**3GPP TSG RAN WG1 #112bis-e R1-230XXXX**

**e-Meeting, April 17th – April 26th, 2023**

**Agenda Item:** 7.2

**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 7.2 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:

[112bis-e-R17-FR2\_2-03] Email discussion on Rel-17 FR2\_2 maintenance (HARQ scheduling) by April 20 – Seonwook (LGE)

# (E) Issue#1: ‘-r17’ suffix for the parameter *pdsch-TimeDomainAllocationListForMultiPDSCH*

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| Company | Views |
| [1] CATT | **Reason for change**: To support multiple PDSCHs scheduling via one DCI format 1\_1, the parameter of *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* is defined in TS 38.331.In the current version of TS 38.213, the parameter is described as *pdsch-TimeDomainAllocationListForMultiPDSCH*, it is not aligned as definition in TS 38.331.  **Summary of change**: Change *pdsch-TimeDomainAllocationListForMultiPDSCH* to *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* |

## [Moderator’s note] The suffix ‘-r17’ for a higher layer parameter is necessary if the parameter had been introduced from the previous release. However, this parameter ‘pdsch-TimeDomainAllocationListForMultiPDSCH’ was introduced first in Rel-17. With this understanding, the suffix ‘-r17’ doesn’t seems to be needed in RAN1 specifications.

Companies are encouraged to provide views on the CR from CATT [1] and above Moderator’s note.

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| Company | Views |
| Samsung | Agree with Moderator. This is the general rule when a new RRC paramenter is added.  No need to add the suffix ‘-r17’ in TS38.213.  In fact, there is a discrepancy between 213 and 214 (TS38.214 used the suffix). To align, it would be better to inform 214 Editor of this discrepancy. |
| Huawei, HiSilicon | Agree with Moderator’s note and with Samsung’s suggestion. |

# Issue#2: TDRA configuration for multi-PDSCH scheduling DCI

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| Company | Views |
| [2], [3] CATT | **Observation 1**: gNB may configure *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* in which no row contains multiple *SLIV*s for PDSCH  **Observation 2**: if gNB configures *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* in which no row contains multiple SLIVs for PDSCH, will be NULL set, there will be an error case from for UE implementation during candidate PDSCH reception determination.  **Proposal 1**: To resolve the error case during candidate PDSCH reception determination, there are two possible schemes can be downtown selected by RAN1.   * **Alt-1**: (No CR) Clarify in RAN1 that if *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* if configured , there is at least one row contains multiple SLIVs; otherwise, if gNB configures TDMA in with each row only include one SLIV, parameter *TimeDomainAllocationList* shall be used . * **Alt-2**: Modify the spec to align the limitation condition generation and candidate PDSCH reception determination as is used in TS 38.214. |

## [Moderator’s note] Companies are encouraged to provide views or preference between two alternatives in [3] CATT. If Alt-1 will be chosen, no CR is needed (Conclusion can be captured in Chairman’s note if proponents request), otherwise, we can consider the CR from CATT [2].

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| Company | Views |
| Xiaomi | Alt-1 is supported, it is nature that if *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* if configured , there is at least one row contains multiple SLIVs |
| Samsung | We prefer Alt-1. If all rows contain only one SLIV, it can be configured by Rel-15/16 RRC structure. So, *pdsch-TimeDomainAllocationListForMultiPDSCH* can be configued only if at least one row contains more than one SLIVs. |
| Huawei, HiSilicon | We support Alt-1. |
| CATT | We are ok both alternatives. If RAN1 choose alt1 after the discussion, then this should be clarified in the chairman’s note to remove any misunderstanding. |

# Issue#3: 32-HPN support for e-type3 HARQ-ACK codebook

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| Company | Views |
| [4] CATT | **Proposal 1:** In order to support 32 HARQ processes, there is a need to update the above corresponding text in TS38.331. It is suggested to send RAN2 LS indicating such correction, which is marked in green as in the following:  PDSCH-HARQ-ACK-EnhType3-r17 ::= SEQUENCE {  pdsch-HARQ-ACK-EnhType3Index-r17 PDSCH-HARQ-ACK-EnhType3Index-r17,  applicable-r17 CHOICE {  perCC SEQUENCE (SIZE (1..maxNrofServingCells)) OF INTEGER (0..1),  perHARQ SEQUENCE (SIZE (1..maxNrofServingCells)) OF BIT STRING (SIZE (32))  },  pdsch-HARQ-ACK-EnhType3NDI-r17 ENUMERATED {true} OPTIONAL, -- Need R  pdsch-HARQ-ACK-EnhType3CBG-r17 ENUMERATED {true} OPTIONAL, -- Need S |

