**3GPP TSG RAN WG1 #105e R1-** **210xxxx**

**May 10th – 27th, 2021**

**Agenda item:** 7.2.5

**Source:** Moderator (Qualcomm)

**Title:** Summary of the Preparation Phase: Remaining Issues on HARQ and Scheduling Enhancements for URLLC

**Document for:** Discussion and Decision

# 1 Introduction

In this document, proposals and remaining issues related to URLLC HARQ and scheduling are summarized. The list of the proposals is as follows:

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| **Topic** | **Companies supporting the discussion in RAN1 #104e** | **FL Comment** |
| **Issue #1:** UE procedure for prioritization | Ericsson [1], OPPO [3], Apple [4] | Please refer to the FL comments in Section 2. From FL’s point of view, the specification is clear; it does not introduce **multiplexing of HP channels** in every intermediate steps. If RAN1 prefers it to have this also as a conclusion to conclude this discussion, it should be fine. |
| **Issue #2:** Handling of collision between DL/SSB symbols and configured HP PUCCH and PUSCH | Nokia/NSB [2], DCM [5] | Discuss during the meeting |

# 2 Issue #1

In [1], it is argued that the following step from the intra-UE prioritization makes the UE implementation complicated:

**“***A UE cancels the transmission of a LP channel including any intermediate scheduled LP transmission that does not overlap with any LP channel, if any DCI schedules an overlapping HP transmission with the LP channel, before performing multiplexing/overriding HP channels if any.”*

To address the case, the following TP is presented:

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| ============== START of Text Proposal 1 for TS38.213 ==========================  9 UE procedure for reporting control information  \*\*\*Unchanged text is omitted\*\*\*  When a UE determines overlapping for PUCCH and/or PUSCH transmissions of different priority indexes other than PUCCH transmissions with SL HARQ-ACK reports, including repetitions if any, the UE first resolves the overlapping for PUCCH and/or PUSCH transmissions of ~~smaller~~ a same priority index as described in Clauses 9.2.5 and 9.2.6. Then,  - if a transmission of a first PUCCH of larger priority index ~~scheduled by~~ corresponding to a DCI format in a PDCCH reception would overlap in time with a repetition of a transmission of a second PUSCH or a second PUCCH of smaller priority index, the UE cancels the repetition of a transmission of the second PUSCH or the second PUCCH before the first symbol that would overlap with the first PUCCH transmission  - if a transmission of a first PUSCH of larger priority index ~~scheduled by~~ corresponding to a DCI format in a PDCCH reception would overlap in time with a repetition of the transmission of a second PUCCH of smaller priority index, the UE cancels the repetition of the transmission of the second PUCCH before the first symbol that would overlap with the first PUSCH transmission  where  - ~~the overlapping is applicable before or after resolving overlapping among channels of larger priority index, if any, as described in Clauses 9.2.5 and 9.2.6~~  -    the UE is not expected a later DCI in a PDCCH reception overrides cancellation of a repetition of a PUCCH/PUSCH transmissions of smaller priority index due to overlapping with a PUCCH/PUSCH transmission of larger priority index scheduled by an earlier DCI format in a PDCCH reception  - any remaining PUCCH and/or PUSCH transmission after overlapping resolution is subjected to the limitations for UE transmission as described in Clause 11.1  - the UE expects that the transmission of the first PUCCH or the first PUSCH, respectively, would not start before after a last symbol of the corresponding PDCCH reception  - is the PUSCH preparation time for a corresponding UE processing capability assuming [6, TS 38.214], based on and as subsequently defined in this Clause, and is determined by a reported UE capability  \*\*\*Unchanged text is omitted\*\*\*  ============== END of Text Proposal1 for TS38.213 ========================== |

In [3], it is mentioned that the intermediate checking of collisions leads to a different behavior in terms of multiplexing as compared to Rel. 15. Based on the arguments in the paper, the following proposals are made:

***Proposal 1: Intermediate multiplexing should be removed from intra UE prioritization.***

***Proposal 2: The following intra UE prioritization procedure can be supported:***

* ***Overlapping resolution by multiplexing low priority PUCCH/PUSCH***
* ***Overlapping resolution by multiplexing high priority PUCCH/PUSCH***
* ***Prioritization/cancellation HP over LP***
* ***Add error case: It is not expected a later DCI in a PDCCH reception overrides cancellation of a repetition of a PUCCH/PUSCH transmissions of smaller priority index due to overlapping with a PUCCH/PUSCH transmission of larger priority index scheduled by an earlier DCI format in a PDCCH reception***

**FL comment: This is not the case; the UE performs multiplexing for HP channels in the same way as in Rel. 15 and with a deadline defined for UCI multiplexing. The only difference is that if a HP channel is “scheduled by DCI”, it can initiate the cancellation of overlapping LP channels even before multiplexing. In other words, the UE does not need to check the overlapping and multiplexing every time there is a new grant. The UE checks the overlapping of the HP channel scheduled by a DCI. If not overlapping, then it only checks one more time after all HP channels are multiplexed.**

