**3GPP TSG RAN WG1 #107-e R1-211xxxx**

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

**Agenda Item:** 8.2.5

**Source:** Moderator (LG Electronics)

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

**Document for:** Discussion and decision

# Introduction

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

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

[107-e-NR-52-71GHz-06] Email discussion/approval on scheduling particularly w.r.t. multi-PDSCH/PUSCH with a single DCI, HARQ, with checkpoints for agreements on November 15 and 19 – Seonwook (LGE)

# Multi-PDSCH/PUSCH scheduling

## CBG-based (re)transmission

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| Company | Views |
| [3] vivo | Proposal 6: For CBG based scheduling, the same behaviour for multi-PUSCH scheduling with 120 kHz SCS is applied to 480/960 kHz SCS as well, i.e., CBG based scheduling is supported only when a DCI schedules a single PUSCH.Proposal 7: For multi-PDSCH scheduling, do not support CBG based scheduling for 120/480/960 kHz SCS. |
| [10] Panasonic | Proposal 2: For SCSs of 480 kHz and 960 kHz, for a DCI that can schedule multiple PUSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs,* If CBG-based (re)transmission is configured, CBGTI field is not present when more than one PUSCHs are scheduled, but is present when a single PUSCH is scheduled, as in Rel. 16.

Proposal 3: For SCSs of 120 kHz, 480 kHz, and 960 kHz, for a DCI that can schedule multiple PDSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs,* If CBG-based (re)transmission is configured, CBGTI/CBGFI fields are not present when more than one PDSCHs are scheduled, but are present when a single PUSCH is scheduled, as in Rel. 16.
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| [11] Ericsson | Proposal 6: For 480/960 kHz SCS, for a DCI that can schedule single and/or multiple PUSCHs, configuration of CBG-based (re)-transmission is not supported, and thus the CBGTI fields is not present.Proposal 7: For a DCI that can schedule single and/or multiple PDSCHs, configuration of CBG-based (re)-transmission is not supported, and thus the CBGTI and CBGFI fields are not present |
| [12] Intel | Proposal 1 * For multi-PDSCH/PUSCH scheduling, CBG based transmission is supported for 120/480/960kHz subcarrier spacing when a single PDSCH/PUSCH is scheduled.
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| [16] Samsung | Proposal 6: For multi-PUSCH scheduling DCI: * CBG:
	+ Not support CBG-based transmission for single and multi-PUSCH scheduling for 480/960 KHz.
	+ Not support CBG-based transmission for multi-PUSCH scheduling for 120KHz, but applicable for single-PUSCH scheduling for 120KHz.
* Frequency hopping: Support intra-PUSCH hopping
* FDRA: Support increased RBG size using the same mechanism introduced in Rel-16 URLLC

Proposal 7: For multi-PDSCH scheduling, the bit field common for DL and UL grant use the same design as multi-PUSCH scheduling, and at least following DL-specific bit field should be specified,* CBG-based transmission is not applicable to single and multi-PDSCH scheduling
* HARQ-ACK relevant bit field is applicable to all PDSCHs and single PUCCH
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| [17] InterDigital | Proposal 5: For 480/960 kHz SCS, apply the same behavior of 120 kHz SCS for CBGTI field configuration in the DCI that can schedule multiple PUSCHs, i.e., if CBG-based (re)transmission is configured, CBGTI field is not present when more than one PUSCHs are scheduled, but is present when a single PUSCH is scheduled, as in Rel-16. Proposal 6: The same behavior of multi PUSCH could be applied for CBGTI/CBGFI fields when a DCI schedule multiple PDSCHs, i.e., CBGTI/CBGFI fields are not present if multiple PDSCHs are scheduled, but present if only one PDSCH is scheduled. |
| [18] Apple | Proposal 4: For Rel-17 multi-PUSCH transmission* The maximum number of PUSCHs that can be scheduled can be further restricted based on UE capabilities.
* For 480 kHz and 960 kHz SCS, no support for CBGTI field configuration in the DCI that can schedule multiple PUSCHs
* The FDRA size should be optimized to reduce the FDRA overhead.
* Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz

Proposal 5: For Rel-17 multi-PDSCH transmission* The maximum number of PDSCHs that can be scheduled can be further restricted based on UE capabilities.
* For a DCI that can schedule multiple PDSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs, do not support/configure CBGTI/CBGFI fields
* The FDRA size should be optimized to reduce the FDRA overhead.
* Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz
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| [19] LG Electronics | Proposal #5: For multi-PDSCH scheduling DCI, CBGTI/CBGFI cannot be configured, for 120/480/960 kHz SCSs.Proposal #6: For multi-PUSCH scheduling DCI, if CBG-based (re)transmission is configured, CBGTI is not present when more than one PUSCH is scheduled, but is present when a single PUSCH is scheduled, for 120/480/960 kHz SCSs. |
| [20] NTT DOCOMO | Proposal 1: * For multi-PUSCH scheduled by single DCI,
	+ CBG based scheduling is not supported when multiple PUSCHs are scheduled by one DCI.
	+ Support frequency hopping for multi-PUSCH scheduling, by reusing existing PUSCH frequency hopping scheme, i.e. intra-slot PUSCH frequency hopping.
* For multi-PDSCH scheduled by single DCI,
	+ CBG based scheduling is not supported when multiple PDSCHs are scheduled by one DCI.
	+ For two-TB scheduling, support limitation on the maximum number of PDSCHs when 2-TB is scheduled. When RRC parameter enables two TB scheduling,
		- If the number of scheduled PDSCHs is no larger than value X (X>1), two TBs can be scheduled for each PDSCH.
		- If the number of scheduled PDSCHs is larger than value X (X>1), only single TB can be scheduled for each PDSCH.
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| [22] MediaTek | Proposal 3: CBG (re)transmission feature for 480kHz and 960kHz is not supported in FR2-2. |

### Issue 2.1-1) CBGTI field in multi-PUSCH scheduling DCI:

Agreement: (RAN1#105-e)

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

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

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

[Moderator’s note] According to the slight majority view, the following proposal can be made. It is noted that the support of CBGTI field for multi-PUSCH scheduling DCI doesn’t lead to additional specification impact. This issue is indicated as “HIGH” since it is essential for WI completion.



### [HIGH] Proposal #2.1-1 (CBG for UL):

* In addition to 120 kHz SCS, for 480/960 kHz SCS, for a DCI that can schedule multiple PUSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs,
	+ If CBG-based UL (re)transmission is configured, CBGTI field is not present when more than one PUSCH are scheduled, but is present when a single PUSCH is scheduled, as in Rel-16.
	+ Note: Specification impact is not expected.

Companies are encouraged to provide views on Proposal #2.1-1.

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| Company | Views |
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### Issue 2.1-2) CBGTI/CBGFI field in multi-PDSCH scheduling DCI:

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

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

* Same behaviour as in Rel-16
	+ Supported by Panasonic, Intel, InterDigital, NTT DOCOMO
* Do not support CBGTI/CBGFI field configuration for multi-PDSCH scheduling DCI for 120/480/960 kHz
	+ Supported by vivo, Ericsson, Samsung, Apple, LG Electronics, MediaTek

[Moderator’s note] According to the slight majority view and working assumption as captured above, the following proposal can be made. This issue is indicated as “HIGH” since it is essential for WI completion.

### [HIGH] Proposal #2.1-2 (CBG for DL):

* If a UE configured with a DCI that can schedule multiple PDSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs, for a serving cell,
	+ The UE does not expect to be configured with CBG-based DL (re)transmission for the serving cell, and CBGTI and CBGFI fields are not present in the DCI.

Companies are encouraged to provide views on Proposal #2.1-2.

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| Company | Views |
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## Frequency hopping

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| Company | Views |
| [3] vivo | Proposal 10: For frequency hopping for multi-PUSCH scheduling, only intra-slot frequency hopping is applicable, and is applied to each scheduled PUSCH when configured and enabled, while inter-slot frequency hopping is inapplicable. |
| [11] Ericsson | Proposal 8: Support intra-slot frequency hopping for multi-PUSCH in Rel-17. |
| [12] Intel | Proposal 4* For multi-PDSCH scheduling,
	+ Up to 8 PDSCHs can be configured and scheduled for 2 TBs.
* For multi-PUSCH scheduling,
	+ Support intra-slot frequency hopping for scheduled PUSCHs.
	+ Do not support enhancement on FDRA.
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| [13] Xiaomi | Proposal 5: Support to study intra-TTI frequency hopping and its enabling mechanism for multi-TTI scheduling. |
| [16] Samsung | Proposal 6: For multi-PUSCH scheduling DCI: * CBG:
	+ Not support CBG-based transmission for single and multi-PUSCH scheduling for 480/960 KHz.
	+ Not support CBG-based transmission for multi-PUSCH scheduling for 120KHz, but applicable for single-PUSCH scheduling for 120KHz.
* Frequency hopping: Support intra-PUSCH hopping
* FDRA: Support increased RBG size using the same mechanism introduced in Rel-16 URLLC
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| [17] InterDigital | Proposal 10: When multiple PUSCHs are scheduled using the same DCI, support only intra-slot frequency hopping |
| [18] Apple | Proposal 4: For Rel-17 multi-PUSCH transmission* The maximum number of PUSCHs that can be scheduled can be further restricted based on UE capabilities.
* For 480 kHz and 960 kHz SCS, no support for CBGTI field configuration in the DCI that can schedule multiple PUSCHs
* The FDRA size should be optimized to reduce the FDRA overhead.
* Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz
 |
| [20] NTT DOCOMO | Proposal 1: * For multi-PUSCH scheduled by single DCI,
	+ CBG based scheduling is not supported when multiple PUSCHs are scheduled by one DCI.
	+ Support frequency hopping for multi-PUSCH scheduling, by reusing existing PUSCH frequency hopping scheme, i.e. intra-slot PUSCH frequency hopping.
* For multi-PDSCH scheduled by single DCI,
	+ CBG based scheduling is not supported when multiple PDSCHs are scheduled by one DCI.
	+ For two-TB scheduling, support limitation on the maximum number of PDSCHs when 2-TB is scheduled. When RRC parameter enables two TB scheduling,
		- If the number of scheduled PDSCHs is no larger than value X (X>1), two TBs can be scheduled for each PDSCH.
		- If the number of scheduled PDSCHs is larger than value X (X>1), only single TB can be scheduled for each PDSCH.
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### Summary (on frequency hopping):

Company views on frequency hopping enhancement:

* Intra-slot frequency hopping
	+ Supported by: vivo, Ericsson, Intel, Samsung, InterDigital, NTT DOCOMO
* Inter-slot frequency hopping
	+ Supported by: Apple

[Moderator’s note] Even though the clarification on frequency hopping for multi-PUSCH scheduling in Rel-16 has not yet been resolved, it seems to be a common sense that intra-slot frequency hopping is supported for multi-PUSCH scheduling in Rel-16. For Rel-17 multi-PUSCH scheduling case, a majority of companies suggested to support intra-slot PUSCH hopping, so the following proposal can be made. This issue is indicated as “HIGH” since it is essential for WI completion.

### [HIGH] Proposal #2.2 (FH):

* 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.

Companies are encouraged to provide views on Proposal #2.2.

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| Company | Views |
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## 2-TB transmission

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| Company | Views |
| [1] Huawei | Proposal 6: No limitation on the maximum number of PDSCHs when 2 TB is enabled or when 2 TB is scheduled. |
| [2] Futurewei | Proposal 5. No further restriction on the number of PDSCHs is needed when 2-TB is enabled or scheduled. |
| [3] vivo | Proposal 11: When two-codeword transmission is enabled, the maximum number of configured SLIVs in a row of TDRA table for multi-PDSCH scheduling can be further restricted.Proposal 12: Regarding TB disabling for multi-PDSCH scheduling, when two codeword transmission is configured, for a DCI format scheduling more than one PDSCH, a given TB can be disabled for each scheduled PDSCH individually, by setting IMCS = 26 and the 1-bit RV for a scheduled PDSCH to a predefined value, e.g. ‘1’, to indicated the given TB for the scheduled PDSCH is disabled. |
| [4] ZTE | Proposal 1: The maximum number of PDSCHs can be restricted as 2 or 4 when 2 TB is actually scheduled. |
| [6] Nokia | Proposal 3: UE can be scheduled for up-to 8 PDSCHs also when 2 TB is enabled or 2 TB is scheduled. |
| [7] CATT | Proposal 8: The gNB can implement limitation on maximum number of PDSCHs when 2 TB is enabled or when 2 TB is scheduled, and there is no further specification needed. |
| [11] Ericsson | Proposal 9: Do not introduce a constraint on the maximum number of PDSCHs that can be scheduled by a DCI when 2 TB is enabled or when 2 TB is scheduled. |
| [12] Intel | Proposal 4* For multi-PDSCH scheduling,
	+ Up to 8 PDSCHs can be configured and scheduled for 2 TBs.
* For multi-PUSCH scheduling,
	+ Support intra-slot frequency hopping for scheduled PUSCHs.
	+ Do not support enhancement on FDRA.
 |
| [16] Samsung | Proposal 5: If two codeword transmission is supported and enabled for FR2-2, the maximum configured number of PDSCHs in a row of TDRA table in a DCI format scheduling multi-PDSCH is limited to 2. |
| [19] LG Electronics | Proposal #8: For NR FR2-2, if 2-TB is enabled, 2-TB transmission can be allowed only when a DCI schedules up to N (e.g., N=1) PDSCH(s).Proposal #9: Discuss how to disable one of 2 TBs if 2-TB is enabled and 2 TB transmission is allowed for the case where more than one PDSCH is scheduled by multi-PDSCH scheduling DCI. |
| [20] NTT DOCOMO | Proposal 1: * For multi-PUSCH scheduled by single DCI,
	+ CBG based scheduling is not supported when multiple PUSCHs are scheduled by one DCI.
	+ Support frequency hopping for multi-PUSCH scheduling, by reusing existing PUSCH frequency hopping scheme, i.e. intra-slot PUSCH frequency hopping.
* For multi-PDSCH scheduled by single DCI,
	+ CBG based scheduling is not supported when multiple PDSCHs are scheduled by one DCI.
	+ For two-TB scheduling, support limitation on the maximum number of PDSCHs when 2-TB is scheduled. When RRC parameter enables two TB scheduling,
		- If the number of scheduled PDSCHs is no larger than value X (X>1), two TBs can be scheduled for each PDSCH.
		- If the number of scheduled PDSCHs is larger than value X (X>1), only single TB can be scheduled for each PDSCH.
 |
| [21] Qualcomm | Proposal 16: To indicate that the second TB is disabled for a certain DCI that schedules multiple PDSCHs, use a combination of MCS and rv­id such that rvid bit of PDCSH i-1 is the complement of the one of PDSCH i for i=1 : number of maximum PDSCHs -1.Proposal 17: Do not introduce additional limitations on the maximum number of PDSCHs when 2 TB is enabled or when 2 TB is scheduled. |

### Issue 2.3-1) Whether or not to restrict the maximum number of PDSCHs when 2 TB is enabled or scheduled:

Agreement: (RAN1#106bis-e)

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

Company views on whether or not to restrict the maximum number of PDSCHs when 2 TB is enabled or scheduled:

* No restriction
	+ Supported by Huawei, Futurewei, Nokia, CATT, Ericsson, Intel, Qualcomm
* Up to X SLIVs can be configured for multi-PDSCH scheduling DCI
	+ Supported by vivo, Samsung (X=2)
* 2-TB can be scheduled only if up to N PDSCHs are scheduled, but 1-TB is scheduled otherwise
	+ Supported by ZTE (N=2 or 4), LG Electronics, NTT DOCOMO

[Moderator’s note] Considering the majority view, the following proposal can be made. This issue is indicated as “HIGH” since it is essential for WI completion.

### [HIGH] Proposal #2.3-1 (2-TB TX):

* The maximum number of PDSCHs/PUSCHs 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.

Companies are encouraged to provide views on Proposal #2.3-1.

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### Issue 2.3-2) TB-disabling mechanism:

[Moderator’s note] Several companies (vivo, LG Electronics, and Qualcomm) brought up the issue on how to disable a TB when bit-width of RV field corresponding to a PDSCH is one and the RV field cannot indicate RV index 1. In Rel-15 NR, one TB between two TBs can be disabled when MCS=26 & RV index=1. To resolve this issue, the following three alternatives are identified:

* Alt 1 in [3]: For the M bits for indicating RV information for a given TB in a DCI format scheduling more than one PDSCH, a predefined value vector can be used to indicate the given TB is disabled for all PDSCHs scheduled by the DCI format, e.g. assuming M = 8, the 8-bit RV corresponding to a TB in the DCI format can be set to ‘11111111’ to indicate the TB is disabled for all PDSCHs scheduled by the DCI format.
* Alt 2 in [3]: For each PDSCH scheduled by a DCI format scheduling more than one PDSCH, a given TB can be disabled individually, i.e. a 1-bit RV for the given TB and for a PDSCH scheduled by the DCI format can be set to a predefined value, e.g. ‘1’, to indicate the given TB of the PDSCH is disabled.
* Alt 3 in [21]: To indicate that the second TB is disabled for a certain DCI that schedules multiple PDSCHs, use a combination of MCS and rv­id such that rvid bit of PDCSH i-1 is the complement of the one of PDSCH i for i=1 : number of maximum PDSCHs -1

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

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| Company | Views |
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## FDRA enhancement

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| Company | Views |
| [3] vivo | Proposal 5: Legacy frequency domain scheduling in NR Rel-15/16 is reused for multi-PUSCH/PDSCH scheduling. |
| [10] Panasonic | Proposal 4: No need to have the optimization of FDRA size. |
| [11] Ericsson | Proposal 4: Introduce new RBG configuration for PDSCH/PUSCH frequency resource allocation Type 0 to reduce FDRA granularity and DCI size.Proposal 5: Support configurable Resource Allocation Granularity (P) up to 32 for DCI Format 0\_1 and 1\_1 with PUSCH/PDSCH frequency resource allocation Type 1 to reduce FDRA granularity and DCI size. |
| [12] Intel | Proposal 4* For multi-PDSCH scheduling,
	+ Up to 8 PDSCHs can be configured and scheduled for 2 TBs.
* For multi-PUSCH scheduling,
	+ Support intra-slot frequency hopping for scheduled PUSCHs.
	+ Do not support enhancement on FDRA.
 |
| [13] Xiaomi | Observation 1: The current DCI 0-2/1-2 can be reused to allow frequency domain resource by multi-PRB granularity. |
| [16] Samsung | Proposal 6: For multi-PUSCH scheduling DCI: * CBG:
	+ Not support CBG-based transmission for single and multi-PUSCH scheduling for 480/960 KHz.
	+ Not support CBG-based transmission for multi-PUSCH scheduling for 120KHz, but applicable for single-PUSCH scheduling for 120KHz.
* Frequency hopping: Support intra-PUSCH hopping
* FDRA: Support increased RBG size using the same mechanism introduced in Rel-16 URLLC
 |
| [17] InterDigital | Observation 3: It is observed that required payloads of DCI for frequency domain resource allocation do not increase as maximum number of RBs does not increase.Observation 4: Larger RB size reduces frequency domain resource allocation flexibility, and this may be a crucial disadvantage as higher SCSs occupies larger bandwidths than lower SCSs with the same RBG size.Proposal 11: The benefits from frequency domain resource allocation enhancements should be carefully evaluated. |
| [18] Apple | Proposal 4: For Rel-17 multi-PUSCH transmission* The maximum number of PUSCHs that can be scheduled can be further restricted based on UE capabilities.
* For 480 kHz and 960 kHz SCS, no support for CBGTI field configuration in the DCI that can schedule multiple PUSCHs
* The FDRA size should be optimized to reduce the FDRA overhead.
* Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz

Proposal 5: For Rel-17 multi-PDSCH transmission* The maximum number of PDSCHs that can be scheduled can be further restricted based on UE capabilities.
* For a DCI that can schedule multiple PDSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs, do not support/configure CBGTI/CBGFI fields
* The FDRA size should be optimized to reduce the FDRA overhead.
* Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz
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### Summary on FDRA enhancement:

Company views on FDRA enhancement:

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

[Moderator’s note] Given the low interest from companies, we can conclude that FDRA enhancement is deprioritized in this release. This issue is indicated as “HIGH” since it is essential for WI completion.

### [HIGH] Proposed conclusion #2.4 (FDRA):

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

Companies are encouraged to provide views on Proposed conclusion #2.4.

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## TDRA enhancement

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| Company | Views |
| [11] Ericsson | Proposal 3: If the UE is configured with a TDRA table in which one or more rows contains multiple SLIVs, the UE is not expected to be configured with legacy single TRP PDSCH/PUSCH repetition. Legacy single-TRP repetition refers to either Rel-15 repetition through configuration of pdsch-AggregationFactor / pusch-AggregationFactor, or Rel-16 repetition through configuration of repetitionNumber / numberOfRepetitions within the TDRA table. |
| [21] Qualcomm | Proposal 11: Support the ability to schedule a single TB to be repeated over multiple allocations and multiple TBs, with no repetitions, using the same DCI format.  |

### Summary on TDRA enhancement:

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

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

[Moderator’s note] Although the number of inputs is quite small, this issue needs to be figured out. Ericsson’s approach seems straight-forward and aligned with Rel-16 multi-PUSCH DCI design. With this regard, the following proposal can be made. This issue is indicated as “HIGH” since it is related to RRC parameter discussion.

### [HIGH] Proposal #2.5 (TDRA):

* If a UE is configured with a TDRA table in which one or more rows contain multiple SLIVs, the UE does not expect to be configured with *pdsch-AggregationFactor* or *repetitionNumber* for PDSCH, and with *pusch-AggregationFactor* or *numberOfRepetitions* for PUSCH.
	+ 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*.

