**3GPP TSG RAN WG1 #104-e R1-210xxxx**

**e-Meeting, January 25th - February 5th, 2021**

Source: Moderator (vivo)

Title: Email discussion on [104-e-NR-L1enh-URLLC-06] for intra-UE prioritization

Agenda Item: 7.2.5

Document for: Discussion and Decision

1. Introduction

This document is used to discuss the following:

[104-e-NR-L1enh-URLLC-06] Email discussion/approval on remaining issues on intra-UE prioritization – Lihui (Vivo) by Feb 3

* Issue 1: PHY behavior for collision between CG and DG with same/different PHY-priority index
* Reply LS to [R1-2100026](file:///C:\\Users\\wanshic\\OneDrive%20-%20Qualcomm\\Documents\\Standards\\3GPP%20Standards\\Meeting%20Documents\\TSGR1_104\\Docs\\R1-2100026.zip) on overlapped data and SR with equal L1 priority for Rel-16 URLLC

Note that the 1st deadline for the views input is set to be 26th Jan. 11:59pm UTC.

1. Discussions

* 1. Discussion on overlapped data and SR of equal L1 priority

Following LS is received from RAN2 [14]:

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| RAN2 confirms the intended UE behavior: For the case of overlapping PUSCH and SR with equal L1 priority and MAC has not yet delivered MAC PDU for the PUSCH to PHY, if SR is prioritized in MAC, MAC shall not deliver the MAC PDU for the PUSCH and shall instruct PHY for SR transmission.  RAN2 respectfully asks RAN1 to confirm if the intended UE behavior mentioned above can be supported. |

Precondition on above LS should be that the LCH based prioritization is configured.

Before detailed discussion, it may be good to make some clarifications on the following agreed CR in R1-2009687:

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| **38.214 6.1           UE procedure for transmitting the physical uplink shared channel**  <unchanged part omitted>  A UE shall upon detection of a DCI format scheduling a PUSCH transmit the corresponding PUSCH unless the UE does not generate a transport block as described in [10, TS38.321]. Upon detection of a DCI format 0\_1 or 0\_2 with "UL-SCH indicator" set to "0" and with a non-zero "CSI request" where the associated "reportQuantity" in *CSI-ReportConfig* set to "none" for all CSI report(s) triggered by "CSI request" in this DCI format 0\_1 or 0\_2, the UE ignores all fields in this DCI except the "CSI request" and the UE shall not transmit the corresponding PUSCH as indicated by this DCI format 0\_1 or 0\_2.  <unchanged part omitted> |

The initial intention for this CR is mainly for the UL skipping agreement. However, from the agreement made in RAN1#103 meeting, it should be understood by the group that the CR can also cover the intended behavior for some collision scenarios in PHY layer when *lch-basedPrioritization* is configured.

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| **Agreement**  Send an LS to RAN2 to convey the following:   * For the collision scenario between CG and DG with same/different PHY-priority index, if there is no collision between PUCCH and the CG and there is no collision between PUCCH and the DG, the behavior mentioned in the LS is consistent with RAN1’s understanding if taking into account the TP to Rel-16 TS 38.214, i.e., revision CR in R1-2008655. * When the MAC entity is configured with *lch-basedPrioritization*, for the collision scenario between CG and DG with same/different PHY-priority index, and when there is collision between PUCCH and the CG with the same priority and/or there is collision between PUCCH and the DG with the same priority, RAN1 is still discussing the related PHY layer behavior. |

Therefore, it is more constructive to first discuss the preferred PHY layer behavior for the collision case that overlapped data and SR of equal L1 priority as asked by RAN2; then we can check whether the CR in R1-2009687 covers the intended behavior and/or any modification need to be made for the current specification.

Based on the submitted contributions, following cases should be considered:

* + 1. Case 1 of overlapping only between SR and PUSCH of equal L1 priority
* **Case 1: overlapping is only between the SR and PUSCH with equal L1 priority**



Figure 1: overlapping UL-SCH resource(s) and SR of equal L1 priority only (borrow from R1-2100318)

For Case 1, companies’ views are summarized as below:

* Option 1: RAN1 support the intended behavior as asked by RAN2 that if SR is prioritized in MAC, MAC shall not deliver the MAC PDU for the PUSCH to PHY and MAC shall instruct PHY for SR transmission.
  + Reasons:
    - Consistency can be kept between RAN1 and RAN2.
    - With LCH based prioritization, the SR associated with the logical channels having high priority should be prioritized over the PUSCH associated with the logical channels having low priority. Although SR and PUSCH are of equal L1 priority.
* Option 2: RAN1 do not support the intended behavior as asked by RAN2, the PUSCH should be transmitted and SR should be dropped.
  + Reasons:
    - Workload at Network side for blind detection between SR and PUSCH.
    - In current RAN1 specification TS 38.213 section 9.2.5, if SR and PUSCH with the same priority overlaps in the time domain, the UE does not transmit SR when performing UCI multiplexing in the PUSCH.

