 should indicate a TDRA row which includes only one SLIV when DCI format 1\_1/0\_1 is provided with a TDRA table in which one or more TDRA rows include multiple SLIVs.   * *pdsch-AggregationFactor/pusch-AggregationFactor* in *pdsch-Config*/*pusch-Config* should be applicable for the single PDSCH/PUSCH for SPS/CG retransmission scheduled by the DCI. |
| [17] Samsung | Proposal 1: For SPS/CG retransmission, down select one of options.   * Option 1. It is allowed for gNB to indicate a TDRA row with single SLIV only. * Option 2. It is allowed for gNB to indicate a TDRA row with more than one SLIVs, where   + Alt 1: A UE does not expect to be receive a DCI format scheduling multiple SPS PDSCHs (or CG PUSCHs) retransmissions with a HARQ process ID not dedicated for any SPS configurations (CG configurations).   + Alt 2: A UE does not receive (or transmit) a SPS PDSCH (or CG PUSCH) retransmission with a HARQ process ID not dedicated for any SPS configurations (CG configurations).   + Alt 3: A UE receives (or transmit) a SPS PDSCH (or CG PUSCH) retransmission corresponding to [the first/last SLIV] in the TDRA table.   Proposal 2: 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   Proposal 3: For a DCI format carrying TCI-State indication, a UE does not expect that the DCI format indicates a TDRA row with more than one SLIVs. |
| [21] LG Electronics | Proposal #4: A DCI format indicating SCell dormancy or TCI state update without scheduling PDSCH reception can indicate a TDRA row index including only one SLIV. It is clarified that 1-bit NDI and 2-bit RV for transport block 1 are used for SCell dormancy indication when a DCI (including multi-PDSCH scheduling DCI) indicates SCell dormancy without scheduling a PDSCH reception. |

### Issue 2.3-1) TDRA information for a DCI format indicating SPS/CG retransmission:

Company views on TDRA information for a DCI format indicating SPS/CG retransmission:

* Option 1: The DCI indicates a TDRA row index including only one SLIV.
  + Supported by CATT, Fujitsu, Samsung
* Option 2: The DCI can indicate a TDRA row index including more than one SLIV, FFS on details.
  + Supported by Samsung

[Moderator’s note] Given a small number of inputs, companies are encouraged to provide views between Option 1 and Option 2.

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| Company | Views |
| Panasonic | Our preference is Option 2 for the flexibility. |
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### Issue 2.3-2) TDRA information for a DCI format indicating SCell dormancy or TCI state update without scheduling PDSCH reception:

Company views on TDRA information for a DCI format indicating SCell dormancy or TCI state update (requiring HARQ-ACK feedback) without scheduling PDSCH reception:

* Option A: The DCI indicates a TDRA row index including only one SLIV.
  + Supported by LG Electronics, Samsung (for TCI state update)
* Option B: The DCI can indicate a TDRA row index including more than one SLIV, FFS on details.
  + Supported by Samsung (for SCell dormancy)

[Moderator’s note] Given a small number of inputs, companies are encouraged to provide views between Option A and Option B.

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| Company | Views |
| Panasonic | Our preference is Option B for the flexibility. |
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### Issue 2.3-3) Application of *pdsch-AggregationFactor/pusch-AggregationFactor* in *pdsch-Config*/ *pusch-Config* for DCI format 1\_1/0\_1 with CS-RNTI:

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

* 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

One company requested a clarification on whether *pdsch-AggregationFactor/pusch-AggregationFactor* in *pdsch-Config*/*pusch-Config* can be applicable to DCI format 1\_1/0\_1 (that can schedule multiple PDSCHs/PUSCHs) scrambled with CS-RNTI or not.

* Fujitsu: *pdsch-AggregationFactor/pusch-AggregationFactor* in *pdsch-Config*/*pusch-Config* can be applicable to DCI format 1\_1/0\_1 (that can schedule multiple PDSCHs/PUSCHs) scrambled with CS-RNTI.

[Moderator’s note] Companies are encourage to provide views on above Fujitsu’s proposal.

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| Company | Views |
| Fujitsu | The cases that need to be clarified include SPS activation, SPS retransmission and CG retransmission.  We would like to elaborate why we think the clarification is necessary.  First, the agreement above in RAN1#107-e meeting was made without consideration on SPS/CG retransmission. Support of SPS/CG activation by DCI format 1\_1/0\_1 (that can schedule multiple PDSCHs/PUSCHs) is concluded just in the last meeting (RAN1#107b-e) meeting, while SPS/CG retransmission is still under discussion, as in issue2.3-1).  Second, it is also ambiguous in TS 38.214 h00. For example, for SPS activation, the yellow part as below states that pdsch-AggregationFactor in pdsch-config may be applied to SPS PDSCH activated by DCI format 1\_1, while the green part says that pdsch-AggregationFactor in pdsch-config would not apply to DCI format 1\_1 when DCI format 1\_1 is provided with a TDRA table in which one or more TDRA rows include multiple SLIVs.   |  | | --- | | PDSCH scheduled without corresponding PDCCH transmission using *sps-Config* and activated by DCI format 1\_1 or 1\_2, the same symbol allocation is applied across the *pdsch-AggregationFactor*, in *sps-Config* if configured, or across the *pdsch-AggregationFactor* in *pdsch-config* otherwise, consecutive slots. |  |  | | --- | | If a UE is configured with *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* in which one or more rows contain multiple SLIVs for PDSCH 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. |   Since it was agreed in RAN1#107b-e meeting that DCI format 1\_1 (that can schedule multiple PDSCHs) can be used for SPS activation only if it indicates a TDRA row single SLIV (same as the legacy situation), it is straight forward and beneficial that pdsch-AggregationFactor in pdsch-Config is applicable.  There are similar ambiguous issues for SPS retransmission and CG retransmission. If Option 1 in 2.3-1) is supported, it is also preferred that pdsch-AggregationFactor/pusch-AggregationFactor in pdsch-Config/pusch-Config is applicable. |
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## [LOW] Other issues

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| Company | Views |
| [13] Ericsson | During RAN1#107e we came to the following agreement on CBG configuration for multi-PDSCH/multi-PUSCH scheduling:   |  | | --- | | **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. |   First of all, it is observed that the above agreements on CBG configuration restrictions have not been captured in the current Rel-17 RAN1 specs. Secondly, if the above agreements were to be implemented in the RAN1 specs, changes would need to be made in quite a few places in multiple TS documents, such as TS 38.212 (DCI format), TS 38.213 (HARQ-ACK codebook), TS 38.214 (PDSCH and PUSCH), etc. Considering the fact that the above agreements focus on CBG configuration restriction, we believe it is more natural and straight-forward to implement the agreements in the RRC specs (TS 38.331) instead, by imposing the configuration restrictions on the existing RRC parameter *codeBlockGroupTransmission*. Then from Layer 1’s perspective, CBG configuration as well as absence/presence of CBGTI/CBGFI fields in DCI format 0\_1 and 1\_1 is solely controlled by the RRC parameter *codeBlockGroupTransmission*.  From the above cited agreement, the control logic for CBG configuration can be summarized as:  For PDSCH:   * If SCS is NOT 480 or 960 kHz, and * If Type-1 codebook is configured and TDRA table for the cell does NOT contains any rows that contain multiple SLIVs, or * If Type-2 codebook is configured and TDRA tables for any cells in the same PUCCH cell group do NOT contain any rows that contain multiple SLIVs   + *codeBlockGroupTransmission* can be configured. If *codeBlockGroupTransmission* is configured, CBGTI/CBGFI fields are present in DCI format 1\_1. * Otherwise   + *codeBlockGroupTransmission* can NOT be configured. CBGTI/CBGFI fields are absent in DCI format 1\_1.   For PUSCH:   * If SCS is NOT 480 or 960 kHz   + *codeBlockGroupTransmission* can be configured. If *codeBlockGroupTransmission* is configured, presence of CBGTI/CBGFI fields in DCI 0\_1 is dependent on the number of scheduled PUSCHs by the DCI. * Otherwise   + *codeBlockGroupTransmission* can be NOT configured. CBGTI/CBGFI fields are absent in DCI 0\_1.   Proposal 6 In order to capture previous agreements, the RRC parameter spreadsheet needs to be updated with configuration restrictions on the existing parameter codeBlockGroupTransmission. |
| [15] NEC | Proposal 2: Consider the impact of minimum applicable scheduling offset when multiple-PXSCH scheduling and cross-slot scheduling are enable simultaneously. |
| [16] Xiaomi | Proposal 3: 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. |
| [17] Samsung | Proposal 4: 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 5: 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. |
| [19] Qualcomm | Proposal 3: 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. |

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

The following issues are brought up by several companies:

* Ericsson: Update of CBG-related configuration restrictions in RRC parameter spreadsheet
* NEC: Clarification on the combination of minK0/minK2 with multi-PXSCH scheduling
* Xiaomi: Interpretation of channel access type indication
* Samsung: Clarification on TDMed PXSCH and collision resolution step of multi-PDSCH scheduling DCI
* Qualcomm: Clarification on PDSCH mapping type for TDM scheme A with m-TRP case

[Moderator’s note] It is noted that the proposal from Ericsson will be treated under [108-e-R17-RRC-52-71GHz] thread. 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 |
| [1] Huawei | Proposal 6: For multi-PDSCH scheduling by single DCI and Type-1 HARQ-ACK codebook, consider the TP#1 in TS38.213 v17.0.0 for the calculation of.   |  | | --- | | **\*\*\* < Beginning of TP#1 for TS 38.213 v17.0.0> \*\*\***  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 only associated with the last SLIV configured in TDRA table is considered as received, a PDSCH other than the PDSCH associated with the last SLIV configured in TDRA table 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.  ============== Unchanged Text Omitted ======================  \*\*\* < **End of TP#1 for TS 38.213 v17.0.0**> \*\*\* | |
| [4] vivo | Proposal 7: For multi-PDSCH scheduling and Type-1 codebook, consider the TP1 in TS38.213 for the calculation of **.**  ---------------------------------------------------Start TP1------------------------------------------------------  **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  - 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 serving cell , for a DCI format indicating a TDRA row that includes more than one SLIV entry on serving cell *c*, a PDSCH associated with the last SLIV is considered as received and carrying one or two transport blocks enabled by the DCI format irrespective of whether the PDSCH is valid or not, 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 TP1------------------------------------------------------- |
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| Company | Views for type-2 HARQ-ACK codebook |
| [1] Huawei | Proposal 7: For multi-PDSCH scheduled by single DCI Type-2 HARQ-ACK codebook, consider the TP#2 in TS38.213 v17.0.0 for the calculation of. |
| [2] Futurewei | Proposal 3. Proposal #3.1-2 is acceptable for the Type-2 HARQ-ACK CB, and the detailed changes for the calculations can be handled by the 38.213 editor. |
| [4] vivo | Proposal 9: For multi-PDSCH scheduling and Type-2 codebook, consider the TP3 in TS38.213 for the calculation of **.** |
| [7] ZTE | Proposal 4: For type 2 HARQ-ACK codebook, multi-PDSCH scheduling by single DCI and HARQ-ACK time domain bundling should be considered to determine a PUCCH transmission power when the UCI payload . |
| [8] Panasonic | Proposal 1: For type-2 HARQ-ACK codebook, if , the UE determines a number of HARQ-ACK information bits for obtaining a transmission power for a PUCCH, as follows.   * For a serving cell c configured with numberOfHARQ-BundlingGroups and with , in formula can be determined based on the number of DCI formats or the number of transport blocks. * If the UE is provided *numberOfHARQ-BundlingGroups* with for a serving cell *c*, or the UE is not provided *numberOfHARQ-BundlingGroups* but configured with multi-PDSCH scheduling for a serving cell *c*, is the summation of and where can be determined based on multi-PDSCH scheduling DCI. |
| [11] Nokia | Proposal 7: For type-2 codebook,is determined:   * for serving cells configured with *numberOfHARQ-BundlingGroups* with *:* within whichis given by the number of TBs enabled in DCI format or by the number of DCI format, without and with spatial bundling,respectively. (Text proposal 1) * when UE is configured with multi-PDSCH scheduling but without time domain HARQ-ACK bundling:within whichis given by the number TBs or by the number of PDSCHs that UE receives, without and with spatial bundling,respectively. (Text proposal 2) * for serving cells configured with time domain HARQ-ACK bundling with *: ,* within whichis given by the number transport block groups for thePDSCHs that UE receives. (Text proposal 3) |
| [13] Ericsson | Specify calculation in Section 9.1.3.1 in TS 38.213 for multi-PDSCH scheduling. The specification details can be left to the spec editor. |
| [17] Samsung | Proposal 11: Adopt TP#4 in Appendix for TS38.213 |
| [21] LG Electronics | Proposal #6: For type-2 HARQ-ACK codebook, when UCI payload size is equal to or less than 11 bits, update the method to derive for PUCCH power control by considering at least the followings.   * For a serving cell *c* configured with *numberOfHARQ-BundlingGroups* with , (in formula) corresponding to a multi-PDSCH scheduling DCI in PDCCH monitoring occasion can be determined as 2 if *harq-ACK-SpatialBundlingPUCCH* is not provided and the DCI schedules two codewords, or can be determined as 1 otherwise. * For a serving cell c configured with *numberOfHARQ-BundlingGroups* with or not configured with *numberOfHARQ-BundlingGroups* but configured with multi-PDSCH scheduling DCI, .   + For a serving cell *c* configured with *numberOfHARQ-BundlingGroups* with , (in formula) corresponding to a multi-PDSCH scheduling DCI in PDCCH monitoring occasion can be determined as 2\*(= the number of TBGs which are constructed based on the scheduled PDSCH(s)) if *harq-ACK-SpatialBundlingPUCCH* is not provided and the DCI schedules two codewords, or can be determined as otherwise.   + For a serving cell *c* not configured with *numberOfHARQ-BundlingGroups* but configured with multi-PDSCH scheduling DCI, (in formula) corresponding to a multi-PDSCH scheduling DCI in PDCCH monitoring occasion can be determined as 2\*(= the number of PDSCH receptions scheduled by the DCI) if *harq-ACK-SpatialBundlingPUCCH* is not provided and the DCI schedules two codewords, or can be determined as otherwise. |

### [LOW] Issue 3.1-1) For type-1 HARQ-ACK codebook, how to calculate for PUCCH power control when UCI payload size is equal to or less than 11 bits

[Moderator’s note] Huawei and vivo’s text proposals seem to be reflected in R1-2200812. Therefore, it is suggested to deprioritize this issue in this meeting.

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

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| Company | Views |
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### Issue 3.1-2) For type-2 HARQ-ACK codebook, how to calculate for PUCCH power control when UCI payload size is equal to or less than 11 bits

[Moderator’s note] It can be observed that there is a consensus on the necessity of updating calculation for multi-PDSCH scheduling DCI when UCI payload size is equal to or less than 11 bits. Some companies provided exemplary text proposals while others suggested that the detailed wording can be up to 213 spec editor’s discretion. Considering that the most controversial point is how to determine , it would be good to reach a consensus on that aspect first and leave other aspects up to spec editor. In that sense, Proposal #3.1-2 can be made.

**[HIGH] Proposal #3.1-2 (Type-2 CB PUCCH power control):**

* For generating type-2 HARQ-ACK codebook corresponding to a DCI that can schedule multiple PDSCHs, if , the UE determines a number of HARQ-ACK information bits for obtaining a transmission power for a PUCCH, considering at least the followings.
  + For a serving cell *c* configured with *numberOfHARQ-BundlingGroups* with , (in formula) corresponding to the DCI in PDCCH monitoring occasion is given by 2 if *harq-ACK-SpatialBundlingPUCCH* is not provided and the DCI schedules two codewords, or given by 1 otherwise.
  + For a serving cell *c* configured with *numberOfHARQ-BundlingGroups* with or not configured with *numberOfHARQ-BundlingGroups* but configured with multi-PDSCH scheduling DCI, .
    - For a serving cell *c* configured with *numberOfHARQ-BundlingGroups* with , (in formula) corresponding to the DCI in PDCCH monitoring occasion is given by 2\*(= the number of TBGs which are constructed based on the PDSCH(s) scheduled by the DCI) if *harq-ACK-SpatialBundlingPUCCH* is not provided and the DCI schedules two codewords, or given by otherwise.
    - For a serving cell *c* not configured with *numberOfHARQ-BundlingGroups* but configured with multi-PDSCH scheduling DCI, (in formula) corresponding to the DCI in PDCCH monitoring occasion is given by 2\*(= the number of PDSCH receptions scheduled by the DCI) if *harq-ACK-SpatialBundlingPUCCH* is not provided and the DCI schedules two codewords, or given by otherwise.

Companies are encouraged to provide views on Proposal #3.1-2.

