**3GPP TSG-RAN WG1 Meeting #102-eR1-200xxxx**

**e-Meeting, August 17th – 28th, 2020**

**Agenda item:** **7.2.5.3**

**Source: Moderator (Apple Inc.)**

**Title: Summary of Email Discussion [102-e-NR-L1enh-URLLC-PUSCH\_Enh-01]**

**Document for: Discussion and Decision**

# 1 Introduction

The following has been agreed for email discussion based on the issues raised in the contributions submitted under AI 7.2.5.3 [11]:

[102-e-NR-L1enh-URLLC-PUSCH\_Enh-01] Remaining issues on URLLC PUSCH – Sigen (Apple)

* Issue #1: Optimization regarding numberInvallidSymbolsForDL-UL-Switching
* Issue #2: Peak rate restriction
* Issue #3: Number of MIMO layers
* Discussions/Agreements by 8/21, TPs by 8/28

This contribution provides the summary for the email discussion.

# 2 Issues #1: Optimization regarding *numberInvallidSymbolsForDL-UL-Switching*

There was some discussion in RAN1#101-e regarding whether *numberInvallidSymbolsForDL-UL-Switching* should also apply to the symbols after SSB or CORESET#0. This was further considered by some companies in this meeting:

* Apply *numberInvallidSymbolsForDL-UL-Switching* to indicate the number of symbols after the last symbol that is indicated by *ssb-PositionsInBurst* in SIB1 or *ssb-PositionsInBurst* in *ServingCellConfigCommon* for reception of SS/PBCH block are invalid symbols for PUSCH repetition Type B transmission.
  + Yes: ZTE[2], CATT[4], WILUS[10]
  + No: Samsung[7]
    - Samsung[7]: A UE that is not required to receive an SSB can transmit a PUSCH Type B repetition starting from a first UL or flexible symbol after the SSB.
* Apply *numberInvallidSymbolsForDL-UL-Switching* to indicate the number of symbols after the last symbol that is indicated by *pdcch-ConfigSIB1* in *MIB* for a CORESET for Type0-PDCCH CSS set are invalid symbols for PUSCH repetition Type B transmission.
  + Yes: ZTE[2], CATT[4], WILUS[10]
  + No: Samsung[7]

## **Proposal 1-1:**

**If *numberInvallidSymbolsForDL-UL-Switching* is configured, *numberInvallidSymbolsForDL-UL-Switching* symbols after the last symbol that is indicated by *ssb-PositionsInBurst* in SIB1 or *ssb-PositionsInBurst* in *ServingCellConfigCommon* for reception of SS/PBCH block are invalid symbols for PUSCH repetition Type B transmission.**

**Companies please indicate if you support the proposal.**

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| **Yes** | CATT |
| **No** | Ericsson, vivo, Samsung, Spreadtrum, Intel |

Companies please provide detailed comments if any.