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| For each PUCCH resource in the set  that satisfies the aforementioned timing conditions, when applicable,  - the UE transmits a PUCCH using the PUCCH resource if the PUCCH resource does not overlap in time with a PUSCH transmission after multiplexing UCI following the procedures described in Clauses 9.2.5.1 and 9.2.5.2  - the UE multiplexes HARQ-ACK information and/or CSI reports in a PUSCH if the PUCCH resource overlaps in time with a PUSCH transmission, as described in Clause 9.3, and does not transmit SR. In case the PUCCH resource overlaps in time with multiple PUSCH transmissions, the PUSCH for multiplexing HARQ-ACK information and/or CSI is selected as described in Clause 9. If the PUSCH transmission by the UE is not in response to a DCI format detection and the UE multiplexes only CSI reports, the timing conditions are not applicable  - the UE does not expect the resource to overlap with a second resource of a PUCCH transmission over multiple slots if the resource is obtained from a group of resources that do not overlap with the second resource. |

* Option 3: RAN1 should discuss and define if and how the processing time in the PHY layer is affected by the LCH-based prioritization in the MAC layer.
  + - Reasons: For the overlapping of SR and DG PUSCH with the same L1 priority in R16, the DG PUSCH may be de-prioritized in the MAC layer and hence the PHY layer needs to wait for a decision from MAC to continue the processing of DG PUSCH, which may result in an increased processing time for DG PUSCH in some cases.

**Q-a: What is your preferred option and your views for other options?**

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| Company | Comments |
| Nokia, NSB | Support Option 1  Reasons:  Option 2 basically would remove the LCH prioritization overall for this case. The quoted RAN1 specs assumes here that a PDU has been delivered.  Option 3: with UL skipping, PHY anyhow cannot react until getting a PDU delivered (this should be the understanding since Rel-15). So unclear need for discussion on processing time-line here. |
| ZTE | We support Option 2.  The collision between SR and PUSCH with the same PHY priority is similar as the collision between PUSCH and PUCCH in case of UL skipping, for which the PUSCH cannot be skipped. The reasoning is similar as UL skipping that we need to avoid blind detection between SR and PUSCH at gNB side. |

* + - 1. Summary for Case 1

[To be updated]

* + 1. Case 2 of overlapping between other UCIs and SR and between SR and PUSCH of equal L1 priority
* **Case 2: other UCI(s) i.e., HARQ-ACK and/or CSI overlap with SR of equal L1 priority and the SR overlaps with the PUSCH of equal L1 priority**



Figure 2: other UCI(s) overlaps with SR and PUSCH of equal L1 priority (borrow from R1-2100318)

* **Case 2-1: PUCCH resource after UCI multiplexing among different PUCCHs does not overlap with PUSCH(s)**



Figure 3: PUCCH resource after UCI multiplexing among different PUCCHs does not overlap with PUSCH(s) (borrow from R1-2100318)

For case 2-1, following can be proposed:

* **Proposal 1: For the case of overlapping between PUSCH and SR with equal L1 priority, if there are other UCI(s) i.e., HARQ-ACK and/or CSI of the same L1 priority overlapping with SR and the PUCCH resource after UCI multiplexing among different PUCCHs does not overlap with the PUSCH, MAC can deliver MAC PDU for the PUSCH and instruct PHY for SR transmission.**

**Q-b: Do you agree above proposal 1? If not, what is your views and proposal for the case 2-1?**

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| Company | Comments |
| Nokia, NSB | We are a bit wondering, if for both cases here actually the MAC could deliver the SR & the PUSCH in the first place. As from MAC perspective for both cases 2a and 2b, SR and PUSCH are overlapping (as any other UCI multiplexing is not considered in MAC) 🡪 with higher SR LCH priority the SR (and no PUSCH TB) would be delivered, with the same LCH priority the PUSCH TB would be delivered to PHY (but not the SR) |
| ZTE | Fine with the proposal.  We prefer not to change the PHY multiplexing behavior. The MAC behavior (whether generate MAC PDU for PUSCH or instruct PHY for SR transmission) could be based on the intermediate decision of multiplexing from PHY. |

