**3GPP TSG RAN WG1 Meeting #108-e R1-22xxxxx**

**e-Meeting, February 21st-March 3rd, 2022**

**Agenda Item: 7.1**

**Source: Moderator (Huawei)**

**Title: [draft] Summary of email discussion [108-e-NR-CRs-01] on bit interleaving length for PUSCH transmission**

**Document for: Discussion and Decision**

# Introduction

As per the agreements below, PUSCH data is rate-matched around UCI (except for HARQ-ACK with up to 2 bits).

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| RAN1#90:  *Agreements:*   * *For frequency first mapping, UCI resource mapping principles (e.g., around RS) are common for PUSCH with DFT-s-OFDM waveform and CP-OFDM waveform* * *At least for periodic CSI report configured by RRC and aperiodic CSI report triggered by UL grant, the UL data is rate-matched around the UCI*   RAN1#NR-Adhoc#3:  *Agreements:*   * *Confirm the working assumption:*   + *For slot-based scheduling, for HARQ-ACK with more than 2 bits, PUSCH is rate-matched.*   + *For slot-based scheduling, for HARQ-ACK with up to 2 bits, PUSCH is punctured.* |

However, according to the discussion in Rel-17 coverage enhancements [2], there seems some misunderstanding that the PUSCH data is always punctured by UCI, because the notation G in Clause 6.2.6 has the same notation as the G in Clause 6.2.7 which includes the bits of UCI.

To avoid the potential misunderstanding, in [1], it is clarified in Clause 6.2.6 that when control information is multiplexed with UL-SCH transmission, is replaced by as defined in Clause 6.2.7, which means that the bit length after code block concatenation should be the total number of coded bits for UL-SCH transmission excluding the control information bits that requires rate-matching operation on PUSCH.

The specific change is proposed in [1] for Rel-15 TS 38.212 as

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| 6.2.6 Code block concatenation  The input bit sequence for the code block concatenation block are the sequences , for  and where  is the number of rate matched bits for the -th code block.  Code block concatenation is performed according to Clause 5.5.  The bits after code block concatenation are denoted by, where  is the total number of coded bits for transmission. When control information is multiplexed with the UL-SCH transmission, is equal to and is replaced by as defined in Clause 6.2.7.  6.2.7 Data and control multiplexing  Denote the coded bits for UL-SCH as .  Denote the coded bits for HARQ-ACK, if any, as .  Denote the coded bits for CSI part 1, if any, as .  Denote the coded bits for CSI part 2, if any, as .  Denote the multiplexed data and control coded bit sequence as .  Denote  as the OFDM symbol index of the scheduled PUSCH, starting from 0 to , where  is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS.  Denote  as the subcarrier index of the scheduled PUSCH, starting from 0 to , where  is expressed as a number of subcarriers.  Denote  as the set of resource elements, in ascending order of indices , available for transmission of data in OFDM symbol , for .  Denote  as the number of elements in set . Denote  as the -th element in .  Denote  as the set of resource elements, in ascending order of indices , available for transmission of UCI in OFDM symbol , for . Denote  as the number of elements in set . Denote  as the -th element in . For any OFDM symbol that carriers DMRS of the PUSCH, . For any OFDM symbol that does not carry DMRS of the PUSCH, .  **<Unchanged parts are omitted>** |

As per chair’s guidance, this CR is discussed and is expected to complete by February xx.

[108-e-NR-CRs-01] Issue#1 Correction on bit interleaving length for PUSCH transmission by February 25 – ??? (Huawei)

* Relevant tdoc: [R1-2200974](file:///C:\Users\Docs\R1-2200974.zip)

# Phase I of Discussions

## Q1: In S6.2.6 of TS 38.212, whether or not the bit length after code block concatenation should be the total number of coded bits for UL-SCH transmission excluding the control information bits that requires rate-matching operation on PUSCH?

If no, please elaborate a bit your understanding on the bit length and whether the bit length for the case of rate-matching is different from that for the case of puncturing.

Companies’ views are welcome.

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| *Company* | *View* |
| Qualcomm | In our view, the wording in 6.2.6 does not impact whether UL-SCH is punctured or not. When both 6.2.6 and 6.2.7 are read together, the procedure is clear from existing text. |
| Samsung | Our understanding is that Clause from 6.2.1 to 6.2.6 describes LDPC coding chain regarding UL-SCH. Thus, in 6.2.6, the bit length after code block concatenation should be the total number of coded bits for UL-SCH transmission excluding the control information bits. |
| Intel | We share similar view as Samsung. |
| ZTE | We have similar view as above companies. The current procedure is clear and has been correctly implemented. |
| LG | Similar understanding with above companies. |
| Ericsson | Similar comment as Qualcomm. |
| DOCOMO | Similar view with other companies. |
| Nokia, NSB | Similar view as other companies. Most importantly UCI muxing on PUSCH is a core functionality that must work for the connection to work. It is clear that the UCI muxing on PUSCH has been understood and implemented across the industry in one way only. |
| Moderator | Thank you very much for the feedbacks.  There is only one interpretation in the RAN1 group. Since the opposite view was once majority view in Rel-17 CovEnh discussion [2], a conclusion to remove the ambiguity of the concerned spec text is helpful for any future discussion. No spec change is needed.  ***Proposal***: *As a conclusion, when control information is multiplexed with the UL-SCH transmission, the bit length after code block concatenation in subclause 6.2.6 of TS 38.212 is equal to as defined in subclause 6.2.7.* |
| Apple | Yes, our understanding is that the bit length after code block concatenation should be the total number of coded bits for UL-SCH transmission, excluding the control information bits to be carried on PUSCH. |

## Draft CR for TS 38.212

Assuming that a common understanding is Yes for Q1, how to capture it is discussed here, with the CR [1] as a starting point.