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| Company | Views |
| Panasonic | We are fine with the proposal #3.1-2. |
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## Time domain bundling

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| Company | Views for type-1 HARQ-ACK codebook |
| [9] Fujitsu | Observation 1: According to the agreement made in RAN#107b-e meeting for type-1 HARQ-ACK codebook with time domain bundling, logical AND operation may be applied to PDSCHs scheduled by different DCIs (up to gNB’s scheduling). However, the current specification (TS 38.213 h00) seems not aligned with the agreement (the specification seems to limit logical AND operation to the case where the associated valid PDSCHs are scheduled by a single DCI).  Proposal 4: For Type-1 HARQ-ACK codebook with time domain bundling, clarify the following in TS 38.213:   * Logical AND operation is applied across all valid PDSCHs associated with a determined candidate PDSCH reception occasion, and the valid PDSCHs may be scheduled by one or more DCIs.   Observation 2: For Type-1 HARQ-ACK codebook with time domain bundling, it has not been discussed how to support SPS PDSCH.  Proposal 5: For Type-1 HARQ-ACK codebook with time domain bundling, discuss how to support SPS PDSCH and consider the following two options.   * Option 1: Logical AND operation is applied across all valid PDSCHs associated with a determined candidate PDSCH reception occasion, and the valid PDSCHs may be scheduled by DCI and SPS. * Option 2: For a determined candidate PDSCH reception occasion, if the UE receives a DCI which schedule a PDSCH associated with the occasion, the UE would not receive SPS PDSCH (if any) associated with the same occasion and not report HARQ-ACK information corresponding to the SPS PDSCH.   Observation 3：According to the TS38.213 h00, for Type-1 HARQ-ACK codebook with time domain bundling, for a candidate PDSCH reception occasion associated with a single valid PDSCH scheduled by a DCI which indicates a TDRA row including more than one SLIV, the corresponding HARQ-ACK information bit is not correctly set.  Proposal 6: For Type-1 HARQ-ACK codebook with time domain bundling, clarify the following in TS 38.213:   * For a candidate PDSCH reception occasion associated with a single valid PDSCH scheduled by a DCI which indicates a TDRA row including more than one SLIV, the corresponding HARQ-ACK information bit is equal to the HARQ-ACK information bit for the single valid PDSCH.   Observation 4: For 120 kHz, it is possible that time domain bundling and more than one PDSCH in a slot are simultaneously supported. However, the candidate PDSCH reception occasion determination for the case is not correct in the current specification (TS 38.213 h00).  Proposal 7: For candidate PDSCH reception occasion determination for the case where time domain bundling and more than one PDSCH in a slot are simultaneously supported, adopt TP#1 to correct the operation. |
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| Company | Views for type-2 HARQ-ACK codebook |
| [1] 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. |
| [2] Futurewei | Proposal 7. Slightly support Alt1 that the PDSCHs corresponding to configured SLIVs in a TDRA row index indicated by multi-PDSCH scheduling DCI allocated to the bundling groups. |
| [4] vivo | Proposal 8: 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. |
| [6] CATT | Proposal 6: For case of time domain bundling is configured, only TBs that are scheduled /enabled by DCI join time domain bundling procedure to generate Type-2 HARQ-ACK codebook.  Proposal 7: The PDSCHs corresponding to valid SLIVs in a TDRA row index indicated by multi-PDSCH scheduling DCI are allocated to the bundling groups |
| [7] ZTE | Proposal 3: Configured SLIV should be support for type-2 HARQ-ACK codebook with multi-PDSCH scheduling and HARQ-ACK time domain bundling. |
| [8] Panasonic | Proposal 2: Support to update the following RAN1#107-e agreement as follows  **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. |
| [11] Nokia | Proposal 6: 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. |
| [12] Intel | Proposal 6: If time bundling is configured,   * 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. |
| [13] Ericsson | Proposal 8 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. |
| [14] Apple | Proposal 3: 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. |
| [15] NEC | Proposal 1: The PDSCHs corresponding to valid SLIVs in a TDRA row index indicated by multi-PDSCH scheduling DCI are allocated to the bundling groups |
| [17] Samsung | Proposal 9: Support to use valid PDSCH-based grouping for Type-2 HARQ-ACK CB with time-domain bundling |
| [18] 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. |
| [19] Qualcomm | Proposal 1: For generating type-2 HARQ-ACK codebook, the formation of the bundling groups should be based on the valid SLIVs |
| [21] LG Electronics | Proposal #7: The PDSCHs corresponding to “configured” SLIVs in a TDRA row index indicated by multi-PDSCH scheduling DCI are allocated to the bundling groups. Adopt the following text proposal in TS 38.213 Section 9.1.3.1. |
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| Company | Views for type-3 HARQ-ACK codebook |
| [12] 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. |

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

[Moderator’s note] Fujitsu brought up several issues on the details of type-1 HARQ-ACK codebook with time domain bundling. However, it seems correlated with issue 2.1 (OOO handling). Therefore, it is suggested to deprioritize this issue until issue 2.1 (OOO handling) is finalized.

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

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| Company | Views |
| Fujitsu | In our understanding, at least issue #4 in our contribution is not correlated with issue 2.1 and can be discussed in parallel to make more progress. For other issues (#1~#3), we also do not see much correlation for now. It would be appreciated if there could be more clarifications regarding the correlation. 😊 |
|  |  |

### [HIGH] 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:

* Alt 1: Construction of bundling group based on “configured” SLIVs
  + Supported by Huawei, Futurewei, ZTE, Panasonic, Nokia, Intel, Apple, MediaTek, LG Electronics
* Alt 2: Construction of bundling group based on “valid” SLIVs
  + Supported by vivo, CATT, Ericsson, NEC, Samsung, Qualcomm

[Moderator’s note] In RAN1#107bis-e meeting, two alternatives were compared with respect to the following aspects:

* 1) Either of alternatives can work and system is not broken.
* 2) Technical benefit
* 3) Specification impact
* 4) UE implementation complexity

According to the discussion in RAN1#107bis-e and Tdoc review, it seems that still companies have different views on 2) Technical benefit and 4) UE implementation complexity. Regarding 3) specification impact, we can use the following two TPs as the starting point.