Companies are encouraged to provide views on Proposal#2.5.

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## Out-of-order handling

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| Company | Views |
| [1] Huawei | Proposal 7: Legacy specification could be used with minimum change if regarding the first valid PDSCH/PUSCH of multiple PDSCH/PUSCH scheduling by single DCI as the “first PDSCH/PUSCH” in current specification for OOO scheduling restriction. |
| [2] Futurewei | Proposal 7. Regarding data, consider allowing for SCS 480/960kHz the out-of-order scheduling for the case of one multi-PxSCH scheduling DCI and one single-PxSCH scheduling DCI, where multi-PxSCH scheduling DCI schedules more than one PxSCH, i.e., the single PxSCH scheduled by its DCI starting later than the multi-PxSCH scheduling DCI can be scheduled before the last PxSCH of the multi-PxSCH. Proposal 8. Regarding HARQ, only consider allowing for SCS 480kHz/960kHz the out-of-order scheduling for a PDSCH scheduled by multi-PDSCH scheduling DCI and other unicast PDSCH scheduled by single-PDSCH scheduling DCI if the range of k1 is to be notably extended. Proposal 9. Consider allowing OOO scheduling for SCS 480/960kHz for the case where two multi-PxSCH scheduling DCIs end in the same symbol but two multi-PxSCH scheduling DCIs have overlapping spans. |
| [3] vivo | Proposal 9: For multi-PDSCH scheduling, UE does not expect any of the scheduled/SPS PDSCHs and the resource for the HARQ-ACK transmission to lead to out-of-order scheduling. |
| [4] ZTE | Proposal 2: It is not recommended to introduce additional specification impact to handle the two cases listed in FFS except existing OOO rule. |
| [7] CATT | Proposal 6: For scheduling multi-PDSCH (or multi-PUSCH), the following two OOO cases are not supported.* 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
 |
| [9] OPPO | Proposal 1: Support scheduling of the following case: * One multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH), and the single-PDSCH (or single-PUSCH) is transmitted at least later than the first PDSCH (or PUSCH) of the multi-PDSCH (or multi-PUSCH).

Proposal 2: Do not specify the following case:* Two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV.
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| [10] Panasonic | Proposal 5: For the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, support the single-PDSCH (or single-PUSCH) scheduling DCI having higher priority than the multi-PDSCH (or multi-PUSCH) scheduling DCI* FFS on details of scheduling and out-of-order handling.

Proposal 6: For the case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol, but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, UE does not expect any of the scheduled PDSCHs (or PUSCHs) to lead to out-of-order scheduling.Proposal 7: For multi-PDSCH scheduling, UE does not expect any of the scheduled/SPS PDSCHs and the resource for the HARQ-ACK transmission lead to out-of-order scheduling. |
| [11] Ericsson | Proposal 11: Out-of-Order scheduling is allowed for the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH).Proposal 12: Out-of-Order scheduling is NOT allowed for the case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV. |
| [12] Intel | Figure 2Figure 3 Proposal 5* For two PDCCHs and the associated PDSCH(s) and PUSCH(s), if at least one PDCCH is scheduling multiple PDSCHs/PUSCHs, referring to Figure 2,
	+ Case A/B/C/D are invalid;
	+ The existing specification should be updated to reflect that Case A/C are invalid
* For two PDSCHs and associated PUCCH, if at least one PDSCH is of multiple PDSCHs/PUSCHs, referring to Figure 3,
	+ Case F/G are valid, and Case H/I is invalid.
	+ The existing specification is sufficient for cases F/G/H/I.
 |
| [15] NEC | Proposal 1: Allow the scheduling case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but scheduled PDSCHs (or PUSCHs) are interlaced |
| [16] Samsung | Proposal 11: For single PDSCH (or PUSCH) scheduling DCIs and multi-PDSCH (or multi-PUSCH) scheduling DCIs, UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCIs to lead to out-of-order scheduling.Observation 1: SPS PDSCH reception has large scheduling restriction on multi-PDSCH scheduling.Proposal 12: UE is not expected to receive a SPS PDSCH if the SPS PDSCH is configured to be received between a PDCCH with a DCI scheduling multiple PDSCHs and the last PDSCH scheduled by the DCI. |
| [18] Apple | Proposal 7: To simplify UE implementation, we propose that for the DCI-to-data out of order issue, the UE does not expect any out-of-order scheduling for the following cases:* for the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH).
* for the case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV

Proposal 8: 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] LG Electronics | Proposal #10: For one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCI to lead to out-of-order scheduling.Proposal #11: For the case where two DCIs end in 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. |
| [20] NTT DOCOMO | Proposal 2: The following two cases are OoO scheduling, and should not be allowed:* the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH).
* the case where two multi-PDSCH (or multi-PUSCH) scheduling DCIs end in the same symbol but two multi-PDSCH (or multi-PUSCH) scheduling DCIs have overlapping spans, where the span is defined from the beginning of the first scheduled SLIV till the end of the last scheduled SLIV.
 |
| [21] Qualcomm | Proposal 19: 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. |
| [22] MediaTek | Proposal 6: For the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, UE doesn’t expect any of the scheduled PDSCHs(or PUSCHs) and the scheduling DCI lead to out-of-order scheduling.Proposal 7: For multi-PDSCH scheduling, UE doesn’t expect any of the scheduled PDSCHs and the resource for the HARQ-ACK transmission lead to out-of-order scheduling. |

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

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

Agreement: (RAN1#106bis-e)

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

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

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

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

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

### Proposal #2.6-1 (DCI-to-data OOO):

* UE does not expect any of the scheduled PDSCHs (or PUSCHs) and the scheduling DCI to lead to out-of-order scheduling, also for the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI, where multi-PDSCH (or multi-PUSCH) scheduling DCI schedules more than one PDSCH (or PUSCH)
* 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.

Companies are encouraged to provide views on Proposal #2.6-1.

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

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

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

* For multi-PDSCH scheduling, UE does not expect any of the scheduled/SPS PDSCHs and the resource for the HARQ-ACK transmission to lead to out-of-order scheduling.
	+ Supported by vivo, Panasonic, Apple, MediaTek
	+ Futurewei and Ericsson suggested to allow PDSCH-to-HARQ-ACK out-of-order scheduling for the case of one multi-PDSCH (or multi-PUSCH) scheduling DCI and one single-PDSCH (or single-PUSCH) scheduling DCI
* UE is not expected to receive a SPS PDSCH if the SPS PDSCH is configured to be received between a PDCCH with a DCI scheduling multiple PDSCHs and the last PDSCH scheduled by the DCI.
	+ Supported by Samsung

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

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## Maximum gap between PDSCHs/PUSCHs

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| Company | Views |
| [2] Futurewei | Proposal 6. It can be beneficial under unlicensed operation to restrict the maximal allowable gap values between adjacent PxSCHs according to the practical needs to avoid excessively large gaps that negatively impact the latency/throughput of the system or triggers additional requirement for LBT. |
| [6] Nokia | Proposal 2: The maximum gap between scheduled PDSCHs/PUSCH does not require additional impact on specification |
| [10] Panasonic | Proposal 1: For TDRA in a DCI that can schedule multiple PDSCHs (or PUSCHs),* The maximum value of the gap between two consecutively scheduled PDSCHs or between two consecutively scheduled PUSCHs is 2 slots,
* The maximum number of gaps is 2.
 |
| [11] Ericsson | Proposal 2: Do not introduce constraints on maximum value of the gap between two consecutively scheduled PDSCHs/PUSCHs or maximum value of the gap between the first and the last scheduled PDSCH/PUSCH other than that inherently provided by the range of K0/K2 value. |
| [14] Lenovo | Proposal 2: For NR operation between 52.6 GHz and 71 GHz, when multiple PDSCHs/PUSCHs can be scheduled by a single DCI, then only the maximum allowed gap between first and last PDSCH/PUSCH is defined, or alternatively, maximum duration to contain all the scheduled PDSCHs/PUSCHs can be defined (in case of non-contiguous allocation)* Maximum allowed gap between two adjacent PDSCHs/PUSCHs need not be defined as network implementation can handle it under the constraint that all the scheduled PDSCHs/PUSCHs are contained within the maximum allowed gap between first and last PDSCH/PUSCH

Proposal 3: For NR operation between 52.6 GHz and 71 GHz, when multiple PDSCHs/PUSCHs can be scheduled by a single DCI, one value to define the maximum allowed gap between first and last PDSCH/PUSCH for each of the SCS value can be defined |
| [17] InterDigital | Proposal 9: As all scheduled PDSCHs/PUSCHs should be transmitted within the channel coherent time, the maximum value of the gap between the first scheduled PDSCH and the last scheduled PDSCH or between the first scheduled PUSCH and the last scheduled PUSCH should be carefully selected. |
| [18] Apple | Proposal 6: On the maximum gap for PxSCH transmission:* The maximum gap between the first and last PxSCH transmissions should be selected (a) based on the maximum values of k0 and k2 i.e. 128 slots and (b) account for the use of a single MCS in the DCI.
* The maximum gap between two consecutive transmissions, can be set to the maximum value between the first and the last transmission in a 2 PDSCH/PUSCH transmission i.e. 128 slots.
 |
| [19] LG Electronics | Observation #1: Adjustment of the gap between PDSCHs (or PUSCHs) for multi-PDSCH (or multi-PUSCH) scheduling DCI can be left up to network implementation. |
| [21] Qualcomm | Proposal 9: Define the maximum slot gap between any two SLIVs, it can be either SCS dependent or fixed values for all SCSs. Proposal 10: Define a maximum allowed span per single DCI as X slots, where X >= 8. |
| [22] MediaTek | Proposal 5: For multi-PDSCH scheduling, if M PDSCHs are scheduled by a DCI, the M PDSCHs should be contained within at most M consecutive slots |

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

Agreement: (RAN1#105-e)

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

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

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

* Between two consecutively scheduled PDSCHs or between two consecutively scheduled PUSCHs
	+ No additional impact on specification: Nokia, Ericsson, Lenovo, Apple?, LG Electronics
	+ To be specified: Futurewei, Panasonic (2 slots), Qualcomm
* Between the first scheduled PDSCH and the last scheduled PDSCH or between the first scheduled PUSCH and the last scheduled PUSCH
	+ No additional impact on specification: Nokia, Ericsson, LG Electronics
	+ To be specified: Lenovo, Apple, Qualcomm (>= 8 slots), MediaTek (M slot span for M PXSCHs)

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

### Proposed conclusion #2.7 (Max gap):

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

Companies are encouraged to provide views on Proposed conclusion #2.7.

