**3GPP TSG RAN WG1 #104e R1-** **21xxxxx**

**January 25th – February 5th, 2021**

**Agenda item:** 7.2.5

**Source:** Moderator (Qualcomm)

**Title:** Summary of [104-e-NR-L1enh-URLLC-04]: Email discussion/approval on remaining issues on Scheduling & HARQ enhancements

**Document for:** Discussion and Decision

# 1 Introduction

Based on the discussions during the preparation phase, it is agreed to discuss the following topics during the RAN1 #104e:

[104-e-NR-L1enh-URLLC-04] Email discussion/approval on remaining issues on Scheduling & HARQ enhancements – Kianoush (Qualcomm) by Feb 3

* Issue 1: Correction on intra-UE prioritization timeline by replacing “before the first overlapping symbol” with “no later than the first overlapping symbol”
* Issue 2: Prioritization due to collision with semi-static DL and SSB symbols
* Issue 4: Active duration of CSI-RS resources in case of cancellation
* Issue 5: Including the agreement that any HP DCI can cancel a LP transmission

# 2 Issue #1

The following TP is proposed in [1]:

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| ------------------------------------ Start of TP 38.213V16.3.0 section 9---------------------------------  <unchanged text omitted>  When a UE determines overlapping for PUCCH and/or PUSCH transmissions of different priority indexes, the UE first resolves the overlapping for PUCCH and/or PUSCH transmissions of smaller priority index as described in Clause 9.2.5. 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 transmission of a second PUSCH or a second PUCCH of smaller priority index, the UE cancels the transmission of the second PUSCH or the second PUCCH ~~before~~ no later than 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 transmission of a second PUCCH of smaller priority index, the UE cancels the transmission of the second PUCCH ~~before~~ no later than 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 Clause 9.2.5  - 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  If a UE is scheduled by a DCI format in a first PDCCH reception to transmit a first PUCCH or a first PUSCH of larger priority index that overlaps with a second PUCCH or a second PUSCH transmission of smaller priority index that, if any, is scheduled by a DCI format in a second PDCCH  - is based on a value of corresponding to the smallest SCS configuration of the first PDCCH, the second PDCCHs, the first PUCCH or the first PUSCH, and the second PUCCHs or the second PUSCHs  - if the overlapping group includes the first PUCCH  - if *processingType2Enabled* of *PDSCH-ServingCellConfig* is set to *enable* for the serving cell where the UE receives the first PDCCH and for all serving cells where the UE receives the PDSCHs corresponding to the second PUCCHs, and if *processingType2Enabled* of *PUSCH-ServingCellConfig* is set to *enable* for the serving cells with the second PUSCHs, *N2* is 5 for , 5.5 for  and 11 for  - else, *N2* is 10 for =0*,* 12 for , 23 for , and 36 for ;  - if the overlapping group includes the first PUSCH  - if *processingType2Enabled* of *PUSCH-ServingCellConfig* is set to *enable* for the serving cells with the first PUSCH and the second PUSCHs and if *processingType2Enabled* of *PDSCH-ServingCellConfig* is set to *enable* for all serving cells where the UE receives the PDSCHs corresponding to the second PUCCHs, *N2* is 5 for , 5.5 for  and 11 for  - else, *N2* is 10 for =0*,* 12 for , 23 for , and 36 for ;  If a UE would transmit the following channels 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 the PUCCH/PUSCH transmissions of smaller priority index ~~before~~ no later than the first symbol overlapping with the PUCCH/PUSCH transmission of larger priority index.  <unchanged text omitted>  ------------------------------------ End of TP 38.213V16.3.0 section 9--------------------------------- |

**Please share your views on the proposed TP in the table below.**

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| **Company** | **Comment** |
| **CATT** | **The current TP is not clear whether it is no later than the start or the end of the first symbol. We assume the intention is the former one. With this understanding, we do not see much difference between the current texts and the proposal therefore the TP is not essential in our view.** |
| **ZTE** | **No need to change, the wording in specification is fine to determine where to start to cancel.** |
| **vivo** | **For determining the starting cancelation symbol, there is no difference between current spec and the proposed TP. We are fine with the description in current spec.** |
| **HW/HiSi** | **Agree with the TP-** |
| **LG** | **If “before the first symbol” could mean “canceling from first symbol”, we think the proposed change is not necessary. if there is no common understanding, we are fine to clarify further more.** |
| **OPPO** | **In our understanding, “Before” means cancellation should start from the symbol before first overlapping symbol. “No later than” means cancellation could start from first overlapping symbol or the symbol before first overlapping symbol. The intention of agreement includes first overlapping symbol for cancellation. So, TP is necessary.**  **Moreover, if we have different understandings on “before”, to make it clear and avoid repeating this issue later, TP is also suggested to adopt.** |
| **DOCOMO** | **We don’t think the TP is needed. In our understanding, ‘before’ means the start of the overlapping first symbol not the end of the first symbol. The current description in spec correctly captures the intention.** |
| **Nokia, NSB** | **We don’t see a need for the change (as most other companies so far). Current specs is clear enough** |
| **Ericsson** | **Although “before” is fine, but in fact, “not later than” is more accurate. We are fine with adopting the TP, to avoid future risks that UE may skip cancellation of first symbol.** |
| **Samsung** | **No need for the TP – the cancelation is before the transmission, the first symbol is not overlapped.** |
| **Spreadtrum** | **We support the TP, it is more accurate.** |
| **Intel** | **No need for the TP. Share same understanding as CATT, Samsung, et al.** |
| **Apple** | **We do not strictly see the need for the TP, but we are fine with the group’s decision whichever it is.** |

# 3 Issue #2

For the order of multiplexing and cancellation due to collision with semi-static DL/SSB symbols, please provide your comments on the following proposal [3]:

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| For the purpose of collision resolution of PUCCH/PUSCH resources with semi-static DL and/or SSBs or with other PUCCH/PUSCH resources in a slot, the following steps are applied:   * 1. When PUCCH/PUSCH resources in a slot are determined, apply the following steps:   2. Step 1: Any PUCCH/PUSCH resource that overlaps with semi-static DL symbols or SSB in the slot is cancelled   3. Step 2: Any overlapping among PUCCH/PUSCH resources is resolved as the following:      + Step 2.1: Overlapping among LP PUCCH/PUSCH channels, if any, is resolved similar to Rel-15 as if HP channels do not exist.      + Step 2.2: Any LP PUCCH/PUSCH that overlaps with a HP PUCCH/PUSCH channel is cancelled.      + Step 2.3: Overlapping among HP PUCCH/PUSCH channels, if any, is resolved similar to Rel-15 as if LP channels do not exist.      + Step 2.4: Any LP PUCCH/PUSCH that overlaps with a HP PUCCH/PUSCH channel is cancelled.   4. Step 3: Any PUCCH/PUSCH resource that overlaps with semi-static DL symbols or SSB is cancelled.   + Note: In steps 2.1 or 2.3, for a scheduled LP or HP PUCCH resource carrying HARQ-ACK, respectively, the corresponding overriding procedure if applicable, is performed prior to any multiplexing procedures involving the PUCCH resource. |

**Please share your views in the table below.**

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| **Company** | **Comment** |
| **CATT** | We would like to discuss the following issues:   1. Whether intermediate HP PUCCH resource in the multiplexing and overriding procedures should cancels overlapping LP PUCCH/PUSCH resource?   It is our understanding that intermediate HP PUCCH resource in the multiplexing and overriding procedures should cancel a LP PUCCH/PUSCH except for the intermediate HP PUCCH resource in the multiplexing and overriding procedures colliding with semi-static DL symbols or SSB symbols to minimize the LP PUCCH/PUSCH dropping.   1. Whether intermediate HP PUCCH resource in the multiplexing and overriding procedure colliding with semi-static DL symbols or SSB symbols is cancelled before multiplexing?   We think that the intermediate HP PUCCH resource in the multiplexing and overriding procedure colliding with semi-static DL symbols or SSB symbols should not be cancelled before multiplexing since the UCI can be finally multiplexed in other PUCCH/PUSCH resource.  Accordingly, we have the following proposal:   * Step 1: Determine all individual LP PUCCH/PUSCH in a slot, the individual LP PUCCH/PUSCHs are determined before any multiplexing and after PUCCH overriding procedure;(LP PUCCH overriding is performed in this step) * Step 2: Each individual LP PUCCH/PUSCH that collides with semi-static DL symbols and/or SSB symbols is cancelled; * Step 3: Multiplexing between LP PUCCH/PUSCHs are performed; (Multiplexing between multiple CSIs is also included in this step; the intermediate LP PUCCH/PUSCHs in the middle of multiplexing are not cancelled when collides with semi-static DL symbols and/or SSB symbols) * Step 4: Determine all individual HP PUCCH/PUSCH in a slot, the individual HP PUCCH/PUSCHs are determined before any multiplexing procedure (The PUCCH resource associated with PUCCH overriding procedure are not included in this step), each individual HP PUCCH/PUSCH that collides with semi-static DL symbols and/or SSB symbols is cancelled; * Step 5: If there is collision between HP PUCCHs/PUSCHs obtained in step 4 and LP PUCCHs/PUSCHs obtained in step 3, LP channels are cancelled; * Step 6: For HP PUCCHs/PUSCHs obtained in step 4 and HP PUCCH resources associated with PUCCH overriding procedure, multiplexing or PUCCH overriding between HP channels are performed. (The intermediate HP PUCCH/PUSCHs in multiplexing and PUCCH overriding are not cancelled when colliding with semi-static DL symbols and/or SSB symbols); * Step 7: For each of the intermediate and final HP PUCCH/PUSCHs obtained in step 6, if it does not collides with semi-static DL symbols and/or SSB symbols and overlaps with LP PUCCH/PUSCHs obtained in step 5, the LP channels are cancelled; * Step 8: For LP PUCCHs/PUSCHs obtained in step 7 and final HP PUCCHs/PUSCHs obtained in step 6, if there is collision with semi-static DL symbols and/or SSB symbols, it/they will be dropped. |
| **ZTE** | Fine with the proposal |
| **vivo** | Support the proposal. |
| **HW/HiSi** | Step 1 has an ambiguity which we would like to have clarified, for example when a PUCCH would overlap with DL but also overlaps with a PUSCH that does not overlap with DL. In this case the UCI from the PUCCH would be multiplexed into the PUSCH. Could it be clarified if a PUCCH cancellation in step 1 would mean that the UCI also is dropped, or will the UCI be transmitted anyway as part of the PUSCH?  Another comment is that we would like to have clarified if the intention is to achieve a good performance (i.e. transmitting UCI as much as possible) or a very simple UE/gNB implementation? The current proposal is not very simple for UE implementation because multiple steps of cancellation are required. If the intended benefit of the current proposal is to transmit UCI as much as possible, then in some cases UCI will still be dropped, for example, in the scenario we mentioned above (if UCI is supposed to be dropped).  If some restrictions on the possible cases could be guaranteed by the gNB, a simpler scheme with better performance could be achieved. |
| **LG** | We have a concern on Step 2.4 due to separated timeline.  If LP PUCCH starts earlier than HP PUCCH, UE should start LP UL multiplexing procedure first. Meanwhile, UE is still able to receive HP indication after starting LP UL multiplexing. In other words, a result of HP PUCCH multiplexing can be changed after staring LP UL multiplexing even if no HARQ-ACK PUCCH overriding.  Therefore, for single procedure, it would be necessary to move/copy step 2.4 to just before LP PUCCH transmission, i.e., “step 4: Any LP PUCCH/PUSCH transmission that overlaps with a HP PUCCH/PUSCH channel is cancelled.” |
| **DOCOMO** | We are fine with the proposal.  Regarding the first question from HW/HiSi, we think UCI is cancelled by Step 1 as LP multiplexing is performed in Step 2. |
| **Nokia, NSB** | Support in principle. We still slightly prefer changing the order of Step 3 and Step 2.4, as discussed in our input contribution. |
| **Ericsson** | * If Step 3 and 2.4 are exchanged, the outcome would not be different. We are fine, if that is preferred, but our thinking was not to mix this operation with overlapping resolution procedure. Hence, it was suggested to add it before the procedure and after the procedure. * Another approach is to consider cancelation by DL/SSB at the end (Step 3). That is also fine with us and minimizes the spec impact. * From our point of view, having a common understanding on the Note in proposal is important. We didn’t not propose a TP to capture the Note, since from our perspective it should be understood that the outcome of clause 9.2.3 is applicable to clause 9.2.5. If that is not the common understanding, it is better to clarify that. |
| **Samsung** | OK in principle with the steps. It is also our understanding that the outcome of clause 9.2.3 is applicable to clause 9.2.5 (couldn’t be otherwise). |
| **Spreadtrum** | We are fine with the proposal.  For the order of Step 3 and Step 2.4, we are fine with the current steps. Because HP UL channels include SR/HARQ-ACK on PUCCH and CG/DG PUSCH. The cases that UL channel resources are reselected during multiplexing procedure are dynamic HARQ-ACK on PUCCH and multi-CSI PUCCH. LP channel canceled in step 3 would be multi-CSI PUCCH, since dynamic HARQ-ACK never expect to collide with DL/SSB. Meanwhile, HP channel never carry out Step 3. So exchange the order of Step 3 and Step 2.4 would be same output. |
| **Intel** | We are fine with the proposal. |
| **Apple** | Even though we are fine with the principle of the proposal, we think there is still some ambiguity in the proposal, and CATT’s proposal tries to resolve the ambiguity. (We also described a 9-step procedure that targeted similar issues in RAN1#103-e. ☺)  But before we go into the detailed description, I still would like to use the following example (from last meeting) and check what companies’ understanding for this case. In this example, DCI1 points to PUCCH1 for HARQ-ACK, which overlaps with SR (PUCCH2). When HARQ-ACK and SR are multiplexed, it would use PUCCH3. Then later on DCI2 comes, and it overrides the previous HARQ-ACK resource and points to PUCCH4 for HARQ-ACK. It still overlaps with SR (PUCCH2), and multiplexing of HARQ-ACK and SR results in PUCCH5.    The questions are:   * + - 1. Among PUCCH1/2/3/4/5, which ones should be checked against semi-static DL symbols/SSB for cancellation? This is related to step 1 in the proposal.          1. I don’t think we had a clear agreement on this. Currently we assume the intention that all of the PUCCH1/2/3/4/5 should be checked against semi-static DL symbols. But companies probably have different understandings.       2. Among PUCCH1/2/3/4/5, which ones should be used to cancel LP channels?          1. Here our understanding of the previous agreements is that all of the PUCCH1/2/3/4/5 should be used to cancel LP channels. But want to see if all the companies share the same understanding.   Related to Q1 above, I think the procedure could be quite complicated, and the effort to align understanding could also be quite significant. Given that the main purpose is to ensure common understanding between gNB and UE, **I wonder if we could take Ericsson’s suggestion to do cancellation due to semi-static DL symbols/SSB as the last step**, together with the cancellation due to dynamic DCI. This would simplify the situation significantly. Of course, we can always find cases where this does not give the best performance (which would be true for any other procedure). But as long as the gNB knows the exact procedure, it can schedule properly to avoid the unfavorable cases. |

# 4 Issue #4

In RAN1 #101e, the following conclusion was made:

**Conclusion: In Rel. 15, if a PUCCH/PUSCH carrying a CSI report is cancelled, the occupied CPUs are remained occupied until the last symbol of “configured/scheduled” PUCCH/PUSCH.**

In [7], it is proposed to define the active time duration of aperiodic CSI-RS in the same manner.From Section 5.2.1.6 of TS 38.214, we have:

*“In any slot, the UE is not expected to have more active CSI-RS ports or active CSI-RS resources in active BWPs than reported as capability. NZP CSI-RS resource is active in a duration of time defined as follows. For aperiodic CSI-RS, starting from the end of the PDCCH containing the request and ending at the end of the PUSCH containing the report associated with this aperiodic CSI-RS. For semi-persistent CSI-RS, starting from the end of when the activation command is applied, and ending at the end of when the deactivation command is applied. For periodic CSI-RS, starting when the periodic CSI-RS is configured by higher layer ignaling, and ending when the periodic CSI-RS configuration is released. If a CSI-RS resource is referred N times by one or more CSI Reporting Settings, the CSI-RS resource and the CSI-RS ports within the CSI-RS resource are counted N times.”*

**Proposal: If the transmission of the PUSCH containing the report associated with the aperiodic CSI-RS is cancelled, the NZP CSI-RS resource is active from the end of the PDCCH containing the request and ending at the end of the “scheduled” PUSCH containing the report.**