## [Moderator’s note] If nrofHARQ-ProcessesForPDSCH-v1700 is provided, a maximum of 32 HARQ processes per cell can be used for the downlink. However, as CATT [4] pointed out, only 16 HARQ processes are being considered for enhanced type-3 HARQ-ACK codebook configuration and it is uncertain how enhanced type-3 HARQ-ACK codebook can work in case 32 HARQ processes are configured for a serving cell.

Companies are encouraged to provide **views on above Proposal 1** in CATT [4]. From my observation, if the proposal is agreeable, we may need not only **to send an LS to RAN2** but also **to consider the following CR for 213 specification**.

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| 9.1.4 Type-3 HARQ-ACK codebook determination  If a UE is provided *pdsch-HARQ-ACK-OneShotFeedback*, the UE determines HARQ-ACK information bits, for a total number of HARQ-ACK information bits, of a Type-3 HARQ-ACK codebook according to the following procedure. If the UE is provided *pdsch-HARQ-ACK-EnhType3ToAddModList* and a DCI format scheduling PDSCH reception and triggering the Type-3 HARQ-ACK codebook includes an enhanced Type 3 codebook indicator field that provides a value for *pdsch-HARQ-ACK-EnhType3Index*, the UE determines a size of a set of indicated serving cells and a size of a set of indicated numbers of HARQ processes for each indicated serving cell and each indicated HARQ process number from the entry in *pdsch-HARQ-ACK-EnhType3ToAddModList* corresponding to the *pdsch-HARQ-ACK-EnhType3Index* value. If the DCI format does not include the enhanced Type 3 codebook indicator field, the *pdsch-HARQ-ACK-EnhType3Index* value is zero.  Set to the number of configured serving cells or, when applicable, to  Set to the value of *nrofHARQ-ProcessesForPDSCH* or *nrofHARQ-ProcessesForPDSCH-v1700* for serving cell , if provided; else, set . When applicable, set to |

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| Company | Views |
| Xiaomi | Support CATT’s proposal and also Moderator’s suggestion about the above CR in 9.1.4 |
| Samsung | We support the proposal from CATT. Also, we support the text proposal suggested by Moderator. |
| Huawei, HiSilicon | We can support Moderator’s TP.  RAN2 would take care of the bitmap size accordingly. |
| CATT | Support TP and the LS to ran2. |

# Issue#4: Clarification on CBG configuration

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| Company | Views |
| [5] Samsung | **Issue 1: Ambiguity on the text “the SCS is 480 or 960kHz” in TS38.331**  From RAN1’s agreement and TS38.331, it is unclear whether CBG-based transmission is allowed in a BWP with 120kHz SCS in a cell when another BWP in the cell is configured with 480kHz or 960kHz SCS.  RAN1 agreements said that CBG-based transmission can be allowed for 120kHz, while CBG-based transmission cannot be configured for 480/960kHz SCS. This was captured in TS38.331.  **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**  For 480/960 kHz SCS, CBG-based HARQ cannot be configured for uplink and downlink.   |  | | --- | | *PUSCH-ServingCellConfig* field descriptions | | ***codeBlockGroupTransmission***  Enables and configures code-block-group (CBG) based transmission (see TS 38.214 [19], clause 5.1.5).  The network does not configure this field if the SCS is 480 or 960 kHz. |   Since *codeBlockGroupTransmssion* field is configured in a cell-common RRC parameter, *PDSCH-ServingCellConfig* orPUSCH-ServingCellConfig*.* That is, all BWPs in a cell share the same CBG configuration.  “the SCS is 480 or 960 kHz” in the field decription of *codeBlockGroupTransmssion* is unclear since a cell may have multiple BWPs, each of which has different subcarrier spacings.  For example, suppose that a cell has two BWPs, the first BWP has 120kHz SCS and the second BWP has 480 or 960kHz SCS. If “the SCS is 480 or 960kHz” is interpreted as “at least one BWP configured in a cell has 480 or 960kHz”, then CBG-based transmission is not allowed in a BWP with 120kHz SCS. That is, gNB cannot configure *codeBlockGroupTransmssion* field in the cell. However, if “the SCS is 480 or 960kHz” is interpreted as “all BWPs configured in a cell has 480 or 960kHz”, then CBG-based transmission is allowed in a BWP with 120kHz SCS.  **Observation 1***. From TS38.331, it is unclear which interpretation of the field description of codeBlockGroupTransmssion is correct between the following two interpretations*  *Interpretation 1: “the SCS is 480 or 960kHz” is interpreted as “at least one BWP configured in a cell has 480 or 960kHz”*  *Interpretation 2: “the SCS is 480 or 960kHz” is interpreted as “all BWPs configured in a cell has 480 or 960kHz”* |