* + - 1. Summary for Case 2-1

[To be updated]

* **Case 2-2: PUCCH resource after UCI multiplexing among different PUCCHs overlaps with PUSCH(s)**



Figure 4: PUCCH resource after UCI multiplexing among different PUCCHs overlaps with PUSCH(s) (borrow from R1-2100318)

For case 2-2, if the PUCCH resource after UCI multiplexing among different PUCCHs overlaps with the PUSCH, the multiplexed UCI excluding SR would be multiplexed in the PUSCH. In other words, the SR cannot be transmitted in PHY based on UL skipping agreement and the specification TS 38.213 section 9.2.5 as cited in section 2.1.1 that “the UE multiplexes HARQ-ACK information and/or CSI reports in a PUSCH if the PUCCH resource overlaps in time with a PUSCH transmission, as described in Clause 9.3, and does not transmit SR”. Therefore, MAC should not instruct PHY for SR transmission but should deliver MAC PDU for the PUSCH.

* **Proposal 2: For the case of overlapping PUSCH and SR with equal L1 priority, if there are other UCI(s) i.e., HARQ-ACK and/or CSI of the same L1 priority overlapping with SR and the PUCCH resource after UCI multiplexing among different PUCCHs overlaps with the PUSCH, MAC shall deliver the MAC PDU for the PUSCH and shall not instruct PHY for SR transmission.**

**Q-c: Do you agree above proposal 2? If not, what is your views and proposal for case 2-2?**

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| Company | Comments |
| Nokia, NSB | Same comment as for the above:  We are a bit wondering, if for both cases here actually the MAC could deliver the SR & the PUSCH in the first place. As from MAC perspective for both cases 2a and 2b, SR and PUSCH are overlapping (as any other UCI multiplexing is not considered in MAC) 🡪 with higher SR LCH priority the SR (and no PUSCH TB) would be delivered, with the same LCH priority the PUSCH TB would be delivered to PHY (but not the SR) |
| ZTE | Fine with the proposal.  As commented above, we prefer not to change the PHY multiplexing behavior. The MAC behavior (whether generate MAC PDU for PUSCH or instruct PHY for SR transmission) could be based on the intermediate decision of multiplexing from PHY. In this particular case, MAC can generate BSR in MAC PDU, and the data can still be triggered based on BSR. |

* + - 1. Summary for Case 2-2

[To be updated]

* + 1. Case 3 of overlapping between other UCIs and SR and between SR and PUSCH of equal L1 priority
* **Case 3: other UCI(s) i.e., HARQ-ACK and/or CSI overlap with a PUSCH of equal L1 priority and SR overlaps with the PUSCH, but other UCI(s) do not overlap with SR of equal L1 priority**



Figure 5: other UCI(s) overlap with a PUSCH and the PUSCH overlaps with the SR, but the SR does not overlap with other UCI(s), all UL channels are of the same L1 priority (borrow from R1-2100318)

In case 3, similar as case 2-2 that the SR cannot be transmitted in PHY based on based UL skipping agreement and the specification TS 38.213 section 9.2.5 as cited in section 2.1.1 that “the UE multiplexes HARQ-ACK information and/or CSI reports in a PUSCH if the PUCCH resource overlaps in time with a PUSCH transmission, as described in Clause 9.3, and does not transmit SR”. Therefore, MAC should always deliver MAC PDU for the PUSCH and shall not instruct PHY for SR transmission.

* **Proposal 3: For the case of overlapping PUSCH and SR with equal L1 priority, if there are other UCI(s) i.e., HARQ-ACK and/or CSI of the same L1 priority overlapping with PUSCH for UCI multiplexing but the other UCI(s) do not overlap with the SR, MAC shall deliver the MAC PDU for the PUSCH and shall not instruct PHY for SR transmission.**