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| **Company** | **Comments** |
| Ericsson | The gNB can avoid such unavailable symbols via RRC and/or DCI signaling. As a reference, existing spec in 38.214 do not explicitly provide gap after these symbols. These symbols are not to be set as uplink, but can be set as flexible.  38.214 section 11.1:  *For operation on a single carrier in unpaired spectrum, for a set of symbols of a slot indicated to a UE by ssb-PositionsInBurst in SIB1 or ssb-PositionsInBurst in ServingCellConfigCommon, for reception of SS/PBCH blocks, the UE does not transmit PUSCH, PUCCH, PRACH in the slot if a transmission would overlap with any symbol from the set of symbols and the UE does not transmit SRS in the set of symbols of the slot. The UE does not expect the set of symbols of the slot to be indicated as uplink by tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated, when provided to the UE.* |
| CATT | As we commented in the last meeting, the gap after the SSB/Type0 CSS is necessary to avoid UL-DL interference from system perspective considering the propagation delay and timing advance.  In Rel-15, only slot based repetition is supported so that gNB can avoid the collision by proper scheduling/configuration. However, for PUSCH repetition type B, it is not feasible for gNB to avoid colliding with flexible symbols after SSB/Type0 CSS which are used as GP. That is the reason we defined the invalid symbols and it should be applied here as well. |
| vivo | UE is not mandated to receive SSB/type0-PDCCH CSS set when transmitting PUSCH repetition type B. So, Rx-Tx switching time is not needed if UE does not receive SSB/type-0 CSS symbols.  Additionally, considering there is valid TA when transmitting PUSCH repetition type B, applying a GP indicated by *numberInvallidSymbolsForDL-UL-Switching* after SSB reception or type0-PDCCH CSS set is not needed.  If there would be issue for the gNB to receive the UL transmission, the gNB can simply configure these symbols as semi-static DL instead, or use invalid symbol pattern to indicate some symbols as invalid symbols for PUSCH type B repetition. |
| Samsung | As we analysis in our paper, gNB already has many method to avoid UL/DL conflict, as well as for the switching gap. On the other hand, with created gap, the spectral efficiency will degrade and it impact on latency and reliability of type B PUSCH if UE can skip SSB decoding. |
| Spreadtrum | The flexibility and efficiency would be low if ***numberInvallidSymbolsForDL-UL-Switching*** is applied after both semi-static DL symbol and SSB/type0 CSS since not all UEs are necessary to monitor broadcast signals. In addition, the gap can also be configured by other ways such as invalid symbol pattern. |
| Intel | Prefer to avoid further optimizations in this topic, especially given that there are issues highlighted by the companies above. |

## **Proposal 1-2:**

**If *numberInvallidSymbolsForDL-UL-Switching* is configured, *numberInvallidSymbolsForDL-UL-Switching* symbols after the last symbol that is indicated by *pdcch-ConfigSIB1* in *MIB* for a CORESET for Type0-PDCCH CSS set are invalid symbols for PUSCH repetition Type B transmission.**

**Companies please indicate if you support the proposal.**

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| **Yes** | CATT |
| **No** | Ericsson, vivo, Samsung, Spreadtrum, Intel |

Companies please provide detailed comments if any.

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| **Company** | **Comments** |
| Ericsson | The gNB can avoid such unavailable symbols via RRC and/or DCI signaling. As a reference, existing spec in 38.214 do not explicitly provide gap after MIB or SIB1. These symbols are not to be set as uplink, but can be set as flexible.  38.214 section 11.1:  *For a set of symbols of a slot indicated to a UE by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set, the UE does not expect the set of symbols to be indicated as uplink by tdd-UL-DL-ConfigurationCommon, or tdd-UL-DL-ConfigurationDedicated.* |
| CATT | Same as response above |
| vivo | Same comments as for proposal 1-1. |
| Samsung | Even less motivation to create the gap for CORSEST 0. Other than the reason for SSB (proposal 11), there are some additional reasons as:   * For FR 1, CORESET 0 is always in the beginning of each slot and for FR 2, symbol(s) for CORESET 0 are same as SSB ones or right before SSB ones. * In Rel-15, for PRACH collision with CORESET 0, PRACH will be transmitted on the symbols of CORESET 0 if these symbols are indicated as flexible. |
| Spreadtrum | Same comments as for proposal 1-1. |
| Intel | Prefer to avoid further optimizations in this topic in the maintenance phase |

# 3 Issues #2: Peak rate restriction

Huawei/HiSi[5] and Apple[8] discussed the issues on the peak rate restrictions related to PUSCH repetition Type B. There are two aspects, one is the per-cell peak rate restriction, the other one is the aggregated data rate restriction. The corresponding TPs have been proposed.