## [Moderator’s note] Samsung [5] pointed out an ambiguity issue on CBG configuration if a UE configured with the first BWP with 120 kHz SCS and the second BWP with 480/960 kHz SCS, for a serving cell.

Companies are encouraged to provide **views or preference between two interpretations from the above Observation 1** in Samsung [5]. Detailed TP can be dependent on which interpretation is supported. It is noted that there seems to be the same issue for DL case, as follows.

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| *PDSCH-ServingCellConfig* field descriptions |
| ***codeBlockGroupTransmission***  Enables and configures code-block-group (CBG) based transmission (see TS 38.213 [13], clause 9.1.1). Network does not configure for a UE both spatial bundling of HARQ ACKs and *codeBlockGroupTransmission* within the same cell group.  The network does not configure this field if  - the SCS is 480 or 960 kHz  - Type-1 HARQ-ACK codebook is configured and *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* for this serving cell contains pdsch-AllocationList with multiple entries (multiple PDSCH)  - Type-2 HARQ-ACK codebook is configured and *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* for any cell in the same PUCCH cell group associated with this serving cell contains pdsch-AllocationList with multiple entries (multiple PDSCH) |

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| Company | Views |
| Samsung | We support interpretation 1.  We don’t see any motivations to limit CBG-based operation in a BWP with 120kHz SCS by other BWP configurations with 480/960kHz SCS. |
| Huawei, HiSilicon | We agree with Samsung’s intention.  However, we understand that ‘interpretation 1’ in Samsung’s view above does not achieve that intention.  The correct interpretation that should be supported is rather ‘interpretation 2’ as Samsung initially proposed in R1-2303104 |
| CATT | *Interpretation 1: “the SCS is 480 or 960kHz” is interpreted as “at least one BWP configured in a cell has 480 or 960kHz”*  We support the above interpretation 1. This is the intention of the original agreement. Also, with this interpretation, there will be no need for any changes in the CR , and it will not complicate #issue5. |