TP#1 (from [21] LG Electronics) for Alt 1 (Construction of bundling group based on “configured” SLIVs): It is noted that UE generates NACK for a TBG including only invalid PDSCHs based on the sentence “*For a HARQ-ACK information bit, a UE generates a positive acknowledgement (ACK) if the UE detects a DCI format that provides a SPS PDSCH release or correctly decodes a transport block, and generates a negative acknowledgement (NACK) if the UE does not correctly decode the transport block.*” in TS 38.213 Clause 9.1.

|  |
| --- |
| If a UE is provided *numberOfHARQ-BundlingGroups* and is not provided *harq-ACK-SpatialBundlingPUCCH* for a serving cell , the UE generates HARQ-ACK information over transport block groups (TBGs) for PDSCH receptions where, for a maximum number of PDSCH receptions scheduled by a DCI format on the serving cell, a maximum number of TBGs is provided by *numberOfHARQ-BundlingGroups*. If the UE detects a DCI format scheduling PDSCH receptions on the serving cell , the UE generates HARQ-ACK information bits for first TBs and, if applicable, generates HARQ-ACK information bits for second TBs in the PDSCH receptions as described in clause 9.1.1 by setting and and by assuming a PDSCH overlapping with a UL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* is correctly received, if any, for a TBG with at least one actual PDSCH reception. |

TP#2 (from [4] vivo) for Alt 2 (Construction of bundling group based on “valid” SLIVs)

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| --- |
| If a UE is provided *numberOfHARQ-BundlingGroups* and is not provided *harq-ACK-SpatialBundlingPUCCH* for a serving cell , the UE generates HARQ-ACK information over transport block groups (TBGs) for PDSCH receptions where, for a maximum number of PDSCH receptions scheduled by a DCI format on the serving cell, a maximum number of TBGs is provided by *numberOfHARQ-BundlingGroups*. If the UE detects a DCI format scheduling PDSCH reception(s) on the serving cell , where from the PDSCH reception(s) there are PDSCH reception(s), each of which the UE receives as described in clause 11.1, the UE generates HARQ-ACK information bits for first TBs and, if applicable, generates HARQ-ACK information bits for second TBs in the PDSCH receptions as described in clause 9.1.1 by setting and . |

[Moderator’s note] After having concrete text proposals for each alternative, the final decision between two alternatives can be drawn. Companies are encouraged to provide views on the above two TPs and/or to suggest a way forward.

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| --- | --- |
| Company | Views |
| Panasonic | We support the construction of bundling group based on “configured” SLIVs as shown in TP#1 for Alt. 1. |
|  |  |

## [LOW] Remaining issues of Type-1 (semi-static) HARQ-ACK codebook

|  |  |
| --- | --- |
| Company | Views |
| [12] 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 |

### Issue 3-3) Remaining issues of Type-1 (semi-static) HARQ-ACK codebook

[Moderator’s note] Intel proposed to apply extended K1 set values also to DCI format 1\_0. However, considering it can be categorized into optimization, it is suggested to deprioritize this topic in this meeting.

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

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| Company | Views |
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## [LOW] Remaining issues of Type-2 (dynamic) HARQ-ACK codebook

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| --- | --- |
| Company | Views |
| [12] Intel | Proposal 7: In HARQ-ACK codebook generation,   * 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. |
| [17] Samsung | Proposal 12: 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. * The valid PDSCHs are only considered. |
| [19] Qualcomm | Proposal 2: If all PDSCHs scheduled by a DCI that schedules multi-PDSCHs (TDRA row has multiple SLIVs) except one PDSCH will not be transmitted due to overlap with semi-static UL symbols, then A/N bit of the valid PDSCH will be carried in the codebook of fallback and single-PDSCH grants. |

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

[Moderator’s note] As to Intel’s proposal, the corresponding agreement seems to be reflected in R1-2200812. As to Samsung’s proposal, whether interlaced scheduling is allowed or not is being discussed through issue 2.1. As to Qualcomm’s proposal, it had been discussed during previous meetings without consensus. Therefore, it is suggested to deprioritize those issues in this meeting.

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

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| --- | --- |
| Company | Views |
|  |  |
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## [LOW] HARQ process

|  |  |
| --- | --- |
| Company | Views |
| [2] Futurewei | Proposal 2. It is recommended to pursue the HARQ-disabling feature for FR2-2 consistently with similar features across other AI (such as NTN). |
| [5] OPPO | Proposal 2: Do not support HARQ disabling feature in Rel-17 NTN with multi-PDSCH scheduling. |
| [13] Ericsson | Observation 1 It is beneficial and straight-forward to support feedback-disabled HARQ processes in FR2-2  Proposal 9 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 10 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 11 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 12 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. |

### Issue 3-5) 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, while other two companies proposed to discuss in other agenda or not to discuss. Therefore, it is suggested to deprioritize those issues in this meeting.

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

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| Company | Views |
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## [LOW] Other issues

|  |  |
| --- | --- |
| Company | Views |
| [14] Apple | Proposal 4: RAN1 should support a single HARQ-ACK feedback for multi-PDSCH transmissions within a single COT only.  Proposal 5: 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. |
| [16] Xiaomi | Proposal 1: 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 2: 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. |
| [18] 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:

* 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.

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| Company | Views |
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# TPs

## TP#A (was from [5] OPPO)

--------------------------------------------Start of TP#A for TS 38.213 Clause 9.2.3 ------------------------------------------------

9.2.3 UE procedure for reporting HARQ-ACK

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

If the UE detects a DCI format scheduling a number of PDSCH receptions with a last scheduled PDSCH indicated by the TDRA information field ending in DL slot  or if the UE detects a DCI format generating a HARQ-ACK information bit and does not schedule a PDSCH reception through a PDCCH reception ending in DL slot , the UE provides corresponding HARQ-ACK information in a PUCCH transmission within UL slot , where is the last UL slot for PUCCH transmission that overlaps with slot and is a number of slots and is indicated by the PDSCH-to-HARQ\_feedback timing indicator field in the DCI format, if present, or provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2*, or *dl-DataToUL-ACK-r17*, or *dl-DataToUL-ACK-MulticastDciFormat4\_1*.