Huawei/HiSi[5]:

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| **Proposal 1: Apply per-cell peak rate restriction for PUSCH repetition type B.**  The text proposal for 38.214 could be found in the following:  --------------------------------------------Start of text proposal-------------------------------------------------------- 6.1.4 Modulation order, redundancy version and transport block size determination \*\*\* Unchanged text is omitted \*\*\*  For a *j*-th serving cell, if higher layer parameter *processingType2Enabled* of *PUSCH-ServingCellConfig* is configured for the serving cell and set to *enable,* or if at least one *IMCS > W* for a PUSCH, where *W* = 28 for MCS tables 5.1.3.1-1 and 5.1.3.1-3, and *W* = 27 for MCS tables 5.1.3.1-2, 6.1.4.1-1, and 6.1.4.1-2, or if *PUSCHRepTypeIndicator-ForDCIFormat0\_1* is set to '*pusch-RepTypeB*' for PUSCH scheduled by DCI format 0\_1, or if *PUSCHRepTypeIndicator-ForDCIFormat0\_2* is set to '*pusch-RepTypeB*' for PUSCH scheduled by DCI format 0\_2, the UE is not required to handle PUSCH transmissions, if the following condition is not satisfied:  where  - is the number of symbols assigned to the PUSCH  - *M* is the number of TB in the PUSCH  - where μ is the numerology of the PUSCH  - for the *m*-th TB,  - *A* is the number of bits in the transport block as defined in Clause 6.2.1 [5, TS 38.212]  - *C* is the total number of code blocks for the transport block defined in Clause 5.2.2 [5, TS 38.212]  - is the number of scheduled code blocks for the transport block as defined in Clause 5.4.2.1 [5, TS 38.212]  - [Mbps] is computed as the maximum data rate for a carrier in the frequency band of the serving cell for any signaled band combination and feature set consistent with the serving cell, where the data rate value is given by the formula in Clause 4.1.2 in [13, TS 38.306], including the scaling factor *f(i).*  - each actual repetition for PUSCH repetition type B is treated as one PUSCH.  ---------------------------------------------End of text proposal-------------------------------------------------------- |

Apple[8]:

TP for TS 38.214 Clause 6.1.4:

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| Within a cell group, a UE is not required to handle PUSCH(s) transmissions in slot *sj* in serving cell-*j*, and for *j* = 0,1,2.. *J-1*, slot *sj* overlapping with any given point in time, if the following condition is not satisfied at that point in time:  ,  where  *- J* is the number of configured serving cells belong to a frequency range  - for the *j-th* serving cell,  *- M* is the number of TB(s) transmitted in slot-*sj*. For PUSCH repetition Type B, each actual repetition is counted separately.  *- Tslotμ(j)* =10-3/2*μ(j*), where *μ(j)* is the numerology for PUSCH(s) in slot *sj* of the *j*-th serving cell.  - for the *m*-th TB,  *- A* is the number of bits in the transport block as defined in Clause 6.2.1 [5, TS 38.212]  *- C* is the total number of code blocks for the transport block defined in Clause 5.2.2 [5, TS 38.212].  - is the number of scheduled code blocks for the transport block as defined in Clause 5.4.2.1 [5,38.212]  - [Mbps] is computed as the maximum data rate summed over all the carriers in the frequency range for any signaled band combination and feature set consistent with the configured servings cells, where the data rate value is given by the formula in Clause 4.1.2 in [13, TS 38.306], including the scaling factor *f(i).*  For a *j*-th serving cell, if higher layer parameter *processingType2Enabled* of *PUSCH-ServingCellConfig* is configured for the serving cell and set to *enable,* or if at least one *IMCS > W* for a PUSCH, where *W* = 28 for MCS tables 5.1.3.1-1 and 5.1.3.1-3, and *W* = 27 for MCS tables 5.1.3.1-2, 6.1.4.1-1, and 6.1.4.1-2, or if it is an actual repetition for PUSCH repetition Type B, the UE is not required to handle PUSCH transmissions, if the following condition is not satisfied:  where  - is the number of symbols assigned to the PUSCH  - *M* is the number of TB in the PUSCH  - where μ is the numerology of the PUSCH  - for the *m*-th TB,  - *A* is the number of bits in the transport block as defined in Clause 6.2.1 [5, TS 38.212]  - *C* is the total number of code blocks for the transport block defined in Clause 5.2.2 [5, TS 38.212]  - is the number of scheduled code blocks for the transport block as defined in Clause 5.4.2.1 [5, TS 38.212]  - [Mbps] is computed as the maximum data rate for a carrier in the frequency band of the serving cell for any signaled band combination and feature set consistent with the serving cell, where the data rate value is given by the formula in Clause 4.1.2 in [13, TS 38.306], including the scaling factor *f(i).* |

## **Proposal 2-1:**

**Adopt the following TP for TS 38.214:**

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| TP for TS 38.214 Clause 6.1.4  6.1.4 Modulation order, redundancy version and transport block size determination  < Unchanged parts are omitted >  Within a cell group, a UE is not required to handle PUSCH(s) transmissions in slot *sj* in serving cell-*j*, and for *j* = 0,1,2.. *J-1*, slot *sj* overlapping with any given point in time, if the following condition is not satisfied at that point in time:  ,  where  *- J* is the number of configured serving cells belong to a frequency range  - for the *j-th* serving cell,  *- M* is the number of TB(s) transmitted in slot-*sj*. For PUSCH repetition Type B, each actual repetition is counted separately.  *- Tslotμ(j)* =10-3/2*μ(j*), where *μ(j)* is the numerology for PUSCH(s) in slot *sj* of the *j*-th serving cell.  - for the *m*-th TB,  *- A* is the number of bits in the transport block as defined in Clause 6.2.1 [5, TS 38.212]  *- C* is the total number of code blocks for the transport block defined in Clause 5.2.2 [5, TS 38.212].  - is the number of scheduled code blocks for the transport block as defined in Clause 5.4.2.1 [5,38.212]  - [Mbps] is computed as the maximum data rate summed over all the carriers in the frequency range for any signaled band combination and feature set consistent with the configured servings cells, where the data rate value is given by the formula in Clause 4.1.2 in [13, TS 38.306], including the scaling factor *f(i).*  For a *j*-th serving cell, if higher layer parameter *processingType2Enabled* of *PUSCH-ServingCellConfig* is configured for the serving cell and set to *enable,* or if at least one *IMCS > W* for a PUSCH, where *W* = 28 for MCS tables 5.1.3.1-1 and 5.1.3.1-3, and *W* = 27 for MCS tables 5.1.3.1-2, 6.1.4.1-1, and 6.1.4.1-2, or if it is an actual repetition for PUSCH repetition Type B, the UE is not required to handle PUSCH transmissions, if the following condition is not satisfied:  where  - is the number of symbols assigned to the PUSCH  - *M* is the number of TB in the PUSCH  - where μ is the numerology of the PUSCH  - for the *m*-th TB,  - *A* is the number of bits in the transport block as defined in Clause 6.2.1 [5, TS 38.212]  - *C* is the total number of code blocks for the transport block defined in Clause 5.2.2 [5, TS 38.212]  - is the number of scheduled code blocks for the transport block as defined in Clause 5.4.2.1 [5, TS 38.212]  - [Mbps] is computed as the maximum data rate for a carrier in the frequency band of the serving cell for any signaled band combination and feature set consistent with the serving cell, where the data rate value is given by the formula in Clause 4.1.2 in [13, TS 38.306], including the scaling factor *f(i).*  - each actual repetition for PUSCH repetition type B is treated as one PUSCH.  < Unchanged parts are omitted > |

**Companies please indicate if you support the intention of the TP.**

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| **Yes** | Ericsson, CATT, vivo, Samsung, Spreadtrum |
| **No** |  |

Companies please provide detailed comments if any.

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| **Company** | **Comments** |
| Intel | We are not sure of the part where each actual repetition is counted separately towards the data rate in the slot. To us, more than one actual PUSCH is still a single TB transmitted with a given SE, and we fail to see why it should be multiplied by the number of actual repetitions.  More discussion is required on this aspect. |
| Nokia, NSB | As Intel, would be good to clarify if this is the same processing load for the gNB as having independent TBs transmitted within a slot (each requiring separate coding etc.) – whereas here just different coded bits are mapped to the different PUSCH repetitions. |
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# 4 Issues #3: Number of MIMO layers

vivo[1] discussed whether to introduce the restriction on the number of MIMO layers for PUSCH repetition Type B, and proposed:

* If *numberofrepetitions* is configured, in case the number of nominal repetitions >1, PUSCH is limited to a single transmission layer.