**Q-d: Do you agree above proposal 3? If not, what is your views and proposal for above case 3?**

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| Company | Comments |
| Nokia, NSB | Same comment as for cases 2 above:  We are a bit wondering, if for both cases here actually the MAC could deliver the SR & the PUSCH in the first place. As from MAC perspective for both cases 3a and 3b, SR and PUSCH are overlapping (as any other UCI multiplexing is not considered in MAC) 🡪 with higher SR LCH priority the SR (and no PUSCH TB) would be delivered, with the same LCH priority the PUSCH TB would be delivered to PHY (but not the SR)  So we think the two scenarios depicted above should not be applicable (as the initial SR PUCCH resource before other UCI multiplexing, there should not be SR overlapping with a PUSCH of the same PHY priority). The handling in 38.213 is based on the fact that due to other UCI multiplexing, the PUCCH resource would be changed based on our understanding. |
| ZTE | Fine with the proposal.  As commented above, we prefer not to change the PHY multiplexing behavior. The MAC behavior (whether generate MAC PDU for PUSCH or instruct PHY for SR transmission) could be based on the intermediate decision of multiplexing from PHY. |

* + - 1. Summary for Case 3

[To be updated]

* 1. UL skipping with LCH prioritization

RAN1 agreements related to Rel-16 uplink skipping for DG and CG PUSCH overlapping with a PUCCH with the same priority can be found in Appendix. In the following, the discussions mainly focus on the CG PUSCH and the DG PUSCH having different LCH priority.

* + 1. General views

Based on the submitted contributions, following high-level options can be summarized for handling overlapping between DG and CG PUSCH and overlapping between grant(s) with a PUCCH with the same PHY priority when LCH based prioritization is configured.

* **Option 1: Handled by gNB scheduling or configuration restrictions**

[R1-2100336] proposed following:

* **Option 1-1:**
  + gNB should avoid scheduling LP DG PUSCH overlapping with both LP PUCCH and HP CG PUSCH when scheduled LP DG PUSCH transmission is earlier than HP CG PUSCH transmission and LP PUCCH doesn’t overlap with HP CG PUSCH
  + When HP CG PUSCH transmission is earlier than scheduled LP DG PUSCH transmission and LP PUCCH doesn’t overlap with HP CG PUSCH, LP UCI is transmitted on the LP PUCCH if MAC delivers PDU to HP CG PUSCH and LP UCI is multiplexed in LP DG PUSCH if MAC delivers PDU to LP DG PUSCH.

[R1-2101264] proposed following:

* **Option 1-2:**
  + The UL skipping feature shall not be simultaneously configured with logical channel prioritization.
    - This is to avoid the situation that following one rule e.g. LCH based prioritization would violate another rule e.g. UL skipping rule
* **Option 2: PHY selects and indicates to MAC the PUSCH that cannot be skipped and the MAC layer can skip other PUSCHs except the one indicated by the PHY layer.**

[R1-2101440] proposed following steps to handle the CG and DG collisions with PUCCH overlap:

* + Step #1: Assume no uplink skipping. For each priority, a UE determines whether UCI will be multiplexed on a PUSCH or not.
  + Step#2: A UE selects one PUSCH that cannot be skipped by comparing the L1 priorities of the PUSCHs in case a 2-level priority is configured for a UE.
  + Step#3: The MAC layer can skip other PUSCHs except the one indicated by the PHY layer.
  + Step #4: The PHY layer performs prioritization/multiplexing as needed.
    - In case the PHY has indicated one PUSCH as non-droppable, and if there is another PUSCH overlapping with it on the same carrier, that PUSCH, including UCI that is expected to be multiplexed on it as part of step #1, are dropped.
* **Option 3: MAC layer decide which MAC PDU should be delivered (based on LCH based priority and data availability and the resource overlapping between the PUSCH and PUCCH of the same L1 priority).**
  + **For the MAC PDU delivered by MAC layer, if it overlaps with the PUCCH of the same PHY priority, then the UCI is multiplexed on the delivered MAC PDU;**
  + **For the MAC PDU not delivered by MAC layer, if it overlaps with the PUCCH of the same PHY priority,**
    - **Option 3-1: The PUCCH is transmitted** 
      * **E.g. possibly with condition that gNB needs to ensure the timing for deciding which MAC PDU will be delivered to PHY is always earlier than the timing for preparing the UCI multiplexing on PUSCH; Otherwise, error case.**
    - **Option 3-2: The PUCCH is dropped**
    - **Option 3-3: Depending on timeline, the PUCCH can be transmitted or dropped.**
      * **E.g. If the timing for deciding which MAC PDU will be delivered to PHY is earlier than the timing for preparing the UCI multiplexing on PUSCH, then the PUCCH is transmitted; Otherwise, the PUCCH is dropped.**

**Without discussing the details case-by-case, it is difficult to directly conclude which options above is the good way to go. Therefore, some detailed cases are present in the following sections to collect companies’ views.**

* + 1. UL skipping with LCH prioritization and a single PHY priority

Following are the cases that there are resource overlapping between DG and CG from agreed LS R1- 2009772 “LS on PUSCH skipping with UCI in Rel-16, RAN1” @RAN1#103-e meeting, see appendix with the difference that the LCH prioritization is configured.