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

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| Company | Views |
| [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.
 |
| [13] Samsung | Proposal 13: * 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 SSB
* If a PUSCH among multiple PUSCHs that are scheduled by a single DCI is collided with SSB symbols indicated by ssb-PositionsInBurst, the UE does not transmit the PUSCH
 |
| [19] LG Electronics | Proposal #1: If one of multiple PUSCHs scheduled by the DCI collides with a flexible symbol (indicated by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated), and if that 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 skipped for the PUSCH.Proposal #2: If a PDSCH among multiple PDSCHs that are scheduled by a single DCI is collided with uplink symbol(s) indicated by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated, NDI/RV fields corresponding to the PDSCH are absent in the DCI.Proposal #3: If a PUSCH among multiple PUSCHs that are scheduled by a single DCI is collided with downlink symbol(s) indicated by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated, NDI/RV fields corresponding to the PUSCH are absent in the DCI.Proposal #4: Discuss in which PUSCH aperiodic CSI report is included if M-th or (M-1)-th scheduled PUSCH is cancelled due to the collision with semi-static DL symbols. |
| [20] NTT DOCOMO | Proposal 3: If multiple PUSCHs are scheduled by single DCI, and there is at least one PUSCH collides with semi-static DL symbol, and/or symbol configured for SSB or CORESET#0 reception, * OoO scheduling limitation is based on valid PUSCHs.
* If CBG based transmission is configured, CBGTI field is present in DCI for the case when multiple PUSCHs are scheduled but only one PUSCH is valid.
* A-CSI reporting triggered by multi-PUSCH scheduling DCI is based on valid PUSCHs. When the A-CSI triggering DCI schedules N valid PUSCHs, the PUSCH that carries the aperiodic CSI feedback is N-th valid PUSCH for N <= 2, or (N-1)-th valid PUSCH for N > 2.
* When timeline is satisfied, the CG PUSCH overlapping with the cancelled DG PUSCH can be transmitted.
* When timeline is satisfied, the CG PUSCH with same HARQ process ID as the cancelled DG PUSCH can be transmitted.

Proposal 4: If multiple PDSCHs are scheduled by single DCI, and there is at least one PDSCH collides with semi-static UL symbol,* OoO scheduling limitation is based on valid PDSCHs.
* If CBG based transmission is configured, CBGTI/CBGFI fields are present in DCI for the case when multiple PDSCHs are scheduled but only one PDSCH is valid.
* DCI scheduling multiple PDSCHs but with only one valid PDSCH is included in the first sub-codebook.
* When timeline is satisfied, the SPS PDSCH overlapping with the cancelled DG PDSCH can be received.
 |
| [21] Qualcomm | Proposal 13: 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 18: For a single DCI that schedules multi-PDSCH/PUSCH, the NDI/ RV should be signaled per SLIV, i.e., a single bit will be assumed for each SLIV in NDI or RV vector even if the corresponding PDSCH/PUSCH is not valid. |

### Issue 2.8-1) How to handle collision between PUSCH and CORESET#0:

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).

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 Samsung, LG Electronics
	+ Objected by Intel

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

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| Company | Views |
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### Issue 2.8-2) Clarification on whether “scheduled PXSCH” in previous agreements implies valid PXSCH or not:

Agreement: (RAN1#104-bis)

For a DCI that can schedule multiple PDSCHs,

* NDI for the 1st TB: This is signaled per PDSCH and applies to the first TB of each PDSCH
* RV for the 1st TB: This is signaled per PDSCH, with 2 bits if only a single PDSCH is scheduled or 1 bit for each PDSCH otherwise and applies to the first TB of each PDSCH

Conclusion: (RAN1#105-e)

For a DCI that can schedule multiple PUSCHs,

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

Agreement: (RAN1#105-e)

* At least for 120 kHz SCS, for a DCI that can schedule multiple PUSCHs and is configured with the TDRA table containing at least one row with multiple SLIVs,
	+ If CBG-based (re)transmission is configured, CBGTI field is not present when more than one PUSCHs are scheduled, but is present when a single PUSCH is scheduled, as in Rel-16.

Agreement: (RAN1#106bis-e)

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

Agreement: (RAN1#106bis-e)

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

* NDI for the 2nd TB: This is signaled per PDSCH and applies to the 2nd TB of each PDSCH
* RV for the 2nd TB: This is signaled per PDSCH, with 2 bits if only a single PDSCH is scheduled or 1 bit for each PDSCH otherwise and applies to the 2nd TB of each PDSCH

[Moderator’s note] The following clarifications seem to be needed.

1. For NDI/RV, are NDI/RV fields for invalid PXSCHs present in multi-PXSCH scheduling DCI?
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?
3. For CSI-request, is the number M determined based on the number of configured SLIVs or valid SLIVs?
4. For CBGTI field, is the presence of CBGTI field determined based on the number of configured SLIVs or valid SLIVs?
5. For out-of-order scheduling, is the rule for OOO scheduling determined based on configured SLIVs or valid SLIVs?

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| Company | Views |
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## SPS/CG-related issues

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| Company | Views |
| [1] Huawei | Proposal 8: For activation of SPS (or CG) by using multi-PDSCH (or multi-PUCH) scheduling DCI, only single SLIV-based activation is allowed. |
| [3] vivo | Proposal 8: For activation/de-activation of SPS/CG by using multi-PDSCH/PUSCH scheduling DCI, the first (valid) SLIV in the row indicated by an activation/de-activation DCI is used for determining SPS/CG occasions. |
| [5] Fujitsu | Proposal 2: For SPS activation/retransmission via DCI format 1\_1 when multi-PDSCH scheduling is supported, the following 3 options can be considered, and Option 2 is slightly preferred for a well trade-off between flexibility and standardization effort. * Option 1: Allow only single SLIV-based (de)activation
* Option 2: Based on the last configured SLIV
* Option 3: Based on the first (valid) SLIV
 |
| [7] CATT | Proposal 7: for (de)activation of SPS (or CG) by using multi-PDSCH (or multi-PUSCH) scheduling DCI, Both the PDSCH time domain and k1 value are obtained based on first valid SLIV. |
| [8] CATT | Proposal 1: When one SPS configuration is activated by a DCI which schedules multiple PDSCHs:* The first valid PDSCH scheduled is used for the SPS PDSCH
* K1 is counted from the first PDSCH slot

Proposal 2: When one SPS configuration is released by a DCI which schedules multiple PDSCHs:* The first valid PDSCH scheduled is used for the SPS PDSCH
* K1 is counted from the first PDSCH slot

Proposal 3: More than one SPS configurations can be defined in a list by RRC. And more than one SPS configurations in one list can be activated or released by a DCI that schedules multiple PDSCHs.Proposal 4: For some special HARQ process ID（e.g. ID assigned to SPS PDSCH by RRC）, UE shall skip occupied HARQ process ID of SPS when the dynamic scheduling overlaps with these process ID. |
| [12] Intel | Proposal 3* A HARQ process number configured for SPS PDSCH/CG PUSCH can be allocated to a PDSCH/PUSCH of multi-PDSCH/PUSCH scheduling, as long as the timeline is met.
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| [16] Samsung | Proposal 8: If a CG PUSCH is configured to be transmitted between the first scheduled PUSCH and the last scheduled PUSCH by a single DCI scheduling multiple PUSCHs, HARQ process number increment is skipped for the HARQ ID used for the CG PUSCH when determining the HARQ ID of the multiple scheduled PUSCHs.Proposal 9: For a DCI capable of scheduling multi-PDSCH/PUSCHs, gNB can only indicate a row with single SLIV for SPS PDSCH/CG PUSCH activation and retransmission.Proposal 10: If a PUCCH overlaps a PUSCH scheduled by a DCI format, UE checks DL collision for the overlapping PUSCH before UCI multiplexing. |
| [19] LG Electronics | Proposal #7: If a DCI that indicates a row index of the TDRA table associated with multiple SLIVs can be used for SPS PDSCH (or CG PUSCH) (de)activation, determine TDRA or PUCCH resource corresponding to SPS (or CG) based on the last SLIV value in the indicated TDRA row index. |

### Issue 2.9-1) How to handle HARQ process number when it collides with that assigned for SPS or CG:

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

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

Timeline for PDSCH:

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| TS 38.2145.1 UE procedure for receiving the physical downlink shared channel……………………………………..<omitted>………………………………………The UE is not expected to decode a PDSCH in a serving cell scheduled by a PDCCH with C-RNTI, CS-RNTI or MCS-C-RNTI and one or multiple PDSCH(s) required to be received according to this Clause in the same serving cell without a corresponding PDCCH transmission if the PDSCHs partially or fully overlap in time except if the PDCCH scheduling the PDSCH ends at least 14 symbols before the earliest starting symbol of the PDSCH(s) without the corresponding PDCCH transmission, where the symbol duration is based on the smallest numerology between the scheduling PDCCH and the PDSCH, in which case the UE shall decode the PDSCH scheduled by the PDCCH. |

Timeline for PUSCH:

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| TS 38.2146.1 UE procedure for transmitting the physical uplink shared channel……………………………………..<omitted>………………………………………A UE is not expected to be scheduled by a PDCCH ending in symbol $i$ to transmit a PUSCH on a given serving cell overlapping in time with a transmission occasion, where the UE is allowed to transmit a PUSCH with configured grant according to [10, TS38.321], starting in a symbol $j$ on the same serving cell if the end of symbol $i$ is not at least $N\_{2}$ symbols before the beginning of symbol $j$. The value $N\_{2}$ in symbols is determined according to the UE processing capability defined in Clause 6.4, and $N\_{2} $and the symbol duration are based on the minimum of the subcarrier spacing corresponding to the PUSCH with configured grant and the subcarrier spacing of the PDCCH scheduling the PUSCH. |

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

### Proposal #2.9-1 (SPS/CG HPN):

* HARQ process number configured for SPS PDSCH (or CG PUSCH) can be allocated to a PDSCH (or PUSCH) of multi-PDSCH (or multi-PUSCH) scheduling, as long as the timeline condition defined in Rel-15/16 is met.

Companies are encouraged to provide views on Proposal #2.9-1.

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| Company | Views |
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### Issue 2.9-2) Activation of SPS (or CG) by using multi-PDSCH (or multi-PUCH) scheduling DCI:

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

* Option 1: Allow only single SLIV-based activation
	+ Supported by Huawei, Samsung
* Option 2: Based on the last (valid) SLIV
	+ Supported by Fujitsu, LG Electronics
* Option 3: Based on the first (valid) SLIV
	+ Supported by vivo, CATT
* Note: As Huawei pointed out, UE does not need to check TDRA table to transmit HARQ-ACK feedback corresponding to SPS release DCI. Therefore, this issue is relevant only to activation of SPS/CG.

[Moderator’s note] Given a small number of inputs, it is encouraged for companies to provide views on the above options, if any, including whether Option 3 affects HARQ timing determination rule.

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| Company | Views |
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## TDMed PDSCHs/PUSCHs in a slot

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| Company | Views |
| [2] Futurewei | Proposal 4. For multi-TRP cases, a UE should not expect to be scheduled with more than one PDSCHs if they are from the same TRP, while it is suggested to allow more than one PDSCHs be scheduled by two different DCIs from two TRPs. |

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

Agreement: (RAN1#106-e)

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

[Moderator’s note] Although a single company expressed their view for multi-TPR case, the suggestion seems reasonable and the following proposal can be made.