## **Proposal 3-1:**

**For PUSCH repetition Type B, if the number of nominal repetitions is larger than 1, the PUSCH is limited to a single transmission layer.**

**Companies please indicate if you support the proposal.**

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| **Yes** | Ericsson, CATT, vivo, Samsung, Spreadtrum, Intel |
| **No** | Nokia / NSB |

Companies please provide detailed comments if any.

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| **Company** | **Comments** |
| CATT | We would like to further clarify whether only a single transmission layer is supported for the case of K=1 with multiple actual repetitions. |
| vivo | We would like to clarify the motivation for the proposal 3-1.  In current spec, for PUSCH repetition Type A, in case *K*>*1*, the PUSCH is limited to a single transmission layer. However, the number of layer(s) for PUSCH repetition type B has not been defined yet.  In our views, the same limit should be applied considering the high reliability requirement for UE configured with more than one nominal repetitions. Therefore, for PUSCH repetition type B, in case *K*>*1,* PUSCH should also be limited to a single transmission layer.  In case *K*=1, there is no limitation on the number of transmission layer for PUSCH repetition type A. Same method can be adopted for PUSCH repetition type B, although one nominal repetition may split into multiple actual repetitions when the nominal repetition runs into invalid symbol(s).  The corresponding TP is provided as below.   |  | | --- | | ***Text Proposal for 38.214***  ----------------------------------------- Start of TP -----------------------------------------  ***6.1.2.1 Resource allocation in time domain***  **….....**  For PUSCH repetition Type B, except for PUSCH transmitting CSI report(s) with no transport block, the number of nominal repetitions is given by *numberofrepetitions*. If *numberofrepetitions* >1, the PUSCH is limited to a single transmission layer. For the *n*-th nominal repetition, *n* = *0*, …, *numberofrepetitions* - 1,  - The slot where the nominal repetition starts is given by , and the starting symbol relative to the start of the slot is given by .  - The slot where the nominal repetition ends is given by , and the ending symbol relative to the start of the slot is given by .  **…….**  --------------------------------------------------------------End of TP ------------------------------------------------------------ | |
| Nokia, NSB | Rel-15 slot based repetition is for coverage enhancement (and potentially reliability enhancement) – so far we agree with the statements from Huawei above.  But PUSCH repetition Type B is not necessarily there to improve the reliability, but is used to reduce the scheduling alignment time by enabling multiple (actual) repetitions to be able to use the available UL resources also towards the end of a slot / before the start of a DL period for TDD. And a larger repetition number may be used to be able to nicely adopt the scheduling to the available resources there. Therefore, for latency critical data (where there is not necessarily very high reliability required) PUSCH repetition type B with K>1 could still be useful without the need to restrict the number of layers there. |

# 5 Agreements

# References

1. R1-2005349 PUSCH enhancements for URLLC vivo
2. R1-2005415 Remaining issues on PUSCH enhancements for NR URLLC ZTE
3. R1-2005508 Remaining Issue of PUSCH Enhancements for NR URLLC Ericsson
4. R1-2005674 Remaining issues on PUSCH enhancements CATT
5. R1-2005793 Corrections on PUSCH enhancement Huawei, HiSilicon
6. R1-2006053 PUSCH enhancements for URLLC OPPO
7. R1-2006111 Remaining issues for PUSCH enhancement Samsung
8. R1-2006489 Remaining Issues on PUSCH enhancements for eURLLC Apple
9. R1-2006776 Remaining issues on PUSCH enhancements for URLLC Qualcomm Incorporated
10. R1-2006883 Remaining issues on PUSCH enhancement for NR URLLC WILUS Inc.
11. R1-2006992 Feature lead summary #2 on PUSCH enhancements for NR eURLLC (AI 7.2.5.3) Moderator (Apple Inc.)