**In [4], the same case is pointed out, and the following three solutions are proposed:**

* **Option 1**: clarify that the UE does not use the outcome of intermediate multiplexing for HP channels to cancel LP channels based on the current specifications.
* **Option 2**: define an error case that the UE does not expect the gNB to change the overlapping between HP and LP channels over time. With the error case being defined, the multiplexing of LP and HP channels can be separately conducted, and only the final HP channels are used to cancel LP channels.
  + The TP from Ericsson in RAN1#104b-e was the following: “the UE is not expected a later DCI in a
* **Option 3**: modify the cancellation timeline to include any HP channel that overrides or overlaps with a HP channel that overlaps with a LP channel.

**FL comment: Option 2 has an impact on URLLC scheduling as it can adds to scheduling latency. It is not clear how Option 3 tries to solve the issue raised in the paper. It seems it is more about extending the timeline even further. In feature leads’ view, Option 1 is already based on the current specification. In the current specification, we have:**

**“where**

**- the overlapping is applicable before or after resolving overlapping among channels of larger priority index, if any, as described in Clauses 9.2.5 and 9.2.6”**

**Which means that multiplexing is based on the sections cited in this clause. In other words, the UE does not perform multiplexing across high priority channels as they come. The UE checks the overlap between any scheduled HP channel and the LP channels. If there is an overlap, the LP channel is cancelled. If there is no overlap, the final check is after all HP channels are multiplexed.**

# 3 Issue #2

In [2], it is mentioned that the following agreement should be applicable to all remaining transmissions regardless of whether they are dynamically scheduled or not:

**Agreement**

To address collision with semi-static DL symbols and SSB, the following easy way is suggested:

* Step1: Perform intra UE prioritization (including multiplexing, overriding) according to related working assumption in 102 e-meeting and produce final PUCCHs/PUSCHs.

Step 2: Final PUCCHs/PUSCHs is cancelled by semi-static DL symbols and SSB symbols.

However, in the current specification, only the scenarios where the high-priority channel(s) is dynamically scheduled by PDCCH are considered. To address this issue, the following TP is proposed:

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| -------------------------------------------------- Start of text proposal ------------------------------------------------------  9 UE procedure for reporting control information  \*\*\* Unchanged text is omitted \*\*\*  If a UE would transmit the following channels before considering limitations for UE transmission as described in clause 11.1, including repetitions if any, that would overlap in time  - a first PUCCH of larger priority index with SR and a second PUCCH or PUSCH of smaller priority index, or  - a configured grant PUSCH of larger priority index and a PUCCH of smaller priority index, or  - a first PUCCH of larger priority index with HARQ-ACK information only in response to a PDSCH reception without a corresponding PDCCH and a second PUCCH of smaller priority index with SR and/or CSI, or a configured grant PUSCH with smaller priority index, or a PUSCH of smaller priority index with SP-CSI report(s) without a corresponding PDCCH, or  - a PUSCH of larger priority index with SP-CSI reports(s) without a corresponding PDCCH and a PUCCH of smaller priority index with SR, or CSI, or HARQ-ACK information only in response to a PDSCH reception without a corresponding PDCCH, or  - a configured grant PUSCH of larger priority index and a configured PUSCH of lower priority index on a same serving cell  the UE is expected to cancel a repetition of the PUCCH/PUSCH transmissions of smaller priority index before the first symbol overlapping with the PUCCH/PUSCH transmission of larger priority index if the repetition of the PUCCH/PUSCH transmissions of smaller priority index overlaps in time with the PUCCH/PUSCH transmissions of larger priority index. Any remaining PUCCH and/or PUSCH transmission after overlapping resolution is subjected to the limitations for UE transmission as described in Clause 11.1.  \*\*\* Unchanged text is omitted \*\*\*  ----------------------------------------------------- End of text proposal ------------------------------------------------------ |

In [5], the following clause is presented:

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| When a UE determines overlapping for PUCCH and/or PUSCH transmissions of different priority indexes other than PUCCH transmissions with SL HARQ-ACK reports, including repetitions if any, the UE first resolves the overlapping for PUCCH and/or PUSCH transmissions of smaller priority index as described in Clauses 9.2.5 and 9.2.6. Then,  - if a transmission of a first PUCCH of larger priority index scheduled by a DCI format in a PDCCH reception would overlap in time with a repetition of a transmission of a second PUSCH or a second PUCCH of smaller priority index, the UE cancels the repetition of a transmission of the second PUSCH or the second PUCCH before the first symbol that would overlap with the first PUCCH transmission  - if a transmission of a first PUSCH of larger priority index scheduled by a DCI format in a PDCCH reception would overlap in time with a repetition of the transmission of a second PUCCH of smaller priority index, the UE cancels the repetition of the transmission of the second PUCCH before the first symbol that would overlap with the first PUSCH transmission  where  - the overlapping is applicable before or after resolving overlapping among channels of larger priority index, if any, as described in Clauses 9.2.5 and 9.2.6  - any remaining PUCCH and/or PUSCH transmission after overlapping resolution is subjected to the limitations for UE transmission as described in Clause 11.1 |

It is mentioned that With the current formulation, especially from the highlighted part, the processing order of intra-UE prioritization/multiplexing and semi-static DL symbols/SSB symbols is determined only for the case where UL channel overlaps with other UL channels of different priority and semi-static DL symbols/SSB symbols. However, the ambiguity issue of the processing order is present also for the case where UL channel overlaps with other UL channels of the same priority and semi-static DL symbols/SSB symbols. To address the issue, the following changes are proposed:

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| ---------------------------------Start of Text Proposal on TS 38.213 v16.5.0-----------------------  9 UE procedure for reporting control information  <Unchanged parts are omitted>  When a UE determines overlapping for PUCCH and/or PUSCH transmissions of different priority indexes other than PUCCH transmissions with SL HARQ-ACK reports, including repetitions if any, the UE first resolves the overlapping for PUCCH and/or PUSCH transmissions of smaller priority index as described in Clauses 9.2.5 and 9.2.6. Then,  - if a transmission of a first PUCCH of larger priority index scheduled by a DCI format in a PDCCH reception would overlap in time with a repetition of a transmission of a second PUSCH or a second PUCCH of smaller priority index, the UE cancels the repetition of a transmission of the second PUSCH or the second PUCCH before the first symbol that would overlap with the first PUCCH transmission  - if a transmission of a first PUSCH of larger priority index scheduled by a DCI format in a PDCCH reception would overlap in time with a repetition of the transmission of a second PUCCH of smaller priority index, the UE cancels the repetition of the transmission of the second PUCCH before the first symbol that would overlap with the first PUSCH transmission  where  - the overlapping is applicable before or after resolving overlapping among channels of larger priority index, if any, as described in Clauses 9.2.5 and 9.2.6  - the UE expects that the transmission of the first PUCCH or the first PUSCH, respectively, would not start before after a last symbol of the corresponding PDCCH reception  - is the PUSCH preparation time for a corresponding UE processing capability assuming [6, TS 38.214], based on and as subsequently defined in this Clause, and is determined by a reported UE capability  <Unchanged parts are omitted>  --------------------------------------End of Text Proposal on TS 38.213 v16.4.0------------------  ---------------------------------Start of Text Proposal on TS 38.213 v16.4.0-----------------------  11.1 Slot configuration  <Unchanged parts are omitted>  For a set of symbols of a slot that are indicated to a UE as downlink by *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated*, the UE does not transmit PUSCH, PUCCH, determined from Caluses 9 and 9.2.5, PRACH, or SRS when the PUSCH, PUCCH, PRACH, or SRS overlaps, even partially, with the set of symbols of the slot.  For a set of symbols of a slot that are indicated to a UE as flexible by *tdd-UL-DL-ConfigurationCommon*, and *tdd-UL-DL-ConfigurationDedicated* if provided, the UE does not expect to receive both dedicated higher layer parameters configuring transmission from the UE in the set of symbols of the slot and dedicated higher layer parameters configuring reception by the UE in the set of symbols of the slot.  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, determined from Clauses 9 and 9.2.5, 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.  If a UE  - is configured with multiple serving cells and is provided *half-duplex-behavior* = 'enable', and  - is not capable of simultaneous transmission and reception on any of the multiple serving cells, and  - indicates support of capability for half-duplex operation in CA with unpaired spectrum, and  - is not configured to monitor PDCCH for detection of DCI format 2\_0 on any of the multiple serving cells,  for a set of symbols of a slot that are indicated to the UE for reception of SS/PBCH blocks in any of multiple serving cells by *ssb-PositionsInBurst* in *SystemInformationBlockType1* or by *ssb-PositionsInBurst* in *ServingCellConfigCommon*, when provided to the UE, the UE does not transmit PUSCH, PUCCH, determined from Clauses 9 and 9.2.5, or 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 in any of multiple serving cells.  <Unchanged parts are omitted>  --------------------------------------End of Text Proposal on TS 38.213 v16.5.0------------------ |

# 9 References

**[1] R1-2104216, “Maintenance of scheduling and HARQ for Rel-16 NR URLLC,” Ericsson**

**[2] R1-2104312, “Rel-16 URLLC/IIoT maintenance of PDCCH, scheduling/HARQ and SPS enhancements,” Nokia, Nokia Shanghai Bell**

**[3] R1-2104800, “Remaining issues on scheduling and HARQ,” OPPO**

**[4] R1-2105084, “Remaining issues on intra-UE multiplexing/prioritization for eURLLC,” Apple**

**[5] R1-2105682, “Corrections on scheduling/HARQ for Rel-16 URLLC,” NTT DOCOMO Inc.**