# Issue#5: BWP switching with CBG-based PUSCH transmission

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| Company | Views |
| [5], [6] Samsung | **Issue 2: BWP switching with CBG-based PUSCH transmission**  It has been agreed that CBG-based PUSCH transmission is allowed only if the indicated TDRA include single PUSCH scheduling. Otherwise, TB-based PUSCH transmission is applied. This UE behaviour was captured in TS38.212 v17.5.0  **Clause 7.3.1.1.2 of TS38.212**  7.3.1.1.2 Format 0\_1  […]  - CBG transmission information (CBGTI) – 0 bit if higher layer parameter *codeBlockGroupTransmission* for PUSCH is not configured or if the number of scheduled PUSCH indicated by the Time domain resource assignment field is larger than 1; otherwise, 2, 4, 6, or 8 bits determined by higher layer parameter *maxCodeBlockGroupsPerTransportBlock* for PUSCH.  […]    **Figure 1.BWP switching with CBG-based transmission**  It is observed that if a UE is configured with two UL BWPs, the first BWP may have a TDRA table with more than one PUSCHs while the second BWP may have a TDRA table with one PUSCH only. This configuration is possible since the UE can be configured with different dedicated TDRA table in different BWP based on the RRC structure. That is, *BWP-UplinkDedicated* IE includes *pusch-Config, a*nd *pusch-Config* includes *pusch-TimeDomainAllocationList* or *pusch-TimeDomainAllocationListDCI-0-1-r16* or *pusch-TimeDomainAllocationListForMultiPUSCH-r16*.  If the active BWP is the first BWP, the DCI format 0\_1 has 0 bit CBGTI. Suppose that the DCI format 0\_1 indicate the second BWP. The second BWP requires 2, 4, 6, or 8 bits CBGTI fieid as defined in the DCI format 0\_1 above. For this case, the defined UE behaviour from TS38.213 (see below) is that zeros are prepended to the CBGTI field until its size is equal to the one required for the interfertation. After the zero padding to CBGTI, all bits in CBGTI is equal to ‘0’ so that the UE’s interpretation of the CBGTI is that the scheduled PUSCH contains no CBGs. This is not the intended UE behaviour.  **Clause 12 of TS38.213**  If a bandwidth part indicator field is configured in a DCI format, the bandwidth part indicator field value indicates the active DL BWP, from the configured DL BWP set, for DL receptions as described in [5, TS 38.212]. If a bandwidth part indicator field is configured in a DCI format, the bandwidth part indicator field value indicates the active UL BWP, from the configured UL BWP set, for UL transmissions as described in [5, TS 38.212]. If a bandwidth part indicator field is configured in a DCI format and indicates an UL BWP or a DL BWP different from the active UL BWP or DL BWP, respectively, the UE shall  - for each information field in the DCI format  - if the size of the information field is smaller than the one required for the DCI format interpretation for the UL BWP or DL BWP that is indicated by the bandwidth part indicator, the UE prepends zeros to the information field until its size is the one required for the interpretation of the information field for the UL BWP or DL BWP prior to interpreting the DCI format information fields, respectively  - if the size of the information field is larger than the one required for the DCI format interpretation for the UL BWP or DL BWP that is indicated by the bandwidth part indicator, the UE uses a number of least significant bits of the DCI format equal to the one required for the UL BWP or DL BWP indicated by bandwidth part indicator prior to interpreting the DCI format information fields, respectively  - set the active UL BWP or DL BWP to the UL BWP or DL BWP indicated by the bandwidth part indicator in the DCI format  It is worth noting that the similar problem occurs when the first BWP does not support CBG-based transmission (e.g., 480kHz/960kHz SCS) and the second BWP supports CBG-based transmission (e.g., 120kHz and single PUSCH scheduled in the indicated TDRA entry). That is, the detected DCI include 0bit CBGTI field while the indicated BWP requires more than 0 bits CBGTI field.  Observation 2. *No CBGs are scheduled if the indicated BWP requires 2, 4, 6, or 8 bits CBGTI field but the detected DCI format 0\_1 includes 0 bit CBGTI field.*  The scheduled PUSCH should include at least one CBGs in this case. The scheduled PUSCH may be used to confirm the UL BWP change is successfully completed. Also, PUSCH transmission with no CBGs is specified in the specification. The one way to address this issue is to not apply zero-padding as defined in TS38.213 and to interprete all CBGs contained in PUSCH are scheduled. The corresponding text proposal for TS38.212 is shown below: |

## [Moderator’s note] The above issue doesn’t seem to be a problem since there will be more than 1 bit allocated to CBGTI field if DCI format 0\_1 (that can schedule multiple PUSCHs in the first BWP and is detected in the first BWP) schedules a single PUSCH in the second BWP, according to the above excerpt from Clause 7.3.1.1.2 of TS38.212 (i.e., the presence of CBGTI field is determined not based on TDRA configuration but based on the number of actually scheduled PUSCHs). However, if Interpretation 1 in Issue #4 will be chosen, we may need to handle this issue as Samsung [5] pointed out. With this understanding, we can put this Issue #5 on hold until Issue #4 is resolved.

Companies are encouraged to provide views on the Moderator’s note.