**Please share your views in the table below.**

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| **Company** | **Comment** |
| **CATT** | **Fine with the proposal.** |
| **ZTE** | Fine with the proposal |
| **vivo** | Fine with the proposal. |
| **HW/HiSi** | Fine with the proposal. |
| **LG** | **Fine with the proposal.** |
| **OPPO** | Fine with the proposal. |
| **DOCOMO** | Fine with the proposal. |
| **Nokia, NSB** | Fine with the proposal |
| **Ericsson** | Fine with the proposal |
| **Samsung** | Fine with the proposal |
| **Spreadtrum** | Fine with the proposal. |
| **Intel** | Fine with the proposal. Just to confirm, here, we consider this as a “Proposed Conclusion” as was done for CPU occupancy. |
| **Apple** | Fine with the proposal. Similar to Intel, we wonder if we plan to have a TP for it or not. It seemed that we had a TP for 38.214 e.g. to change “PUSCH” to “scheduled PUSCH” to reflect the agreement for CPU occupancy, but it did not got incorporated into 38.214. |

# 5 Issue #5

Previously, the following clause was included in Section 9 TS 38.213 and was removed by the Editor later:

*“If a UE detects a first DCI format scheduling a PUCCH or PUSCH transmission of larger priority index that would overlap with a PUCCH or PUSCH transmission of smaller priority index, the UE does not expect to transmit the PUCCHs or PUSCHs of the smaller priority index due to a detection of a second DCI format after the detection of the first DCI format.”*

In the last meeting, it was discussed that for more clarity and to avoid any ambiguity, this clause should be added back.

The following TP captures the proposed changes [7]:

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| **Modified clause (Section 9 of TS 38.213)**  When a UE determines overlapping for PUCCH and/or PUSCH transmissions of different priority indexes, the UE first resolves the overlapping for PUCCH and/or PUSCH transmissions of smaller priority index as described in Clause 9.2.5. 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 transmission of a second PUSCH or a second PUCCH of smaller priority index, the UE cancels the 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 transmission of a second PUCCH of smaller priority index, the UE cancels 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 Clause 9.2.5  - 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  If a UE detects a first DCI format scheduling a PUCCH or PUSCH transmission of larger priority index that would overlap with a PUCCH or PUSCH transmission of smaller priority index, the UE does not expect to transmit the PUCCHs or PUSCHs of the smaller priority index due to a detection of a second DCI format after the detection of the first DCI format.  **End** |

**Please share your views on the TP in the table below.**

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| **Company** | **Comment** |
| **CATT** | **It can be discussed together with issue #2.** |
| **ZTE** | Fine with the proposal |
| **vivo** | Fine with the proposal. |
| **HW/HiSi** | Our view is that there is no need for this TP, because the specification already captures “*the overlapping is applicable before or after resolving overlapping among channels of larger priority index, if any, as described in Clause 9.2.5*”. Thus, if LP channel is cancelled before resolving overlapping among channels of larger priority index, then the low priority channel cannot be transmitted again. |
| **LG** | **Though we are fine with the proposal, it is true that this proposal is relevant to step 2 in issue #2. It would be safe to discuss later than or together with issue #2** |
| **OPPO** | We share view with HW/HiSi. Additional information from red wording is not clear. |
| **DOCOMO** | We share same view with HW/HiSi. |
| **Nokia, NSB** | We share similar view as Huawei, OPPO & DCM that, the current specifications potentially cover what is proposed by the TP already. Anyhow, it would be good to clarify this point. |
| **Ericsson** | We share the same view. Adding the current text, would be redundant in a sense that in that point, there wont be no overlapping HL and LP. |
| **Samsung** | No need for the TP. Agree with HW/HiSi |
| **Intel** | Similar understanding as Huawei and others that the TP may not be needed. |
| **Apple** | We agree this can be discussed together with Issue #2. |

# 6 References

**[1] R1-2100178, “*Text proposal for intra UE prioritization timeline*,” OPPO**

**[2] R1-2100179, “*Remaining issues on scheduling and HARQ,*” OPPO**

**[3] R1-2100267, “*Maintenance of scheduling/HARQ for NR URLLC,*” Ericsson**

**[4] R1-2100338, “Remaining issues on intra-UE prioritization,” CATT**

**[5] R1-2100414, “Maintenance on scheduling/HARQ,” vivo**

**[6] R1-2100826, “Maintenance of Rel. 16 URLLC Intra-UE and inter-UE prioritization/multiplexing enhancements,” Nokia, NSB**

**[7] R1-2101439, “Remaining issues on HARQ and scheduling for URLLC,” Qualcomm**

**[8] R1-2101585, “Corrections on scheduling/HARQ for Rel. 16 URLLC,” NTT DOCOMO**

**[9] R1-2101263, “Remaining issues on UCI enhancements,” Huawei/HiSi**