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| 6.2.6 Code block concatenation  The input bit sequence for the code block concatenation block are the sequences , for  and where  is the number of rate matched bits for the -th code block.  Code block concatenation is performed according to Clause 5.5.  The bits after code block concatenation are denoted by, where  is the total number of coded bits for transmission. When control information is multiplexed with the UL-SCH transmission, is equal to and is replaced by as defined in Clause 6.2.7.  6.2.7 Data and control multiplexing  Denote the coded bits for UL-SCH as .  Denote the coded bits for HARQ-ACK, if any, as .  Denote the coded bits for CSI part 1, if any, as .  Denote the coded bits for CSI part 2, if any, as .  Denote the multiplexed data and control coded bit sequence as .  Denote  as the OFDM symbol index of the scheduled PUSCH, starting from 0 to , where  is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS.  Denote  as the subcarrier index of the scheduled PUSCH, starting from 0 to , where  is expressed as a number of subcarriers.  Denote  as the set of resource elements, in ascending order of indices , available for transmission of data in OFDM symbol , for .  Denote  as the number of elements in set . Denote  as the -th element in .  Denote  as the set of resource elements, in ascending order of indices , available for transmission of UCI in OFDM symbol , for . Denote  as the number of elements in set . Denote  as the -th element in . For any OFDM symbol that carriers DMRS of the PUSCH, . For any OFDM symbol that does not carry DMRS of the PUSCH, .  **<Unchanged parts are omitted>** |

### Q2: Whether or not the CR proposed in [1], as copied above, is acceptable? Or any suggestion?

Companies’ views are welcome.

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| *Company* | *View* |
| Qualcomm | No, we don’t think any change is necessary. |
| Samsung | We do not think further clarification is needed, since the *G* in 6.2.6 can refer the *G* in 5.4.2 which is defined as 'the total number of coded bits available for transmission of the transport block'. Regarding the definition of *G* in 5.4.2, our understanding is that 'coded bits available..' describes the UCI bits are already taken out. So it can be known that the *G* in 6.2.6 is already *G\_UL-SCH* in 6.2.7. |
| Intel | We think this is common understanding that G in Clause 6.2.6 only refers to the total number of coded bits available for transmission of the transport block in a slot.  We do not see the need to update the spec. If majority support, we slightly prefer to update the definition of G as “total number of coded bits available for transmission of the transport block in a slot”. This is also discussed in Rel-17 coverage enhancement WI for TBoMS. |
| ZTE | No need to update the spec. |
| LG | The CR doesn’t seem to be necessary. |
| Ericsson | Change is not necessary. |
| vivo | We don’t think any change is necessary. If companies think it is clearer with the CR, we can accept the change. |
| DOCOMO | We don’t think the CR is necessary. |
| Nokia, NSB | As commented in 2.1, this change cannot qualify as essential when this functionality has been in place and working across the industry for years. We do not support the CR |
| Apple | We support the CR to clarify the understanding in Q1. |

## Other Issues

Issues or comments that do not fit in any of the previous sections of this document can be provided here.

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| *Company* | *View* |
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# Phase II of Discussions

## Q1: In S6.2.6 of TS 38.212, whether or not the bit length after code block concatenation should be the total number of coded bits for UL-SCH transmission excluding the control information bits that requires rate-matching operation on PUSCH?

**Summary:**

Thank you very much for your feedbacks.

There is only one view in the RAN1 group. Since the opposite view was once majority view in Rel-17 CovEnh discussion [2], a conclusion to remove the ambiguity of the concerned spec text is expected and surely helpful for any future discussion. No spec change is needed.

***FL Proposal***: *As a conclusion, when control information is multiplexed with the UL-SCH transmission, the bit length after code block concatenation in subclause 6.2.6 of TS 38.212 is equal to as defined in subclause 6.2.7.*

Companies’ views are welcome.

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## Draft CR for TS 38.212

### Q2: Whether or not the CR proposed in [1], as copied above, is acceptable? Or any suggestion?

Thank you very much for your feedbacks.

No specification change is majority view. It seems no need to discuss Q2 further.

# Conclusions

TBD

# References

1. R1-2200974 Correction on bit interleaving length for PUSCH transmission, Huawei, HiSilicon
2. R1-2200752 Final FL summary of TB processing over multi-slot PUSCH (AI 8.8.1.2), Moderator (Nokia, Nokia Shanghai Bell)

# Appendix: