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

**May 10th – 27th, 2021**

**Agenda item:** 7.2.5

**Source:** Moderator (Qualcomm)

**Title:** [105-e-NR-L1enh-URLLC-03]  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 #105e:

[105-e-NR-L1enh-URLLC-03]  Email discussion/approval on remaining issues on Scheduling & HARQ enhancements – Wei (Qualcomm):

* Issue #2: Handling of collision between DL/SSB symbols and configured HP PUCCH and PUSCH
* Issue #1: Clarification on UE procedure for prioritization
* Discussion and decision by May 24, TPs by May 27

Please provide your first round comments by 11:59 am (PST), Friday May 21th.

# 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 HP 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 transmissionwhere - ~~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 $T\_{proc,2}+d\_{1}$ after a last symbol of the corresponding PDCCH reception- $T\_{proc,2} $is the PUSCH preparation time for a corresponding UE processing capability assuming $d\_{2,1}=0$ [6, TS 38.214], based on $μ$ and $N\_{2}$ as subsequently defined in this Clause, and $d\_{1}$ 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***

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.

**Notes for discussion from the feature lead:**

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”**

Based on the discussions in the previous meetings, this means that the UE should check the overlapping between the intermediate HP channels and the LP channels (which could themselves be the final channel for transmission or intermediate channels.) In other words, as the HP DCIs are received, the UE should check whether the HP channels should be multiplexed or not; if the do, it should check the overlapping between the resulting HP channel and the low priority channels. This is illustrated with an example in the figure below:



Let us first assume that the LP channel is scheduled; the UE first receives HP DCI #1 and checks that there is no overlap between the HP PUCCH #1 and the LP channel. Then, the UE receives the HP DCI #2 scheduling HP PUCCH #2. If PUCCH #1 and #2 are multiplexed, then the intermediate HP PUCCH is overlapping with a LP channel. Since the UE is given enough time gap between the HP DCI #2 and the intermediate HP PUCCH, the UE can initiate the cancellation of the LP channel.

Now, let us assume that the UE does not check the intermediate channels. In this case, the UE does not know whether the gNB is planning to transmit more DCIs and schedule more HP transmissions or not. As shown in the figure, if the UE waits, but no DCI is received, e.g., the HP DCI #3 is not sent by the gNB or missed by the UE, then the effective cancellation time is smaller than what is required to be.

The benefit of checking the intermediate HP channels on reducing the UE complexity, by ensuring sufficient processing time, is explained above. On the other hand, in [1], [3]-[4], it is argued that the intermediate checking steps make the UE implementation complicated.

For RAN1 #105e, the recommendation from the feature lead is as follows:

1. Discuss whether the intermediate checks are complicating the UE complexity.
2. Discuss how the proposed solutions could remove the intermediate checks, while still ensuring a guaranteed amount of time for cancellation (i.e., not requiring a UE to wait for initiating cancellation).

**In the table below, please provide your comments on**

**Question 1-1: For intra-UE prioritization, do you agree that the intermediate checks complicates UE implementation?**

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| --- | --- |
| Company | Comments |
| Nokia, NSB | Agree. Intermediate checks may complicate UE implementation and may lead to additional unnecessary LP channel cancelation / dropping |
| DOCOMO | Agree the statement above that intermediate check my complicate UE implementation. |
| HW/HiSi | Before we go into the detailed discussion, it would be good to check if everyone has the same understanding:About the example figure:It seems that the case described in the example figure above is not reflecting a situation that actually can happen, and we would like to hear the understanding from other companies on that matter. In our view, the two blue PUCCHs (HP PUCCH1 and HP PUCCH2) have to carry HARQ-ACK, since they are HP and scheduled by DCI. In that case, their overlapping should not be resolved by multiplexing but by PUCCH overriding. This means for the given example, the yellow intermediate HP PUCCH would not be generated. Is this a correct understanding in the view from other companies?[OPPO] Yes. We share the same understanding with you. [Samsung] Yes, the figure is misleading. In our understanding, HP PUCCH #1 is an intermediate PUCCH since HP PUCCH #2 overrides HP PUCCH #1. Multiplexing for HARQ-ACK and SR:However, if the situation above is understood correctly by us, still a similar scenario can occur. For example the HP PUCCH2 could be a SR, in that case multiplexing between HP PUCCH1/PUCCH2 would be done.In order to discuss the above further, we would like to firstly reconfirm our view for the situation when there is no HP SR present. In this case there would only be HP HARQ-ACKs and we have an earlier agreement that any (intermediate or final) HP channel scheduled by DCI will cancel an overlapping LP channel.Then, the question is what to do for multiplexing between HARQ-ACK and SR? We think we need to clarify whether multiplexing between HARQ-ACK and SR is only done between the final PUCCH for HARQ-ACK and the SR or also between intermediate PUCCHs for HARQ-ACK and the SR? What is the view from other companies on this? [OPPO] Intermediate multiplexing includes multiplexing between intermediate HARQ-ACK and SR and multiplexing between the final PUCCH for HARQ-ACK and SR, of which, the former breaks R15 PUCCH multiplexing definition. [Samsung] We have different understanding from OPPO. In our understanding, intermediate PUCCH only includes the PUCCHs during HARQ-ACK overriding procedure. As shown in the figure below, PUCCH#1 and PUCCH #5 are intermediate PUCCH. In our understanding, PUCCH #2, #4 and #6 are not intermediate PUCCH. We think we need to first align our understanding regarding intermediate PUCCH.UE does not know whether a PUCCH is intermediate PUCCH or not, UE needs to perform multiplexing for intermediate PUCCH as shown in the figure below. The deadline for HARQ-ACK overriding is not clear, before receiving HP DCI #2, UE may perform intermediate PUCCH multiplexing.Or in other words, can an intermediate HP channel be the result of multiplexing intermediate HARQ-ACK and SR, or can an intermediate HP channel only be the result of multiplexing a final HARQ-ACK and a SR? Note, that in the Rel-15 this does not matter, since there is no cancellation of LP involved. |
| OPPO | Agree.It requires UE to perform multiplexing in time, which consumes much more calculation resource than legacy solution. Moreover, intermediate multiplexing leads overkill and waste system resource. |
| Ericsson | Agree.Additionally, as we explained in our contributions, now only complicates UE implementation, but depending when UE assumes which DCI is last DIC, it may go ahead and does HP multiplexing and canceling LP, while gNB is not expecting that. Hence, due to UE implementation, it is extra burden and creates potential ambiguity.  |
| Samsung | Agree. Here an essential issue is how can UE differentiate whether a PUCCH is an intermediate PUCCH, or alternatively whether UE should perform HARQ-ACK overriding/mux whenever UE receives a DCI or UE can wait to a deadline to perform HARQ-ACK overriding and then mux, intra UE prioritization.Considering the figure below, DCI#2 schedules HP PUCCH#2 overrides HP PUCCH#1, DCI#3 schedules HP PUCCH#3 overrides HP PUCCH#2.From gNB's perspective, HP PUCCH#1 and HP PUCCH#2 are intermediate PUCCH. If there is no fixed deadline for HARQ-ACK overriding, UE needs to determine a PUCCH whenever UE receives a DCI. Further, UE needs to do multiplexing of the intermediate PUCCH with other overlapping PUCCHs. On the contrary, if the deadline for HARQ-ACK overriding is fixed, for example, at T0, UE can wait until T0 to perform Step 1 HP HARQ-ACK overriding and then Step 2 HP PUCCH mux and in the end Step 3 intra UE prioritization.According to current spec, UE cannot determine a proper deadline. For example, if UE determines a deadline (T0) based on HP PUCCH#1 and timeline restriction for HARQ-ACK overriding. If UE waits to T0 to do HARQ-ACK overriding, it may not be enough time for preparing HP PUCCH#3. To avoid HP intermediate PUCCH cancel LP PUCCH, a scheduling restriction is necessary for UE to determine a deadline for HARQ-ACK overriding, we have the follow proposal.**Proposal: If a UE determines a first resource for a PUCCH transmission with HARQ-ACK information corresponding only to a PDSCH reception without a corresponding PDCCH or detects a first DCI format indicating a first resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot and also detects at a later time a second DCI format indicating a second resource for a PUCCH transmission with corresponding HARQ-ACK information in the slot, UE does not expect the second resource starts earlier than the start of the first resource.**With the above proposal, UE can wait to T0 to do HARQ-ACK overriding.cid:image024.png@01D74D9B.F0113C50 |
| Apple | Agree. |
| ZTE | Agree.  |
| Vivo | Agree.Intermediate checks would complicate UE implementation.On the other hand, if the scenario as Figure depicted is valid, the cancellation time between HP DCI 3 and intermediate PUCCH should be satisfied.  |
| Intel | Yes, the additional cancelations imply more complexity than not having to do so. However, the tradeoff is fundamentally between scheduling restrictions (e.g., as implied by Options 1 or 2 in Question 1-2) vs. UE complexity. There is nothing fundamentally wrong with the current specs.  |
| Qualcomm | Agree that intermediate checks complicates the UE implementation. However, it’s not clear to us how these intermediate checks can be removed with the proposed options (Option 1 or Option 2) below.  |

**Question 1-2: Please provide your view/preference on the following options for intra-UE prioritization.**

* **Option 1: The UE does not use the outcome of intermediate multiplexing for HP channels to cancel LP channels [1][3][4].**
	+ **The UE is not expected a later DCI in a PDCCH reception overrides cancellation of a repetition of 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**
* **Option 2: The UE does not use the outcome of intermediate multiplexing for HP channels to cancel LP channels [4].**
	+ **Any HP channel that overrides or overlaps with a HP channel that overlaps with a LP channel shall meet the cancellation timeline.**
* **Option 3: No change from the spec is needed.**
* **Note: in Option 1 and Option 2, all HP PUCCH/PUSCH channels except the final HP PUCCH/PUSCH that gets transmitted by the UE are intermediate channels.**

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| Company | Comments |
| Nokia, NSB | Maybe a clarification on the ‘intermediate multiplexing’ would be needed, because our understanding is that current specs only talk ‘before’ or ‘after mux’ the cancelation is done (but not intermediate step is defined). The question would also be here if PRI overriding is considered as ‘intermediate multiplexing’ or not. Looking at Option 2 vs. Option 1, we prefer Option 2 as Option 1 is rather restrictive in terms of HP channel (i.e. urgent URLLC traffic) operation.  |
| DOCOMO | Support the intention of the proposal and Option 2 seems preferable. |
| Huawei, HiSilicon | We think as described in our answer for the previous question, we should firstly clarify what intermediate multiplexing means, e.g. can it include the multiplexing between an intermediate HARQ-ACK and SR or is it only between final HARQ-ACK and SR?[OPPO] In our understanding, intermediate multiplexing includes both multiplexing between an intermediate HARQ-ACK and SR and multiplexing between final HARQ-ACK and SR, which will be multiplexed in PUSCH later. Another clarification that would be nice is how to understand the cancellation time-line mentioned in Option 2. The cancellation time-line “proc2+d1” is defined between the end of the scheduling DCI and the start of the HP channel, how to understand that “any HP channel that overrides or overlap” [OPPO] In our understanding, option 2 means any HP DCI for overlapping or overriding HP, i.e. HP DCI1, HP DCI2, HP DCI3 should be before cancellation timeline deadline.  |
| OPPO | According to discussion in previous meetings, diverse understanding on spec can be seen. So at least clarification change from spec is required.To clarify that intermediate multiplexing is not considered for prioritization and ensure enough prioritization processing time without intermediate multiplexing, option 1 and option 2 are fine for us and slightly prefer to option 2 due to it expresses our intention more clearly. |
| Ericsson | We are fine with both Option 1 and Option 2.Just to clarify, we introduced error case in Option 1 as we explained in our contribution, does not impact URLLC. However, we are fine with Option 2 as well. |
| Samsung | Similar view with Nokia. Based on following conclusion, we don’t think that intermediate multiplexing is included in the specification. Regarding options, option 3 is our preference. However, we wonder how option 2 and option 3 are different. **Conclusion**In the following clause from Section 9 of TS 38.213:“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 meaning of “before or after” should be interpreted as follows: A UE checks the overlap between a HP channel and a low priority channel before multiplexing. If there is an overlap, the LP channel gets cancelled. If not, a UE performs multiplexing across the HP channels. If then there is an overlap with a LP channel, the LP channel gets cancelled. |
| Apple | Currently the intermediate multiplexing is not included in the spec, because now we only have “before or after” multiplexing in Clause 9.2.5, which is basically before or after the final multiplexing. However, during the discussion in RAN1#104b-e, most companies seemed to think that intermediate channel during the PUCCH overriding procedure should also be used to cancel the LP channel, with the previous agreements/working assumption. Companies seemed to have different understanding on whether the UE is required to do intermediate multiplexing for the intermediate channels during the PUCCH overriding procedure.The merit of Option 1 and 2 is that (1) it removes the need for intermediate multiplexing at the UE, which simplifies the UE implementation; (2) only the final HP transmissions are used to cancel the LP channel, which is good for network operation. This means the UE does not even need to use the HP channel before multiplexing to cancel LP.For the cancellation timeline in Option 2, what we have in mind is Tproc,2+d2, which is from the HP DCI to the first symbol that would be cancelled.We are fine with both Option 1 and Option 2. |
| ZTE | Either option 1 or option 2 can be accepted. Option 2 is more preferable as less restriction. |
| vivo | We are fine with both Option 1 and Option 2. For the first question from Huawei/HiSilicon, we think that the intermediate multiplexing includes both multiplexing between an intermediate HARQ-ACK and SR and multiplexing between final HARQ-ACK and SR. |
| Intel | Effectively, Options 1 or 2 mean that the prioritization would be mostly limited to a single point of decision in time (@ gNB scheduler) – that is, gNB has to decide on one or more channels involved in the mux/prioritization process but subject to the start of the earliest cancelation event. On the other hand, Option 3 (current specs) allows more flexibility at gNB side for “cascaded overriding or prioritizations” by shifting some additional burden at the UE side and with some possibly avoidable cancelations of LP channels in some cases. Between Options 1 and 2, we do not see a big difference. They will most likely end up looking very similar in practice since cases wherein the first cancelation trigger occurring significantly ahead of the minimum cancelation timeline is rather low. If a gNB is having to resort to intra-UE prioritization, it is likely to be a somewhat of a “last minute decision”, and by the same logic, in effect, the real-world difference from Option 3 would also not be significant. Therefore, while our first preference is not to change spec (Option 3) since there is nothing fundamentally broken, we can live with either Options 1 or 2.  |
| Qualcomm  | We are not sure how Option 1 and Option 2 can remove the intermediate checks. In our view, even in Rel-15, the UE needs to perform intermediate checks in order to determine the multiplexing deadline. To illustrate the point, consider the example shown in the figure below: the UE is scheduled by a DCI to transmit HARQ-ACK on PUCCH 2, and the transmission of HARQ-ACK overlaps with P-CSI on PUCCH 1. As a result of multiplexing, the UE needs to multiplex P-CSI and HARQ-ACK on PUCCH 3, which starts earlier in time than PUCCH 1 and PUCCH 2. The PUCCH 3 is determined by the UE based on the total payload of P-CSI and HARQ-ACK and the PRI from the DL grant. In this case, the PDSCH is arrived > N1 prior to the earliest of PUCCH 1, PUCCH2, and PUCCH 3, and therefore the multiplexing timeline condition defined in NR Rel-15 is satisfied. However, in this example, although T1 is the deadline for multiplexing, but the UE needs to perform some intermediate checking (e.g., at least to determine the PUCCH resource for multiplexing the P-CSI and HARQ-ACK) before T1. This is because, prior to the intermediate checking, the UE has no idea where the PUCCH 3 will be placed. Therefore, the latest time the UE can perform the intermediate checking is at the end of PDSCH, although the actual multiplexing could be deferred to T1, after the intermediate checking. In particular, the UE can not wait till T2 in the figure to perform the multiplexing, since it will be too late for the UE to prepare the transmission. From this example, one can see that, even in Rel-15, the UE has to perform some intermediate checks for UCI multiplexing, and the deadline for UCI multiplexing may gets updated each time the UE receives a DCI. Because of the above, it is unclear to us how defining error cases (Option 1) or relaxing the timeline (Option 2) could remove the intermediate checks, and let the UE perform a single HP multiplexing till the deadline, since the deadline itself depends on the intermediate checks…. On the other hand, the most straightforward way to reduce the UE implementation complexity and meeting the cancellation timeline is to leave the intermediate checks up to the UE implementation. In other words, UE can decide whether to use the intermediate checks to cancel the LP channels based on its own implementation.  |

## 3.1 Summary of First Round of Discussions

Thank you all for the comments. Based on the inputs, it seems that companies still have different views on the current spec behavior regarding checking intermediate multiplexing. To facilitate the discussion, it may be beneficial to first clarify the existing behavior for checking intermediate multiplexing.

Based on the discussion above, two basic cases (Case 1 and Case 2) have been identified, which correspond to UCI multiplexing and PUCCH overriding, respectively. Furthermore, Case 3 is added as a combination of Case 1 and Case 2, as suggested by Huawei/HiSi.

* **Case 1**: UCI multiplexing between SR and HARQ-ACK. The multiplexed HARQ-ACK and SR may be moved



* **Case 2**: PUCCH overriding. A later HP DL grants schedules HARQ-ACK transmission on a new PUCCH resource, which overrides a previously scheduled PUCCH with HARQ-ACK.



* **Case 3**: UCI multiplexing + PUCCH overriding. Consider the case illustrated by the following figure: a first HP HARQ-ACK on PUCCH #1 overlaps with HP SR, and gets multiplexed to HP PUCCH #5, and later the first HP HARQ-ACK gets override to HP PUCCH #2. The HP PUCCI #2 may or may not overlap further with SR. However, regardless, the HP PUCCH #5 resulting from multiplexing HP HARQ-ACK on PUCCH 1 and SR will not be transmitted by the UE.



From the moderator’s view, the following HP channels should be checked for intra-UE prioritization:

* For case 1, the HARQ-ACK, the SR and the intermediate HP PUCCH for SR and HARQ-ACK mux all need to be checked for colliding with LP channel.
* For case 2, both the PUCCH 1 and PUCCH 2 (before and after PUCCH overriding) need to be checked for colliding with LP channel.
* For case 3, all HP channels generated in the procedure of UCI multiplexing (including PUCCH #1-#6) need to be checked for colliding with LP channel.

As explained in the beginning of the FL summary, the reason that UE needs to check every intermediate channel (defined above) is that, the UE needs to make sure there’re sufficient time to cancel the LP channel. If the UE waits till a further time, then it may not have enough time to cancel the LP channel, as illustrated in case 1 and case 3 above.

Based on this discussion above, can we make a conclusion to clarify the current UE behavior? **Note that, this conclusion is aimed to facilitate the discussion of the topic, and doesn’t mean to exclude further enhancements to reduce the UE/gNB implementation complexity.**

**Proposed Conclusion: In the following clause from Section 9 of TS 38.213:**

**“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 meaning of “before or after” should be interpreted as follows: the UE checks overlapping between HP and LP channel for each HP grant it receives, including any intermedate HP channel that resuts from UCI multiplexing and PUCCH overriding triggered by each of the HP grant.**

**Question 1-3: In the table below, please provide your comments on the above proposed conclusion.**

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| Company | Comments |
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Even though the exact meaning of intermediate collision checking is not yet settled within the group, most of the companies think that these intermediate checkings complicates the UE implementation. Hence, the feature lead recommendation is to further discuss the possible solutions to reduce UE implementation burden caused by the intermediate checkings.

Looking at the proposed solutions, it seems that companies who support Option 1 also supports Option 2 (with higher preference). Therefore, I removed Option 1 from the discussion. Please raise your comment if you want to put Option 1 back. Furthermore, one company proposes to leave the decidion of whether to perform intermediate checks up to UE implementation. This is added as Option 4 below.

**Question 1-4: Please provide your view/preference on the following options for intra-UE prioritization.**

* **~~Option 1: The UE does not use the outcome of intermediate multiplexing for HP channels to cancel LP channels [1][3][4].~~**
	+ **~~The UE is not expected a later DCI in a PDCCH reception overrides cancellation of a repetition of 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~~**
* **Option 2: The UE does not use the outcome of intermediate multiplexing for HP channels to cancel LP channels.**
	+ **Any HP channel that overrides or overlaps with a HP channel that overlaps with a LP channel shall meet the cancellation timeline, namely all HP DCIs must arrive *Tproc,2+d1* before the earliest symbol that would be cancelled by the final HP channel.**
* **Option 3: No change from the spec is needed.**
* **Option 4: whether the intermediate HP channels is used to cancel the LP channels is left to UE implementation.**
* **Note: in Option 1, 2 and 4, all HP PUCCH/PUSCH channels except the final HP PUCCH/PUSCH that gets transmitted by the UE are intermediate channels.**

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| Company | Comments |
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# 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, denoted as TP 1, is proposed [2]:

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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 cellthe 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], 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 TP, denoted as TP 2, is 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 transmissionwhere - 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 $T\_{proc,2}+d\_{1}$ after a last symbol of the corresponding PDCCH reception- $T\_{proc,2} $is the PUSCH preparation time for a corresponding UE processing capability assuming $d\_{2,1}=0$ [6, TS 38.214], based on $μ$ and $N\_{2}$ as subsequently defined in this Clause, and $d\_{1}$ 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------------------ |

**Question 2-1: What is your view on TP1 and TP2?**

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| Company | Comments |
| Nokia, NSB  | We prefer TP1On TP2: Within the same priority the Rel-15 order of multiplexing the current specification (based on Rel-15) should be applicable as the TP2 seems to change (!?). There is only a need to clarify the order to PHY priorization and transmission restrictions based on Sec. 11.1, but not for the order of multiplexing within a priority and the transmission restrictions of Sec. 11.1. Small comment on TP2: there is a typo *Caluses* 🡪 *Clauses* |
| DOCOMO | Firstly, we think the two TPs should be discussed separately since the intended issues are different. In our understanding, TP1 is for resolving the ambiguity of the processing order of intra-UE prioritization/multiplexing and semi-static DL symbols/SSB symbols when there is any semi-static UL channels. On the other hand, TP2 is for resolving the ambiguity of the processing order of intra-UE multiplexing for same priority UL channels and semi-static DL symbols/SSB symbols.Regarding TP1, we support the intention.Regarding TP2, we think it should be discussed and resolved as there is also the same ambiguity of the processing order. Let us provide one example with the figure below, which is cited from R1-2002060. With this figure, there are two possible processing orders in Rel-15/16:1) first intra-UE multiplexing of same priority is performed and secondly cancellation due to semi-static DL symbols is performed (Outcome: both HARQ-ACK and PUSCH are transmitted on dynamic PUSCH)2) first cancellation due to semi-static DL symbols is performed and secondly intra-UE multiplexing of same priority is performed (Outcome: only dynamic PUSCH is transmitted)gNB needs to do blind decoding on the outcome as it is not determined whether intra-UE multiplexing or cancellation due to semi-static DL symbols is performed first. To avoid the gNB complication, it is important to resolve this issue as well. Since the current spec takes only the different priority case into account, we think it is better to adopt the same processing order (i.e. intra-UE multiplexing first and then cancellation) for same priority case and introduce consolidated description in spec regardless of UL channel priorities as proposed in [5].  |
| HW/HiSi | The issue is valid.Regarding the TPs, our initial understanding is that TP2 also is covering TP1. In that case we would prefer TP2 since it appears simple.  |
| OPPO | Share views as Nokia/NSB |
| Ericsson | We understand the issue. I think it is better to avoid unnecessary text. Isnt it better to do as following based on these TPs as TP3.I also think we don’t need to add references in 11.1 because it is clear from this text that we do overlapping resolution first and then go to 11.1. When we read the whole spec, the order would be clear. For the same reason, we don’t need to add the green text at the beginning to emphasize this is done before 11.1.**TP3:** 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 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 transmissionwhere - 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 $T\_{proc,2}+d\_{1}$ after a last symbol of the corresponding PDCCH reception- $T\_{proc,2} $is the PUSCH preparation time for a corresponding UE processing capability assuming $d\_{2,1}=0$ [6, TS 38.214], based on $μ$ and $N\_{2}$ as subsequently defined in this Clause, and $d\_{1}$ is determined by a reported UE capability\*\*\* Unchanged text is omitted \*\*\*If a UE would transmit the following channels, 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 cellthe 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 ------------------------------------------------------ |
| Samsung | - For TP1, it is unclear how this TP reflects the agreement. Cases in TP1 are only for configured HP PUSCH/PUCCH, not dynamically scheduled HP PUSCH/PUCCH. - For TP2, similar view with Nokia. - The motivation of agreement is that semi-static DL symbols and SSB symbols are not considered before intra-UE multiplexing/prioritization. Thus, we would like to suggest following specification text.

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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 before considering limitations for UE transmission as described in clause 11.1, 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, <Unchanged parts are omitted> |

- This case should be extended to the case of only HP or only LP. Therefore, we would like to suggest following text proposal.

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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>In the remaining of this Clause, a UE multiplexes UCIs with same priority index in a PUCCH or a PUSCH before considering limitations for UE transmission as described in clause 11.1. A PUCCH or a PUSCH is assumed to have a same priority index as a priority index of UCIs a UE multiplexes in the PUCCH or the PUSCH  |

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| Apple | Our understanding of the agreement is that it intends to cover both R15 and R16 intra-UE multiplexing cases, because the discussion started from R15 CR discussion and then moved to be resolved together with R16 URLLC.Ericsson’s suggestion might be a good direction to fix it for all the cases. But the sentence may need to be moved towards the end of Clause 9 so that it covers all the overlapping resolution cases. |
| ZTE | The issue from TP2 is valid. The revisions from either Ericsson or Samsung is fine for me. |
| vivo | For TP1, we share the same views with Samsung that TP 1 does not include all cases, e.g., dynamic scheduled PUCCHs.We prefer the form of TP2 considering the simple description in spec. On the other hand, we have a question on the relation between ‘the limitations in Clause 11.1 and Clause 11.1.1’ and the description order in spec.For clause 9.2.3 and 9.2.4, when HARQ-ACK and SR are reported, the limitations in Clause 11.1 and Clause 11.1.1 is considered while UCI multiplexing is described in subsequent clause 9.2.5. Whether it means before UCI multiplexing, the HARQ-ACK and SR collided with semi-static DL symbols have been canceled, i.e., first cancellation due to semi-static DL symbols is performed and secondly intra-UE multiplexing is performed?

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| 9.2.3 UE procedure for reporting HARQ-ACK……….A PUCCH transmission with HARQ-ACK information is subject to the limitations for UE transmissions described in Clause 11.1 and Clause 11.1.1.……. |

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| 9.2.4 UE procedure for reporting SR……….SR transmission occasions in a PUCCH are subject to the limitations for UE transmissions described in Clause 11.1 and Clause 11.1.1.  |

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| Intel | Either the Ericsson TP (probably the location may need to be moved further down, closer to start of 9.1 as hinted by Apple) or the Samsung TP should be fine. |

## 3.1 Summary of First Round of Discussions

Thank you all for the comments. From some of the inputs, it seems that most companies agree that the RAN1 104e agreement shall be applicable to both the case intra-UE prioritization and intra-UE multiplexing (i.e., collision within the same priority). In the moderator’s view, both the TPs from Ericsson and Samsung could work. And Samsung’s TP seems more precise. For the Ericsson TP, it is still unclear to me what’s the best place to add the corresponding text, without creating ambiguity. Therefore, I would like to ask every one to consider the following proposal based on the Samsung TP for the second round of discussions.

**Proposal 3-1: Adopt the following TP to capture the RAN1 104e agreement on collision with semi-static DL and SSB symbols.**

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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 before considering limitations for UE transmission as described in clause 11.1, 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, <Unchanged parts are omitted>In the remaining of this Clause, a UE multiplexes UCIs with same priority index in a PUCCH or a PUSCH before considering limitations for UE transmission as described in clause 11.1. A PUCCH or a PUSCH is assumed to have a same priority index as a priority index of UCIs a UE multiplexes in the PUCCH or the PUSCH |

**Please provide your comments if you have concerns with the above TP.**

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| Company | Comments |
| FL  | @Nokia: the first part of the TP in Proposal 3-1 shall address the case of configured PUCCH/PUSCH.@Nokia, Oppo: as discussed from the views in the first round discussion, the agreement on collision with semi-static DL/SSB symbols reached in 104e applies to multiplexing within the same priority as well.  |
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# 4 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.**