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| Company | Views |
| Samsung | Regarding the Moderator’s note, we have different understanding. The problem still occurs when the presence of CBGTI field is determined by the number of actually scheduled PUSCHs.  Consider that following case.   * A cell has two BWPs and CBG based transmission is configured on the cell. * TDRA table in active BWP has more than one SLIVs. That is, the actually scheduled row in the active BWP has more than one SLIVs * TDRA table in indicated BWP has one SLIV. That is, the actually scheduled row in the indicated BWP has only one SLIV. * DCI format 0\_1 monitored in the active BWP has 0-bit CBGTI field (since the actually scheduled TDRA row in the active BWP has more than one SLIVs)   In this case, what is UE behavior intended? |
| Moderator | **@ Samsung,**  Thanks for the further clarification. Now I can understood more details. It seems that we have different interpretations on the following yellow part.  **Clause 7.3.1.1.2 of TS38.212**  7.3.1.1.2 Format 0\_1  […]  - CBG transmission information (CBGTI) – 0 bit if higher layer parameter *codeBlockGroupTransmission* for PUSCH is not configured or if the number of scheduled PUSCH indicated by the Time domain resource assignment field is larger than 1; otherwise, 2, 4, 6, or 8 bits determined by higher layer parameter *maxCodeBlockGroupsPerTransportBlock* for PUSCH.  […]  If the DCI format 0\_1 indicates a bandwidth part other than the active bandwidth part,   * Interpretation 1: PUSCH (indicated by the Time domain resource assignment field) above implies PUSCH in **the active bandwidth part** * Interpretation 2: PUSCH (indicated by the Time domain resource assignment field) above implies PUSCH in **the indicated bandwidth part**   What I thought was Interpretation 2, but Samsung seems to think Interpretation 1 is right. Is this correct?  Even if Interpretation 1 holds as Samsung claimed, gNB can indicate TDRA row index configured with a single PUSCH both in the active bandwidth part and in the indicated bandwidth part, for which case there is no issue brought up by Samsung.  Also, if this is the problem, we may consider to fix Rel-16 specification as well. |
| Huawei, HiSilicon | We agree with Moderator’s understanding. Nonetheless, we prefer to put this issue on hold until a decision is made on Issue #4 |
| CATT | Agree with Moderator. Put this on hold after Issue#4, for which if interpretation #1 is chosen, there is no need. |

# Issue#6: TBoMS support of multi-PUSCH scheduling

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| Company | Views |
| [7] ASUSTeK | **Observation 1**: There is no clear agreement and conclusion specifying whether *numberOfSlotsTBoMS-r17* and *pusch-TimeDomainAllocationListForMultiPUSCH* could be configured simultaneously.  **Proposal**: For TBoMS and multi-PUSCHs, down-select one alternative:   * **Alt1**: a UE does not expect to be configured with both *numberOfSlotsTBoMS* and *pusch-TimeDomainAllocationListForMultiPUSCH*. * **Alt2**: a UE could be configured with both *numberOfSlotsTBoMS* and *pusch-TimeDomainAllocationListForMultiPUSCH* when gNB can make sure that for all n, n-th allocation with *numberOfSlotsTBoMS* and (n+1)-th allocation does not overlap in time domain. |

## [Moderator’s note] From my understanding, the following agreement is aligned with above Alt1 in ASUSTeK [7].

Agreement: (RAN1#104-e)

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

Companies are encouraged to provide views on the above Proposal from ASUSTeK [7] and Moderator’s note. If **Alt1** is taken, we may need to send an LS to RAN2 to inform RAN1’s understanding.

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| Company | Views |
| Samsung | It is unclear the agreement moderator pointed out is relevant to TBoMS or not since TB is not repeated in TBoMS. One TB is just mapped to multiple slot.  We have no strong views on TBoMS with multi-PUSCH scheduling. But, since TBoMS is basically used for coverage limited scenarios, DCI scheduling multi-PUSCH is not a good option. DCI payload size is too large to support coverage limited scenarios. |
| Moderator | Sorry for the confusion.  What I intended to highlight was not the yellow one but the cyan one above. |
| Huawei, HiSilicon | We support Alt1 which is also inline with the agreement cited by the Moderator. |

# Reference

1. R1-2302670 Draft CR on editorial correction of pdsch-TimeDomainAllocationListForMultiPDSCH CATT
2. R1-2302671 Draft CR on alignment of the condition on R\_Tgeneration and candidate PDSCH reception determination CATT
3. R1-2302672 Discussion on R\_Tgeneration and candidate PDSCH reception determination for the features extending NR operation to 71 GHz CATT
4. R1-2302673 Discussion on 32 HARQ process in PDSCH-HARQ-ACK-EnhType3 configuration for the features extending NR operation to 71 GHz CATT
5. R1-2303104 Discussion on BWP operations in FR2-2 Samsung
6. R1-2303105 Draft CR on BWP switching with CBG-based transmission in FR2-2 Samsung
7. R1-2303816 Discussion on TBoMS regarding multi-PUSCH ASUSTeK

# TPs

## TP#A (TBA)