### Proposal #2.10 (TDMed PDSCHs/PUSCHs in a slot for mTRP):

* 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.

Companies are encouraged to provide views on Proposal #2.10.

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| Company | Views |
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## Others

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| Company | Views |
| [13] Xiaomi | Proposal 3: Support to indicate more than one channel access types in a single DCI. |
| [16] Samsung | Proposal 7: For multi-PDSCH scheduling, the bit field common for DL and UL grant use the same design as multi-PUSCH scheduling, and at least following DL-specific bit field should be specified,* CBG-based transmission is not applicable to single and multi-PDSCH scheduling
* HARQ-ACK relevant bit field is applicable to all PDSCHs and single PUCCH

Proposal 14: 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
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| [17] InterDigital | Observation 2: Ability to schedule a single slot with SCSs 480 kHz and 960 kHz can be useful to support delay sensitive applications.Proposal 7: Minimum number of slots that can be schedule by a single DCI for SCSs 480 kHz and 960 kHz is 1. |

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

The following issues are brought up by several companies:

* Xiaomi: Support of more than one channel access type indication fields in a single DCI
* Samsung: HARQ-ACK relevant bit field is applicable to all PDSCHs and single PUCCH
* Samsung: Clarification on SCell dormancy indication of multi-PDSCH scheduling DCI
* InterDigital: Minimum number of slots that can be schedule by a single DCI for SCSs 480 kHz and 960 kHz is one.

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

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| Company | Views |
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# HARQ

## Time domain bundling

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| Company | Views for type-1 HARQ-ACK codebook |
| [1] Huawei | Proposal 9: For FR2-2, Time domain bundling of Type-1 HARQ-ACK codebook can be supported in granularity of DCI scheduling. Reuse the legacy specification that the size and mapping of the HARQ-ACK codebook are determined by the number and position of the last non-overlapped valid SLIV after pruning of the invalid SLIVs with UL symbols by semi-static TDD configuration. |
| [3] vivo | Proposal 15: Regarding time domain bundling for Type-1 codebook when multi-PDSCH scheduling is configured, consider the following alternatives:* Alt. 1: A set of occasions is determined based on the last (valid) SLIV in each row of the TDRA table, and time domain bundling is performed across all valid PDSCH(s) scheduled by a DCI by indicating a row in the TDRA table.
* Alt. 2: A set of occasions is determined based on the last (valid) SLIV in each sub-row, which is divided from each row of the TDRA table, and time domain bundling is performed across all valid PDSCH(s) for each of one or more sub-rows scheduled by a DCI by indicating a row, from which the one or more sub-rows are divided, in the TDRA table.
* Alt. 3: A set of occasions is determined based on all (valid) SLIVs in each row of the TDRA table, in the same way as the case when time domain bundling is not configured, and time domain bundling is performed for each subset of occasions divided from the set of occasions.
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| [4] ZTE | Proposal 3: If time domain bundling for Type1 HARQ-ACK codebook is performed across all PDSCHs scheduled by a DCI and pruning procedure is based on the last SLIV, method to ensure HARQ-ACK information report for valid SLIVs should be introduced. |
| [5] Fujitsu | Proposal 1: For Type-1 HARQ-ACK codebook, support time domain bundling.* For each $K\_{1}$, the corresponding candidate PDSCH reception occasion can be determined based on all the SLIVs of each row in the TDRA table. If at least one of SLIVs in a row in the TDRA table is not colliding with UL symbols configured by RRC signaling, it corresponds to one candidate PDSCH reception occasion.
* For each determined candidate PDSCH reception occasion, HARQ-ACK information for all PDSCHs in slots that include SLIV(s) not colliding with UL symbols can be bundled as 1 bit.
 |
| [6] Nokia | Proposal 5: For Type-1 and Type-2 codebook, configurable time domain bundling of HARQ-ACK feedback with M bundling groups for PDSCHs scheduled by the same DCI is supported. Proposal 6: For Type-1 codebook with configurable time domain bundling of HARQ-ACK feedback: * Modified TDRA table is used in the codebook determination
* TDRA rows are modified by keeping the last SLIV(s) of the row corresponding to the number of bundled HARQ-ACK bit(s) and removing other SLIVs from that row.

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| [9] OPPO | Proposal 3: Support time domain bundling operation for both Type-1 and Type-2 HARQ-ACK codebooks. * Time domain bundling is performed across subset of PDSCHs scheduled by a DCI.
* gNB can configure the subset of scheduled PDSCHs.
 |
| [11] Ericsson | Proposal 14: Support Option 1 for time domain bundling for Type-1 HARQ-ACK codebook. I.e., time domain bundling is performed across all PDSCHs scheduled by a DCI. The time domain bundling is RRC configurable. |
| [12] Intel | Proposal 6* Time domain bundling is supported in HARQ-ACK transmission.
* The PDSCHs associated with the HARQ-ACKs that are time bundled should be scheduled by the same DCI.
* The maximum number of PDSCHs for which HARQ-ACKs are bundled can be configured by high layer.
* UE does not expect to be configured with both of CBG operation and time domain bundling for multi-PDSCH scheduling in the same PUCCH cell group.
* Confirm the work assumption that 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.

Proposal 7* For Type-1 HARQ-ACK codebook with time domain bundling
	+ For each row in TDRA table, N SLIVs are selected and associated with N bundled HARQ-ACK of the row.
		- It is beneficial that the selected SLIVs of each row in TDRA table for each K1 value can be mapped to the same slot(s).
	+ A modified TDRA table can be obtained with each row only containing the N selected SLIVs.
	+ Rel-16 Type-1 HARQ-ACK codebook generation can be applied based on the modified TDRA table.
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| [13] Xiaomi | Proposal 7: Support the HARQ-ACK bundling that all the scheduled multiple PDSCHs’ HARQ-ACK information are bundled as one HARQ-ACK information, and the PUCCH resource for HARQ-ACK information is based on the location of the last PDSCH. |
| [14] Lenovo | Proposal 5: For NR operation between 52.6 GHz and 71 GHz, for HARQ-ACK information corresponding to PDSCHs scheduled by the DCI, time domain bundling should be supported for both type-1 and type-2 HARQ-ACK codebook, where the time domain bundling is performed across a subset of PDSCHs scheduled by a DCI. |
| [16] Samsung | Proposal 19: Postpone the discussion on whether/how to support time domain bundling for type-1 HARQ-ACK codebook until RAN1 makes the decision for the HARQ-ACK bundling mechanism. |
| [17] InterDigital | Proposal 3: Support bundling of HARQ-ACK information bits for multiple PDSCHs. the number of HARQ-ACK information bits for a candidate PDSCH reception occasion is determined based on the number of bundled PDSCHs. |
| [18] Apple | Proposal 9: Time domain bundling is performed across subset of PDSCHs scheduled by a DCI. The bundling operation is performed after the codebook is constructed. |
| [19] LG Electronics | Proposal #13: If time domain bundling is to be supported for type-1 HARQ-ACK codebook construction,* Only allow bundling operation for all PDSCHs corresponding to each DCI.
* Each PDSCH reception occasion is determined based on the last SLIV among multiple SLIVs associated with a row index.
 |
| [20] NTT DOCOMO | Proposal 6: Support time domain HARQ-ACK bundling for multi-PDSCH scheduling.* Time domain bundling is enabled/disabled by RRC parameter, where the enabling/disabling should depend on other configuration, e.g. whether CBG is supported/enabled for multiple PDSCH scheduling, and/or whether two-TB scheduling is supported/enabled for multiple PDSCH scheduling, and/or whether spatial bundling is enabled if two-TB scheduling is supported/enabled for multiple PDSCH scheduling.
* Time domain bundling is performed across all PDSCHs scheduled by a DCI.
* For type 1 HARQ-ACK feedback, PDSCH candidate occasion determination and pruning procedure is based on the last SLIV.
* For type 2 HARQ-ACK feedback, multi-PDSCH DCI scheduled PDSCHs and single-PDSCH DCI scheduled PDSCHs are included in the same sub-codebook.
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| Company | Views for type-2 HARQ-ACK codebook |
| [1] Huawei | Proposal 10: For FR2-2, Time domain bundling of Type-2 HARQ-ACK codebook can be supported in granularity of DCI scheduling where only one ACK/NACK is feedback for all the scheduled valid/invalid PDSCHs. |
| [3] vivo | Proposal 16: Regarding time domain bundling for Type-2 codebook when multi-PDSCH scheduling is configured, consider the following alternatives:* Alt. 1: Time domain bundling is performed across all valid PDSCH(s) scheduled by a DCI by indicating a row in the TDRA table.
* Alt. 2: Time domain bundling is performed across a subset of valid PDSCHs, which is divided from the set of valid PDSCH(s) scheduled by a DCI by indicating a row in the TDRA table.
 |
| [6] Nokia | Proposal 5: For Type-1 and Type-2 codebook, configurable time domain bundling of HARQ-ACK feedback with M bundling groups for PDSCHs scheduled by the same DCI is supported. |
| [7] CATT | Proposal 11: If Time bundling of HARQ-ACK feedback is used, the following two issues are suggested: * The number of HARQ-ACK bit N per multi-PDSCH scheduling after bundling process can be configured, the N can be {1,2,4,8}
* Only the ACK/NACK bits of valid PDSCH can join the timing bundling process
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| [9] OPPO | Proposal 3: Support time domain bundling operation for both Type-1 and Type-2 HARQ-ACK codebooks. * Time domain bundling is performed across subset of PDSCHs scheduled by a DCI.
* gNB can configure the subset of scheduled PDSCHs.
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| [11] Ericsson | Proposal 15: Support Option 2-1 for time domain bundling for Type-2 HARQ-ACK codebook. I.e., with configurable number of bundling groups.Proposal 16: When time domain bundling is applied to Type-2 HARQ-ACK codebook, ACK should be reported for invalid PDSCHs (due to collision with UL symbols) in the codebook prior to bundling. |
| [12] Intel | Proposal 6* Time domain bundling is supported in HARQ-ACK transmission.
* The PDSCHs associated with the HARQ-ACKs that are time bundled should be scheduled by the same DCI.
* The maximum number of PDSCHs for which HARQ-ACKs are bundled can be configured by high layer.
* UE does not expect to be configured with both of CBG operation and time domain bundling for multi-PDSCH scheduling in the same PUCCH cell group.
* Confirm the work assumption that 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.

Proposal 8* For Type-2 HARQ-ACK codebook with time domain bundling,
	+ If the maximum number of bundled HARQ-ACK per DCI is one, single HARQ-ACK codebook can be used. Otherwise, two sub-codebooks are generated.
	+ When two sub-codebooks are used, if the actual number of bundled bits is 1 for a DCI, the first sub-codebook is used to carry the bundled HARQ-ACK for the DCI. Otherwise, the second sub-codebook is used.
 |
| [14] Lenovo | Proposal 5: For NR operation between 52.6 GHz and 71 GHz, for HARQ-ACK information corresponding to PDSCHs scheduled by the DCI, time domain bundling should be supported for both type-1 and type-2 HARQ-ACK codebook, where the time domain bundling is performed across a subset of PDSCHs scheduled by a DCI. |
| [15] NEC | Proposal 3: For Alt 1 of type-2 HARQ-ACK codebook determination:* If time domain bundling is supported, similar grouping way as CBG can be reused, and spatial bundling and time bundling should not be simultaneously configured or applied.
* If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, how to fill the NACK bits for the collision slot(s) needs to be determined.
* If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, and only 1 actual scheduled PDSCH left in this DCI scheduling, this PDSCH will belong to sub-codebook 1.
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| [16] Samsung | Proposal 16: If HARQ-ACK bundling is supported, bundling is performed within valid PDSCHs scheduled by a single DCI. Down-select one of the following alternatives:* Alt a: gNB configures a number of HARQ-ACK bundling groups (Nb) per DCI
* Alt b: gNB configures a number of valid PDSCHs per HARQ-ACK bundling groups (Npb)
* Alt c: gNB configures time duration of one HARQ-ACK bundling group (Tb).
* Prioritize HARQ-ACK bundling for Type-2 HARQ-ACK codebook.

Proposal 17: Support to multiplex bundled HARQ-ACK bit for multi-PDSCHs by a DCI with the first sub-codebook* This is applicable to the case where CBG operation is configured or not
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| [18] Apple | Proposal 10: Configure the number of PDSCHs per bundling group. * Introduce signaling mechanism to enable generating a HARQ-ACK bit per ‘M’ scheduled PDSCHs in a multi-PDSCH scheduling by performing HARQ-ACK bundling to compress the HARQ-ACK bits overhead.
 |
| [19] LG Electronics | Proposal #15: If time domain bundling is to be supported for (enhanced) type-2 HARQ-ACK codebook construction,* Only allow bundling operation for all PDSCHs corresponding to each DCI.
* HARQ-ACK bits corresponding to single PDSCH reception and multi-PDSCH reception are merged into the same sub-codebook.
 |
| [20] NTT DOCOMO | Proposal 6: Support time domain HARQ-ACK bundling for multi-PDSCH scheduling.* Time domain bundling is enabled/disabled by RRC parameter, where the enabling/disabling should depend on other configuration, e.g. whether CBG is supported/enabled for multiple PDSCH scheduling, and/or whether two-TB scheduling is supported/enabled for multiple PDSCH scheduling, and/or whether spatial bundling is enabled if two-TB scheduling is supported/enabled for multiple PDSCH scheduling.
* Time domain bundling is performed across all PDSCHs scheduled by a DCI.
* For type 1 HARQ-ACK feedback, PDSCH candidate occasion determination and pruning procedure is based on the last SLIV.
* For type 2 HARQ-ACK feedback, multi-PDSCH DCI scheduled PDSCHs and single-PDSCH DCI scheduled PDSCHs are included in the same sub-codebook.
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| [21] Qualcomm | Proposal 6: For type-2 codebook, in the case of time domain bundling of A/N bits corresponding to PDSCHs scheduled by the same DCI into one bit, a single codebook should be defined at least if CBG operation is not configured.Proposal 7: Allowing different numbers of A/N bits per multi-PDSCH grant, such that for each A/N occasion all the corresponding multi-PDSCH grants will have the same A/N bits, however, from one A/N occasion to another we can allow different number A/N bits per grant* If time domain bundling is enabled, then the bundling pattern can be changed from one A/N occasion to another.
	+ Time-domain bundling patterns to be defined via RRC configuration and the active pattern can be changed by MAC-CE or PDCCH.
 |
| [22] MediaTek | Proposal 1: For Type-2 codebook construction based on the principle of DAI per DCI, support the following PDSCH grouping and HARQ-ACK bit reporting to manage the codebook size.* When a UE is configured with multi-PDSCH scheduling in a cell c, the scheduled PDSCHs from one DCI are grouped into $M$ PDSCH groups based on Rel-15/16 CBG grouping principle
	+ $M=min⁡(N,C)$, where N is the maximum number of PDSCH groups per DCI configured by network and C is the number of scheduled PDSCHs in the DCI.
	+ Let $M\_{1}=mod\left(C,M\right), K\_{1}=\left⌈C/M\right⌉, K\_{2}=\left⌊C/M\right⌋$
	+ Each PDSCH group in the first $M\_{1}$ PDSCH groups contains $K\_{1}$ scheduled PDSCHs and each PDSCH group in the remaining PDSCH groups contains $K\_{2}$ scheduled PDSCHs.
	+ UE reports one HARQ-ACK bit for each PDSCH group
		- If all PDSCHs within a PDSCH group are decoded correctly, UE reports “ACK”
		- Else, UE reports “NACK”
	+ If $M<N$, UE will append $N-M$ “NACK” bits after the M HARQ-ACK bits from the $M$ TB groups to construct the codebook
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| Company | Views for type-3 HARQ-ACK codebook |
| [12] Intel | Proposal 9* Time domain bundling can be applied to Type-3 HARQ-ACK codebook.
	+ HARQ-ACK bits of adjacent HARQ process IDs that are scheduled by the same DCI can be bundled.
 |

### Summary on Time domain bundling:

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

* Option 1: Time domain bundling is performed across all PDSCHs scheduled by a DCI and pruning procedure is based on the last valid SLIVs (after removal of invalid SLIVs)
	+ Supported by Huawei, vivo (Alt 1), Fujitsu, Ericsson, Xiaomi, LG Electronics, NTT DOCOMO
	+ ZTE’s concern could be addressed by pruning the last valid SLIVs after removing invalid SLIVs?
* Option 2: Time domain bundling is performed across subset of PDSCHs scheduled by a DCI, FFS for pruning procedure
	+ Supported by vivo, Nokia, OPPO (w/o details), Intel, Lenovo (w/o details), InterDigital (w/o details), Apple
	+ vivo:
		- Alt 2: A set of occasions is determined based on all (valid) SLIVs in each row of the TDRA table, in the same way as the case when time domain bundling is not configured, and time domain bundling is performed for each subset of occasions divided from the set of occasions.
		- Alt 3: A set of occasions is determined based on all (valid) SLIVs in each row of the TDRA table, in the same way as the case when time domain bundling is not configured, and time domain bundling is performed for each subset of occasions divided from the set of occasions.
	+ Nokia: Modified TDRA table is used in the codebook determination and TDRA rows are modified by keeping the last SLIV(s) of the row corresponding to the number of bundled HARQ-ACK bit(s) and removing other SLIVs from that row.
	+ Intel: For each row in TDRA table, N SLIVs are selected and associated with N bundled HARQ-ACK of the row. A modified TDRA table can be obtained with each row only containing the N selected SLIVs.
	+ Apple: The bundling operation is performed after the codebook is constructed.

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

* Option 1: Time domain bundling is performed across all PDSCHs scheduled by a DCI and corresponding HARQ-ACK bit belongs to the first sub-codebook.
	+ Supported by Huawei, vivo (Alt 1), LG Electronics, NTT DOCOMO
* Option 2: Time domain bundling is performed across subset of PDSCHs scheduled by a DCI, FFS for how to determine the subset of scheduled PDSCHs
	+ Supported by vivo (Alt 2), Nokia, CATT, OPPO, Ericsson, Lenovo, NEC
	+ Nokia, Ericsson, Samsung: Configure the number of bundling groups
	+ Samsung, Apple: Configure the number of PDSCHs per bundling group
	+ NEC, MediaTek: Similar grouping way as CBG
	+ Qualcomm: Time domain bundling pattern can be configured by higher layer parameter.
	+ Samsung: Configure the time duration of bundling group

Company views on time domain bundling for type-3 HARQ-ACK codebook:

* Intel: HARQ-ACK bits of adjacent HARQ process IDs that are scheduled by the same DCI can be bundled.

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

* More than 10 companies are suggesting to support time-domain bundling operation for type-1 and type-2 HARQ-ACK codebook design.
* Some companies suggest different options for each type of HARQ-ACK codebook, however, it would be reasonable to provide the same granularity of time domain bundling to type-1 and type-2 HARQ-ACK codebook.
* For type-1 HARQ-ACK codebook, the majority of companies prefers Option 1, several companies prefer Option 2 but without any detailed designs.
* For type-2 HARQ-ACK codebook, slight majority companies prefer Option 2 but the details on how to define/configure a subset of scheduled PDSCHs are diverged among companies.

Considering this is the last RAN1 meeting for Rel-17 finalization, it must be realistic to go with Option 1 otherwise, time domain bundling operation will be dropped in Rel-17 since it is hard to converge with other options. This issue is indicated as “HIGH” since it is related to RRC parameter discussion.

### [HIGH] Proposal #3.1 (Time domain bundling):

* For FR2-2, introduce new RRC parameters to enable time domain bundling operation for type-1 HARQ-ACK codebook and type-2 HARQ-ACK codebook generation, respectively.
	+ If the RRC parameter enables time domain bundling operation,
		- Logical AND operation is performed across all valid PDSCHs scheduled by a DCI.
		- For type-1 HARQ-ACK codebook, reuse Rel-16 codebook generation procedure by determining PDSCH reception occasion based on the last valid SLIV after removing invalid SLIVs.
		- For type-2 HARQ-ACK codebook, HARQ-ACK bits corresponding to single PDSCH reception and multi-PDSCH reception are merged into the same sub-codebook.

Companies are encouraged to provide views on Proposal #3.1.