A PUCCH transmission with HARQ-ACK information is subject to the limitations for UE transmissions described in clause 11.1 and clause 11.1.1.

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

[Moderator’s note] TP#A is to clarify that K1 denotes the distance between the slot of the last configured SLIV and the PUCCH slot.

Companies are encouraged to provide views on TP#A.

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| Company | Views |
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## TP#B (was TP#1 from [7] ZTE)

--------------------------------------------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

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

If the set of rows includes a row with more than one SLIV entry as described in [6, TS 38.214] and *enableTimeDomainHARQ-Bundling* is not provided, the set of rows and the set of slot timing values are updated in this clause according to the following pseudo-code.

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

[Moderator’s note] TP#B is to keep the unified wording used between different specs or paragraphs.

Companies are encouraged to provide views on TP#B.

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| Company | Views |
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## TP#C (was from [10] NTT DOCOMO)

---------------------------------------------Start TP#C 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 =3, = 5 or = 6.

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

[Moderator’s note] TP#C is to reflect the previous agreement that maximum 32 HARQ processes can be supported for 120 kHz UL. It is noted that maximum 32 HARQ processes 120 kHz DL is already captured in R1-2200824.

Companies are encouraged to provide views on TP#C.

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| Company | Views |
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## TP#D (was from [11] Nokia)

--------------------------------------------Start of TP#D 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 ===================================

If *enableTimeDomainHARQ-Bundling* is provided

- set

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

If the set of rows includes a row with more than one entry as described in [6, TS 38.214] and *enableTimeDomainHARQ-Bundling* is not provided, the set of rows and the set of slot timing values are updated in this clause according to the following pseudo-code.

set to the set of row indexes

set to the cardinality of

set – index of row in set

set

set

while

set to the set of entries for row

set to the set of values of entries for row

set

set to the cardinality of

set to the cardinality of

set – index of element in set – index of element in

while

*;*

;

end while

while

;

;

end while

;

end while

;

For the set of slot timing values, the UE determines a set of occasions for candidate PDSCH receptions or SPS PDSCH releases or TCI state update according to the following pseudo-code. A location in the Type-1 HARQ-ACK codebook for HARQ-ACK information corresponding to a single SPS PDSCH release is same as for a corresponding SPS PDSCH reception. A location in the Type-1 HARQ-ACK codebook for HARQ-ACK information corresponding to multiple SPS PDSCH releases by a single DCI format is same as for a corresponding SPS PDSCH reception with the lowest SPS configuration index among the multiple SPS PDSCH releases. If a UE provides HARQ-ACK information corresponding to detection of a DCI format that provides TCI state update without scheduling PDSCH reception, as described in [6, TS 38.214], a location in the Type-1 HARQ-ACK codebook for the HARQ-ACK information is same as when the DCI format schedules a PDSCH reception with CBGs or with transport blocks that are correctly decoded.

Set - index of occasion for candidate PDSCH reception or SPS PDSCH release or TCI state update

Set

Set

Set to the cardinality of set

Set – index of slot timing values , in descending order of the slot timing values, in set for serving cell

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 PDSCH-TimeDomainResourceAllocationListForMultiPDSCH and enableTimeDomainHARQ-Bundling are provided for serving cell

;

;

elseif PDSCH-TimeDomainResourceAllocationListForMultiPDSCH is provided and enableTimeDomainHARQ-Bundling is not provided for serving cell

;

else

Set to the set of row indexes

end if

Set to the cardinality of

Set – index of row in set

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 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

if the UE does not indicate a capability to receive more than one unicast PDSCH or multicast PDSCH per slot and ,

;

;

else

Set to the cardinality of Set to the smallest last OFDM symbol index, as determined by the *SLIV*, among all rows of

while

Set

while

if for start OFDM symbol index for row

; - index of occasion for candidate PDSCH reception, or SPS PDSCH release, or TCI state update associated with row

;

;

else

;

end if

end while

;

Set to the smallest last OFDM symbol index among all rows of ;

end while

end if

;

end if

end while

end if

;

end while

else

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

Set to the set of row indexes

Set to the cardinality of

Set – index of row in set

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 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 slot overlaps 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 the PDSCH time resource derived by row of set is configured as UL, where = 0,1,…,.

;

;

else

;

end if

end while

if the UE does not indicate a capability to receive more than one unicast PDSCH or multicast PDSCH per slot and ,

;

;

else

Set to the cardinality of

Set to the smallest last OFDM symbol index, as determined by the *SLIV*, among all rows of

while

Set

while

if for start OFDM symbol index for row

; - index of occasion for candidate PDSCH reception, or SPS PDSCH release, or TCI state update associated with row

;

;

else

;

end if

end while

;

;

Set to the smallest last OFDM symbol index among all rows of ;

end while

end if

;

end if

end while

end if

;

end while

end if

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

[Moderator’s note] TP#D is to make the definition of sets and clearer.

Companies are encouraged to provide views on TP#D.

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| --- | --- |
| Company | Views |
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## TP#E (was TP#1 from [12] Intel)

--------------------------------------------Start of TP#E for TS 38.213 Clause 10.2 ------------------------------------------------

10.2 PDCCH validation for DL SPS and UL grant Type 2

A UE validates, for scheduling activation or scheduling release, a DL SPS assignment PDCCH or a configured UL grant Type 2 PDCCH if

- the CRC of a corresponding DCI format is scrambled with a CS-RNTI provided by *cs-RNTI*, and

- the new data indicator field in the DCI format for the enabled transport block is set to '0', and

- the DFI flag field, if present, in the DCI format is set to '0', and

- the time domain resource assignment field in the DCI format indicates a row with single SLIV, and

- if validation is for scheduling activation and if the PDSCH-to-HARQ\_feedback timing indicator field in the DCI format is present, the PDSCH-to-HARQ\_feedback timing indicator field does not provide an inapplicable value from *dl-DataToUL-ACK-r16*.

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

[Moderator’s note] TP#E is to reflect the previous agreement that a UE validates, for scheduling activation or scheduling release, a DL SPS assignment PDCCH or a configured UL grant Type 2 PDCCH if the PDCCH indicates a TDRA row index including only one SLIV.

Companies are encouraged to provide views on TP#E.

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| Company | Views |
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## TP#F (was TP#1 from [17] Samsung)

---------------------------------Start of TP#F for TS 38.214 Clause 5.1.2.1 and Clause 6.1.2.1-------------------------------------

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#F----------------------------------------------------------------

[Moderator’s note] TP#F 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#F.

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

## TP#G (was TP#2 from [17] Samsung)

--------------------------------------------Start of TP#G 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#G----------------------------------------------------------------

[Moderator’s note] As shown in below excerpt from [17], TP#G 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 1: 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 7: 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 8: Adopt TP#2 in Appendix for TS38.213** |

Companies are encouraged to provide views on TP#G.

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| Company | Views |
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## TP#H (was TP#4 from [17] Samsung in Section 4 Appendix)

-------------------------------------Start of TP#H for TS 38.214 Clause 5.1 and Clause 6.1 -----------------------------------------

5.1 UE procedure for receiving the physical downlink shared channel

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

A UE shall upon detection of a PDCCH with a configured DCI format 1\_0, 1\_1 or 1\_2 decode the corresponding PDSCHs as indicated by that DCI. When the UE is scheduled with multiple PDSCHs by a DCI, HARQ process ID indicated by this DCI applies to the first PDSCH not overlapping with a UL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided, HARQ process ID is then incremented by 1 for each subsequent PDSCH(s) in the scheduled order, with modulo operation of *nrofHARQ-ProcessesForPDSCH* applied if *nrofHARQ-ProcessesForPDSCH* is provided, or with modulo operation of 8 applied, otherwise.

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

6.1 UE procedure for transmitting the physical uplink shared channel

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

A UE shall upon detection of a PDCCH with a configured DCI format 0\_0, 0\_1 or 0\_2 transmit the corresponding PUSCH as indicated by that DCI unless the UE does not generate a transport block as described in [10, TS38.321]. Upon detection of a DCI format 0\_1 or 0\_2 with '*UL-SCH indicator*' set to '0' and with a non-zero '*CSI request*' where the associated *reportQuantity* in *CSI-ReportConfig* set to '*none*' for all CSI report(s) triggered by '*CSI request*' in this DCI format 0\_1 or 0\_2, the UE ignores all fields in this DCI except the '*CSI request*' and the UE shall not transmit the corresponding PUSCH as indicated by this DCI format 0\_1 or 0\_2. When the UE is scheduled with multiple PUSCHs by a DCI, HARQ process ID indicated by this DCI applies to the first PUSCH not overlapping with a DL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided, or a symbol of an SS/PBCH block with index provided by *ssb-PositionsInBurst*, HARQ process ID is then incremented by 1 for each subsequent PUSCH(s) in the scheduled order, with modulo operation of *nrofHARQ-ProcessesForPUSCH* applied if *nrofHARQ-ProcessesForPUSCH* is provided, or with modulo operation of 16 applied, otherwise.

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

[Moderator’s note] TP#H is to consider the case where UE is not configured with *nrofHARQ-ProcessesForPDSCH* or *nrofHARQ-ProcessesForPUSCH*.

Companies are encouraged to provide views on TP#H.

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| Company | Views |
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## TP#I (was from [20] 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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## TP#J (was from [21] LG Electronics)

--------------------------------------------Start of TP#J for TS 38.214 Clause 5.1.3.2 ------------------------------------------------

5.1.3.2 Transport block size determination

In case the higher layer parameter *maxNrofCodeWordsScheduledByDCI* indicates that two codeword transmission is enabled, then one of the two transport blocks is disabled by DCI format 1\_1 if *IMCS* = 26 and if *rvid* = 1 for the corresponding transport block. When the UE is configured with higher layer parameter [*pdsch-TimeDomainAllocationListForMultiPDSCH-r17*] and scheduled with multiple PDSCHs by a DCI, either the first or the second transport block of all scheduled PDSCHs is disabled by the DCI format 1\_1 if *IMCS* = 26 and if *rvid* = 2 for the corresponding transport block of all scheduled PDSCHs. If both transport blocks are enabled, transport block 1 and 2 are mapped to codeword 0 and 1 respectively. If only one transport block is enabled, then the enabled transport block is always mapped to the first codeword.

------------------------------------------------------------End of TP#J----------------------------------------------------------------

[Moderator’s note] TP#J is to capture the corresponding agreement precisely and to align the text (which is added in R1-2200824, based on prior RAN1 agreement regarding TB-disabling mechanism for multi-PDSCH scheduling DCI) with the previous sentence.

Companies are encouraged to provide views on TP#J.