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| Company | Views |
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## Impact of invalid PDSCH on HARQ-ACK feedback

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| Company | Views |
| [1] Huawei | Proposal 11: For Type-2 HARQ-ACK codebook, NACK should be reported for the invalid SLIV/PDSCH and mapped in a position according the configured SLIVs of the row of TDRA table. |
| [2] Futurewei | Proposal 10. Deprioritize the issue of HARQ-ACK bit ordering for Type-2 HARQ-ACK codebook generation from Rel-17. |
| [3] vivo | Proposal 19: NACK corresponding to an invalid PDSCH is mapped to an HARQ-ACK bit among L HARQ-ACK bits corresponding to the DCI scheduling the invalid PDSCH in a Type-2 codebook, wherein the position of the HARQ-ACK bit among L HARQ-ACK bits is determined by the position of the SLIV corresponding to the invalid PDSCH among all configured SLIVs in the row indicated by the DCI, and every L HARQ-ACK bits correspond to one DCI in the Type-2 codebook. |
| [4] ZTE | Proposal 4: HARQ-ACK information bits for Type 2 codebook can be generated according to the scheduled PDSCH sequence. Wherein, * HARQ-ACK information bit corresponding to a valid PDSCH is determined according to the decoding result.
* HARQ-ACK information bit corresponding to a invalid PDSCH is padding as NACK.
 |
| [6] Nokia | Proposal 8: In case of Type-2 codebook and UE reporting NACK for the PDSCH skipped due to collision with semi-static UL symbol(s), the NACK is inserted to codebook after the HARQ-ACK bits for scheduled & valid PDSCHs. |
| [11] Ericsson | Proposal 17: Introduce a bit sequence manipulation scheme that is not dependent on the actual number of PDSCHs scheduled by a DCI but still able to relocate padding bits to the beginning of a HARQ-ACK codebook, e.g., based on block interleaver + bit reversal, so that the HARQ-ACK codebook is better suited for Polar coding. |
| [15] NEC | Proposal 3: For Alt 1 of type-2 HARQ-ACK codebook determination:* If time domain bundling is supported, similar grouping way as CBG can be reused, and spatial bundling and time bundling should not be simultaneously configured or applied.
* If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, how to fill the NACK bits for the collision slot(s) needs to be determined.
* If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, and only 1 actual scheduled PDSCH left in this DCI scheduling, this PDSCH will belong to sub-codebook 1.
 |
| [16] Samsung | Proposal 20: The HARQ-ACK bits are ordered according to the time order of valid PDSCHs scheduled by a DCI. |
| [19] LG Electronics | Proposal #12: For type-2 HARQ-ACK codebook generation, HARQ-ACK information bit ordering is based on configured SLIV position in the indicated TDRA row index, regardless of validity of scheduled PDSCH, followed by NACK padding for the last $N\_{HARQ-ACK}^{max} -N\_{TB,c}^{DL}⋅N\_{PDSCH,c}$ HARQ-ACK information bits. |
| [21] Qualcomm | Proposal 5: The NACK bits of the skipped PDSCHs should be appended at the end of the A/N bits corresponding to its scheduling DCI. |

### Summary on HARQ-ACK bit ordering for type-2 HARQ-ACK codebook:

Agreement: (RAN1#106bis-e)

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.

Company views on HARQ-ACK bit ordering for type-2 HARQ-ACK codebook:

* Alt 1: Bit ordering according to the configured SLIVs of the row of TDRA table, regardless of the validity of scheduled PDSCH
	+ Supported by Huawei, vivo, LG Electronics
* Alt 2: Bit ordering for valid PDSCHs first, then NACK padding for the remaining bits
	+ Supported by ZTE, Nokia, Samsung, Qualcomm
* Alt 3: Bit ordering based on bit sequence manipulation scheme (see above figure or [11])
	+ Supported by Ericsson

[Moderator’s note] Unless technical benefit is clearly shown for Alt 2 or Alt 3, Alt 1 seems straight-forward method since UE can construct HARQ-ACK codebook based on configured SLIV and doesn’t need to care the validity of scheduled PDSCHs. However, more company views are needed to draw a proposal, so companies are encouraged to provide more views on the above three alternatives on HARQ-ACK bit ordering for type-2 HARQ-ACK codebook.

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

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| Company | Views |
| [1] Huawei | Proposal 13: For Type-1 and Type-2 HARQ-ACK codebook construction, option 3 is preferred. |
| [7] CATT | Proposal 9: The scheme for pruning candidate PDSCH occasions is based on number of DCIs that can be scheduled for a given PUCCH carrying HARQ-ACK. |
| [9] OPPO | Proposal 4: Clarify whether one PDSCH/PUSCH of the multi-PDSCH/PUSCH scheduled by a single DCI can be cancelled by a dynamic indication. |
| [11] Ericsson | Proposal 13: Confirm the working assumption from RAN1#106bis-e that 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. Extend the configuration striction also to Type-1 codebook and clarify that the configuration restriction applies regardless of whether time domain bundling is applied or not. |
| [19] LG Electronics | Proposal #14: Support to configure CBG-based (re)transmission for a serving cell and configure pdsch-TimeDomainResourceAllocationListForMultiPDSCH for the other serving cell within the same PUCCH cell group, if type-1 HARQ-ACK codebook is configured but type-2 HARQ-ACK codebook is not configured with those serving cells. |

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

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

[Moderator’s note] Three companies expressed their views on whether both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group can be configured with a Type 1 codebook.

* Alt 1 (in [1] and [11]): Do not support
* Alt 2 (in [19]): Support to configure CBG-based (re)transmission for a serving cell and configure *pdsch-TimeDomainResourceAllocationListForMultiPDSCH* for the other serving cell within the same PUCCH cell group, if type-1 HARQ-ACK codebook is configured but type-2 HARQ-ACK codebook is not configured with those serving cells.

It should be noted that CBG configuration in cell#1 and multi-PDSCH configuration in cell#2 does not affect type-1 HARQ-ACK codebook at all for which codebook construction is performed per cell basis.

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

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

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| Company | Views |
| [1] Huawei | Proposal 12: For Type-2 HARQ-ACK codebook, legacy DAI counting procedure can be reused for multiple PDSCH/PUSCH scheduling without enhancement. |
| [3] vivo | Proposal 17: For Type-2 codebook, UE does not expect to be configured with both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group, irrespective of whether time domain bundling operation is supported or not.Proposal 18: Confirm the following working assumption with one update.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~~
 |
| [4] ZTE | Proposal 5: Confirm the working assumption as follows:* 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 not configured.
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| [6] Nokia | Proposal 7: If HARQ-ACK time bundling operation is supported and bundles HARQ-ACK feedback for all PDSCHs scheduled by single DCI, UE can be configured with both of CBG operation and multi-PDSCH scheduling in the same PUCCH cell group with a Type 2 codebook. Otherwise 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. |
| [7] CATT | Proposal 10: It is confirmed that 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. |
| [9] OPPO | Proposal 5: For Type-2 HARQ-ACK codebook construction, HARQ-ACK bits corresponding to CBG-based PDSCH reception and multi-PDSCH reception are merged into the same sub-codebook. |
| [11] Ericsson | Proposal 13: Confirm the working assumption from RAN1#106bis-e that 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. Extend the configuration striction also to Type-1 codebook and clarify that the configuration restriction applies regardless of whether time domain bundling is applied or not. |
| [12] Intel | Proposal 6* Time domain bundling is supported in HARQ-ACK transmission.
* The PDSCHs associated with the HARQ-ACKs that are time bundled should be scheduled by the same DCI.
* The maximum number of PDSCHs for which HARQ-ACKs are bundled can be configured by high layer.
* UE does not expect to be configured with both of CBG operation and time domain bundling for multi-PDSCH scheduling in the same PUCCH cell group.
* Confirm the work assumption that 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.
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| [13] Xiaomi | Proposal 8: CBG operation should not be configured along with HARQ-ACK bundling. |
| [15] NEC | Proposal 3: For Alt 1 of type-2 HARQ-ACK codebook determination:* If time domain bundling is supported, similar grouping way as CBG can be reused, and spatial bundling and time bundling should not be simultaneously configured or applied.
* If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, how to fill the NACK bits for the collision slot(s) needs to be determined.
* If there is a confliction between any of scheduled PDSCHs of a single DCI and uplink symbol(s) indicated by TDD configuration, and only 1 actual scheduled PDSCH left in this DCI scheduling, this PDSCH will belong to sub-codebook 1.
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| [16] Samsung | Observation 2: Including HARQ-ACK bits for 2 PDSCHs scheduled by a DCI in the first HARQ-ACK sub-codebook complicates the specification with marginal gain.Proposal 18: 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.
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| [17] InterDigital | Proposal 4: Type-2 HARQ-ACK codebook construction procedure when CBG is configured for a cell within the same PUCCH cell group should be carefully evaluated. |
| [20] NTT DOCOMO | Proposal 5: Confirm the working assumption that 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. |
| [21] Qualcomm | Proposal 6: For type-2 codebook, in the case of time domain bundling of A/N bits corresponding to PDSCHs scheduled by the same DCI into one bit, a single codebook should be defined at least if CBG operation is not configured.Proposal 8: 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. |

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

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

Company views on the above working assumption:

* Confirm the working assumption, with that CBG + multi-PDSCH cannot be simultaneously configured regardless of time bundling configuration
	+ Supported by vivo, CATT?, Intel, NTT DOCOMO?
* Confirm the working assumption, with that CBG + multi-PDSCH can be simultaneously configured when time bundling is not configured
	+ Supported by ZTE, Nokia, Qualcomm?
* UE does not expect to be configured with both of CBG operation and time domain bundling for multi-PDSCH scheduling in the same PUCCH cell group
	+ Supported by Intel, Xiaomi

[Moderator’s note] Whether/how to confirm the above working assumption can be revisited once the decision on time domain bundling is made. But, it is encouraged for companies to provide views on the above proposal, if any.

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

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| Company | Views |
| [3] vivo | Proposal 13: For multi-PDSCH scheduling, support reporting HARQ-ACK information corresponding to different PDSCHs scheduled by a DCI on different PUCCH(s).Proposal 14: For reporting HARQ-ACK feedback on different PUCCHs, further study how to divide the PDSCHs scheduled by a single DL DCI, as well as indicate or determine more than one PUCCH carrying HARQ-ACK feedback. |
| [4] ZTE | Proposal 6: HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s) considering HARQ-ACK feedback delay. |
| [6] Nokia | Proposal 4: Single transmission of HARQ feedback per multi-PDSCH DCI is only supported. |
| [9] OPPO | Proposal 6: Separate the scheduled PDSCHs into two groups, consider two PUCCH resources allocated for the two PDSCH groups, an earlier PUCCH is used to report HARQ-ACK information of the earlier PDSCH group. |
| [10] Panasonic | Proposal 8: Not to support HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s) in Rel. 17.Observation 1: Different PUCCHs for multi-PDSCH scheduling from a span can be achieved by multiple DCIs using the functionality of FG3-5b specified in TR 38.822. |
| [11] Ericsson | Proposal 18: Do not support HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI to be carried by different PUCCH occasions. |
| [13] Xiaomi | Proposal 4: For latency sensitive service, separate HARQ-ACK PUCCH resources for multiple PDSCHs scheduled by single DCI can be considered. |
| [14] Lenovo | Proposal 4: For NR operation between 52.6 GHz and 71 GHz, for HARQ-ACK information corresponding to PDSCHs scheduled by the DCI, different PUCCH(s) can be used where the PUCCH carrying the HARQ-ACK can be transmitted in the middle of non-contiguous PDSCHs transmissions to allow earlier/faster transmission of HARQ-ACK associated with earlier PDSCHs |
| [15] NEC | Proposal 2: HARQ-ACK information corresponding to the PDSCHs scheduled by a single DCI can be carried in an uplink slot or at most 2 uplink slots. |
| [16] Samsung | Proposal 15: HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI carried by different PUCCH(s) is not supported in Rel-17. |
| [17] InterDigital | Observation 1: Supporting only one PUCCH transmission for HARQ-ACK of all the PDSCHs scheduled by a single DCI introduces excessive HARQ-ACK round trip delay and negative impact on the expected performance gains. Proposal 1: Support multiple PUCCHs carrying HARQ information of multiple PDSCHs scheduled by a single DCI. To this end, multiple sub-codebooks, one for each PUCCH, with HARQ-ACK information of a sub-set of scheduled PDSCHSs can be constructed.Proposal 2: To support multiple PUCCHs carrying HARQ-ACK information of a group of PDSCHs scheduled by a single DCI, extend TDRA table such that each row indicates multiple slot offsets (K0 values) corresponding to multiple HARQ-ACK sub codebooks. |
| [21] Qualcomm | Proposal 2: All HARQ-ACK information corresponding to different PDSCHs scheduled by the same DCI to be carried by the same PUCCH. |
| [22] MediaTek | Proposal 2: The HARQ-ACK information corresponding to the PDSCHs scheduled by a DCI should only be carried by single PUCCH to simplify Type-2 codebook design. |

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

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

* Supported by vivo, ZTE, OPPO, Xiaomi, Lenovo, NEC, IDC
* Objected by Nokia, Panasonic, Ericsson, Samsung, Qualcomm, MediaTek

[Moderator’s note] At least 7 companies suggest to support that HARQ-ACK information corresponding to different PDSCHs scheduled by a DCI is carried by different PUCCHs while 6 companies are against it.

It is observed that the main motivation of this feature is to lower HARQ-ACK feedback delay, which is not well matched with FR2-2 operation. Furthermore, to implement this feature, at least the following aspects should be discussed.

* How to determine resources for two PUCCHs (e.g., K1 timing, PRI)
* How to signal individual DAI values corresponding to two PUCCHs
* Under which condition(s) two PUCCHs are indicated by the DCI (e.g., in case more than N PDSCHs are scheduled)

Considering that the specification impact seems quite large compared to expected advantages, the following proposal can be made. This issue is indicated as “HIGH” since it is essential for WI completion.

### [HIGH] Proposed conclusion #3.5 (two PUCCHs):

* HARQ-ACK information corresponding to different PDSCHs scheduled by a single DCI is not carried over multiple PUCCHs in Rel-17.

Companies are encouraged to provide views on Proposed conclusion #3.5.

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| Company | Views |
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## HARQ process

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| Company | Views |
| [11] Ericsson | Observation 1: The HARQ process ID fields in various DCI formats need to be extended to support 32 HARQ processes. The bit field extension can be handled by the on-going work in the Rel-17 NTN WI.Proposal 1: Monitor the progress on feedback-disabled HARQ process and its impact on Type-1 and Type-2 HARQ-ACK codebook construction in the Rel-17 NTN WI to capture any potential conflicts with HARQ-ACK codebook enhancement for multi-PDSCH scheduling in the Rel-17 60GHz WI. |
| [21] Qualcomm | Proposal 3: In case of BWP switching between SCS 120kHz, and 480/960kHz and when different numbers of HARQ processes are configured, consider one of the following options: * Option 1: No retransmission can be allowed over different SCSs.
* Option 2: No soft combining is assumed between retransmissions over different SCSs.

Proposal 4: To define different numbers of HARQ processes for 480/960kHz SCS and 120kHz SCS, consider one of the following options: * Option 1: Reuse the same parameter in PDSCH-ServingCellConfig and add more values, e.g., 24 and 32.
	+ If UE is configured with more than 16 HARQs and the operating SCS is 120kHz or less, it will assume that number of HARQ processes is 16.
* Option 2: Introduce new parameter(s) for SCSs 480kHz/960kHz.
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### Summary (on the number of HARQ processes):

Agreement: (RAN1#106bis-e)

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

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

Qualcomm brought up two issues when a UE capable of 32 HARQ processes is configured with multiple BWPs having 120/480/960 kHz SCSs in a serving cell:

* Issue 1: Data soft combining after BWP switching
* Issue 2: Whether or not to introduce new higher layer parameter to configure the number of HARQ processes for 480/960 kHz SCS

[Moderator’s note] Given that a single company brought up the above issues, it is encouraged for companies to provide views on them, if any.

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| Company | Views |
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## Others

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| Company | Views |
| [13] Xiaomi | Proposal 1: For multi-slot PDSCH scheduling, the HARQ ID for the PDSCH(s) exceeding the COT is/are still reserved. 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] Apple | Observation 1: HARQ-ACK information corresponding to different PDSCHs scheduled by a single DCI carried by different PUCCHs affects the UE complexity, signaling overhead and transmission latency.Proposal 11: RAN1 should decide whether a multi-PxSCH transmission can occur across multiple COTs and the specify the UE HARQ-ACK feedback behavior in the case that one or more of the PDSCH transmissions occurs outside a valid COT.Proposal 12: RAN1 should support a single HARQ-ACK feedback for multi-PDSCH transmissions within a single COT only.Proposal 13: In the case of BWP switching during multi-PxSCH transmission * Option 1: The UE does not expect an UL or DL BWP change on the serving cell after the DCI scheduling the multi-PDSCH transmission and until the PUCCH is transmitted
* Option 2: The UE will only send HARQ-ACK bits for the effective K1 values after the BWP switch.
 |
| [22] MediaTek | Proposal 4: The UCI information bits including HARQ-ACK information bits should reuse the existing PUCCH payload size limit 1706. |

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

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

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| Company | Views |
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# Reference

1. R1-2110831 PDSCH/PUSCH enhancements for 52-71GHz spectrum Huawei, HiSilicon
2. R1-2110876 Enhancements to support PDSCH/PUSCH for Beyond 52.6GHz FUTUREWEI
3. R1-2111002 Remaining issues on PDSCH/PUSCH enhancements for NR operation from 52.6GHz to 71GHz vivo
4. R1-2111078 Discussion on the data channel enhancements for 52.6 to 71GHz ZTE, Sanechips
5. R1-2111147 Considerations on multi-PDSCH/PUSCH with a single DCI and HARQ for NR from 52.6GHz to 71 GHz Fujitsu
6. R1-2111199 PDSCH/PUSCH enhancements Nokia, Nokia Shanghai Bell
7. R1-2111245 PDSCH/PUSCH enhancements for up to 71GHz operation CATT
8. R1-2111247 Some issues on SPS for one DCI scheduling multiple PDSCHs case CATT
9. R1-2111311 Discussion on PDSCH/PUSCH enhancements OPPO
10. R1-2111424 Discussion on PDSCH/PUSCH enhancements for NR 52.6-71 GHz Panasonic Corporation
11. R1-2111468 PDSCH-PUSCH Enhancements Ericsson
12. R1-2111487 Discussion on PDSCH/PUSCH enhancements for extending NR up to 71 GHz Intel Corporation
13. R1-2111565 PDSCH and PUSCH enhancements for NR 52.6-71GHz Xiaomi
14. R1-2111644 PDSCH/PUSCH scheduling enhancements for NR from 52.6 GHz to 71GHz Lenovo, Motorola Mobility
15. R1-2111692 Discussion on PDSCH enhancements supporting NR from 52.6GHz to 71 GHz NEC
16. R1-2111728 PDSCH/PUSCH enhancements for NR from 52.6 GHz to 71 GHz Samsung
17. R1-2111837 Enhancement for PDSCH/PUSCH to support 52.6 GHz-71 GHz band in NR InterDigital, Inc.
18. R1-2111865 Discussion on PDSCH and PUSCH Enhancements Apple
19. R1-2112049 PDSCH/PUSCH enhancements to support NR above 52.6 GHz LG Electronics
20. R1-2112100 PDSCH/PUSCH enhancements for NR from 52.6 to 71 GHz NTT DOCOMO, INC.
21. R1-2112207 PDSCH/PUSCH enhancements for NR in 52.6 to 71GHz band Qualcomm Incorporated
22. R1-2112303 Multi-PDSCH scheduling design for 52.6-71 GHz NR operation MediaTek Inc.

# Appendix: Previous agreements

### RAN1#104-e

Agreement:

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

Agreement:

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

Agreement:

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

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

Agreement:

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

* FFS: Applicability to multi-PDSCH scheduling.

Agreement:

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

### RAN1#104bis-e

Agreement:

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

Agreement:

For a DCI that can schedule multiple PDSCHs,

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

Agreement:

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

Agreement:

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

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

Conclusion:

The following is observed for alternative 1 from prior agreement.

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

Conclusion:

The following is observed for alternative 2 from prior agreement.

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

Conclusion:

The following is observed for alternative 3 from prior agreement.

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

### RAN1#105-e

Agreement:

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

Conclusion:

For a DCI that can schedule multiple PUSCHs,

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

Agreement:

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

Agreement:

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

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

Agreement:

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

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

Agreement:

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

Agreement:

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

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

Agreement:

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

* PDSCH(s) scheduled by a single DCI is counted firstly, serving cell(s) in the same PUCCH cell group and same PDCCH monitoring occasion is counted secondly, and PDCCH monitoring occasion(s) is counted thirdly.
* The bit width of counter DAI field in fallback DCI (i.e., DCI formats 0\_0 and 1\_0) remains the same as in Rel-15 NR.
* Note: The DAI bit width and number of sub-codebooks shall ensure that at most 3 consecutive missed DCIs can be resolved, same as in Rel-15/16 NR
	+ This shall not impose additional gNB’s scheduling restriction.
* In case where CBG retransmission is not configured for any serving cell in a same PUCCH cell group, the number of bits for each of counter DAI and total DAI in non-fallback DCI is extended (if needed) at least based on
	+ The number of SLIVs associated with the row indexes in TDRA table
		- FFS: details
* FFS: the case with configuration of CBG retransmission
* FFS: the number of sub-codebooks
* FFS: for the UE indicating by *type2-HARQ-ACK-Codebook* support for more than one PDSCH reception on a serving cell that are scheduled from a same PDCCH monitoring occasion

### RAN1#106-e

Working assumption:

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

* FFS: Further limitations on maximum number of PDSCHs

Agreement:

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

Agreement:

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

Agreement:

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

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

Agreement:

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

Agreement:

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

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

Agreement:

For a DCI that can schedule multiple PDSCHs,

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

Working assumption:

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

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

Agreement:

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

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

Agreement:

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

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

Agreement:

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

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

### RAN1#106bis-e

Agreement:

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

Working assumption: (RAN1#106-e)

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

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

Working assumption:

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

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

Agreement:

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

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

Agreement:

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

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

Agreement:

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

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

Agreement:

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

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

Conclusion:

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

* Note: This is the consequence of previous agreements.

Agreement:

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

* A UE does not expect to be scheduled with more than one unicast PDSCH in a slot, by a single DCI or multiple DCIs.
* A UE does not expect to be scheduled with more than one PUSCH in a slot, by a single DCI or multiple DCIs.

Agreement:

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

* MCS for the 2nd TB: This appears only once in the DCI and applies commonly to the 2nd TB of each PDSCH
* NDI for the 2nd TB: This is signaled per PDSCH and applies to the 2nd TB of each PDSCH
* RV for the 2nd TB: This is signaled per PDSCH, with 2 bits if only a single PDSCH is scheduled or 1 bit for each PDSCH otherwise and applies to the 2nd TB of each PDSCH
* FFS: the maximum number of PDSCHs when 2 TB is enabled or when 2 TB is scheduled