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| Company | Views |
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# Reference

1. R1-2200956 Remaining issues of PDSCH/PUSCH enhancement for 52-71GHz spectrum Huawei, HiSilicon
2. R1-2200990 Remaining issues in PDSCH/PUSCH enhancements for Beyond 52.6GHz FUTUREWEI
3. R1-2201037 Remaining issues for PDSCH/PUSCH enhancements to supporting 52.6-71 GHz band in NR InterDigital, Inc.
4. R1-2201088 Remaining issues on PDSCH/PUSCH enhancements for NR operation from 52.6GHz to 71GHz vivo
5. R1-2201269 Discussion on remaining issue for PDSCH/PUSCH enhancements OPPO
6. R1-2201354 Remaining issues on PDSCH/PUSCH enhancements for up to 71GHz operation CATT
7. R1-2201392 Remaining issues on the data channel enhancements for 52.6 to 71GHz ZTE, Sanechips
8. R1-2201433 Discussion on PDSCH/PUSCH enhancements for NR 52.6-71 GHz Panasonic Corporation
9. R1-2201436 Remaining issues of multi-PDSCH scheduling via a single DCI Fujitsu
10. R1-2201473 Remaining issues on PDSCH/PUSCH enhancements for NR in FR2-2 NTT DOCOMO, INC.
11. R1-2201665 PDSCH/PUSCH enhancements Nokia, Nokia Shanghai Bell
12. R1-2201691 Discussion on PDSCH/PUSCH enhancements for extending NR up to 71 GHz Intel Corporation
13. R1-2201739 PDSCH-PUSCH Enhancements Ericsson
14. R1-2201767 On remaining issues for PDSCH PUSCH Enhancements Apple
15. R1-2201900 Remaining issues on PDSCH enhancement for NR operation from 52.6GHz to 71GHz NEC
16. R1-2201915 Remaining issues on PDSCH and PUSCH enhancements for NR 52.6-71GHz Xiaomi
17. R1-2202007 Maintenance on PDSCH/PUSCH enhancements for NR from 52.6 GHz to 71 GHz Samsung
18. R1-2202074 Remaining discussion on multi-PDSCH scheduling design for 52.6-71 GHz NR operation MediaTek Inc.
19. R1-2202132 PDSCH/PUSCH enhancements for NR in 52.6 to 71GHz band Qualcomm Incorporated
20. R1-2202283 Discussion on multi-PUSCH scheduling ASUSTeK
21. R1-2202338 PDSCH/PUSCH enhancements to support NR above 52.6 GHz LG Electronics
22. R1-2202490 Remaining issues of PDSCH/PUSCH enhancement for 52-71GHz spectrum Huawei, HiSilicon

# 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

### RAN1#107bis-e

**Agreement**

* In NR FR2-2, a UE supporting 32 maximum number of HARQ processes for 480/960 kHz SCS for DL (or for UL) shall support 32 as the maximum number of HARQ processes for 120 kHz SCS for DL (or UL), subject to UE capability.

**Agreement**

* If the higher layer parameter *maxNrofCodeWordsScheduledByDCI* indicates that two codeword transmission is enabled and more than one PDSCH is scheduled by a multi-PDSCH scheduling DCI,
  + Either the first or the second transport block of all scheduled PDSCHs is disabled by the DCI if *IMCS* = 26 and if RV bits are set to ‘1’ for the corresponding transport block of all scheduled PDSCHs (i.e. irrespective of whether this is a valid PDSCH).

**Conclusion**

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

**Conclusion**

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.

**Agreement**

* 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~~

**Agreement**

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.

**Conclusion**

* UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCIs 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.
* Note: It is separately discussed whether the scheduled PDSCHs (or PUSCHs or SLIV) is based on configured SLIV or valid SLIV.

**Conclusion**

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

**Agreement**

For a DCI that can schedule multiple PDSCHs or multiple PUSCHs,

* It is clarified that NDI/RV fields in the following previous agreements correspond to scheduled PDSCHs indicated by the TDRA information field.

|  |
| --- |
| 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   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 signalled per PDSCH and applies to the 2nd TB of each PDSCH * RV for the 2nd TB: This is signalled 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 |

* Above clarification also applies to the DCI scheduling multiple PUSCHs, i.e., NDI/RV fields in the DCI correspond to scheduled PUSCHs indicated by the TDRA information field.
* The following example change to 38.214 Sections 5.1.3 and 6.1.4 can be recommended to the editor of 38.214 to use at the editor’s discretion

---------------------------Start of TP for TS 38.214 Clause 5.1.3 -----------------------------------------------

5.1.3 Modulation order, target code rate, redundancy version and transport block size determination

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

When the UE is scheduled with multiple PDSCHs by a DCI, as described in clause 5.1.2.1, the bits of *rv* field and NDI field, respectively, in the DCI are one-to-one mapped to the scheduled PDSCH(s) indicated by the TDRA information field with the corresponding transport block(s) in the scheduled order, where the LSB bits of the *rv* field and NDI field, respectively, correspond to the last scheduled PDSCH indicated by the TDRA information field.

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

---------------------------Start of TP for TS 38.214 Clause 6.1.4 -----------------------------------------------

6.1.4 Modulation order, redundancy version and transport block size determination

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

When the UE is scheduled with multiple PUSCHs by a DCI, as described in clause 6.1.2.1, the bits of *rv* field and NDI field, respectively, in the DCI are one to one mapped to the scheduled PUSCH(s) indicated by the TDRA information field with the corresponding transport block(s) in the scheduled order where the LSB bits of the *rv* field and NDI field, respectively, correspond to the last scheduled PUSCH indicated by the TDRA information field.

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

**Conclusion**

It is clarified that the absence or presence of CBGTI field in the following previous agreement is determined based on scheduled PUSCHs indicated by the TDRA information field (i.e. irrespective of whether this is a valid PUSCH).

|  |
| --- |
| 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**

A UE validates, for scheduling activation or scheduling release, a DL SPS assignment PDCCH or a configured UL grant Type 2 PDCCH if the PDCCH indicates a TDRA row index including only one SLIV.

**Agreement**

For type-1 HARQ-ACK codebook, if , the UE determines a number of HARQ-ACK information bits for obtaining a transmission power for a PUCCH, as follows.

* For a serving cell *c* configured with *enableTimeDomainHARQ-Bundling*, and for a DCI format indicating a TDRA row that includes more than one SLIV entry on the serving cell *c*, the UE considers a PDSCH (which carries one or two transport blocks enabled by the DCI format irrespective of whether the PDSCH is valid or not) only associated with the last SLIV as received, to determine .