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| **Case 1-3** | **Case 1-4** | **Case 1-6** |

Based on the following MAC spec TS 38.321, the priority for the grant for which no data for related logical channels is lower than either priority of the grant for which there is data for related logical channels. Therefore, in addition to the logical channel priority, the data availability for the grant associated with the logical channels needs to be taken into account.

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| For the MAC entity configured with lch-basedPrioritization, priority of an uplink grant is determined by the highest priority among priorities of the logical channels that are multiplexed (i.e. the MAC PDU to transmit is already stored in the HARQ buffer) or have data available that can be multiplexed (i.e. the MAC PDU to transmit is not stored in the HARQ buffer) in the MAC PDU, according to the mapping restrictions as described in clause 5.4.3.1.2. The priority of an uplink grant for which no data for logical channels is multiplexed or can be multiplexed in the MAC PDU is lower than either the priority of an uplink grant for which data for any logical channels is multiplexed or can be multiplexed in the MAC PDU or the priority of the logical channel triggering an SR. |

For Case 1-3,

* 1-3-1: When only one grant (either DG or CG) has available data, it is expected that MAC should generate and deliver the MAC PDU for which there is data available.
* 1-3-2: When both grants have available data, it is expected that MAC should generate and deliver the MAC PDU for which the grant has higher priority of the associated LCH(s)
* 1-3-3: When there is no available data for either grant, (it is similar as Case 1-3 without LCH priority configured), it is expected that MAC should generate the MAC PDU for the DG PUSCH)

Q1-1: Do you agree with above expected MAC layer behavior for case 1-3-1, 1-3-2 and 1-3-3?

* If you do not agree, please elaborate the reason and the expected MAC layer behavior.

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| Company | Comments |
| Apple | In our view, there are 3 stages involves in the UCI multiplexing:  Stage 1: PHY selects a PUSCH for UCI multiplexing from hypothetical PUSCHs (there is at least one or multiple at a single CC or multiple CCs overlapping with resource Z)  Stage 2: PHY indicates the selected PUSCH for UCI multiplexing if any to MAC, and MAC performs any processing deemed suitable from RAN2 point of view;  Stage 3: MAC may deliver a MAC PDU for the selected PUSCH for UCI multiplexing for one occasion (it may not as well at some other occasions), PHY transmits the PUSCH with UCI multiplexed if the selected PUSCH from Stage 1 actually materialized.  RAN1 can focus the discussion on Stage 1 and Stage 3, Stage 2 should be delegated to RAN2. The cases listed somehow mix RAN1 design and RAN2 design.  For example, for 1-3-1: RAN1 should discuss between DG PUSCH and CG PUSCH occasion (note at Stage 1 there is no MAC PDU from MAC yet, “CG PUSCH” in the illustration is just CG PUSCH occasion, not actual CG PUSCH, which one should be assumed for UCI multiplexing, and what indication will be generated, whether MAC deliver the MAC PDU is up to RAN2.  For 1-3-2: again RAN1 should discuss between CG PUSCH occasion and DG PUSCH (two hypothetical transmissions) , which one will be assumed for UCI multiplexing. To have a somewhat deterministic behavior at UE (so there is a reasonable chance gNB can guess correctly), DG PUSCH should be assumed for UCI multiplexing in Stage 1.  For 1-3-3: again RAN1 should discuss between CG PUSCH occasion and DG PUSCH (two hypothetical transmissions) , which one will be assumed for UCI multiplexing. From the choice given, then we can deduce between CG PUSCH occasion and DG PUSCH (two hypothetical transmissions), DG PUSCH is assumed for UCI multiplexing in Stage 1. |
| ZTE | Agree.  In our understanding, this is also in line with the current MAC spec for case 1-3-1 and case 1-3-2. For case 1-3-3, we think it is reasonable since DG has higher priority than CG in Rel-15. |

For case 1-3-1, 1-3-2, 1-3-3, the UCI should be multiplexed on the PUSCH delivered by MAC.

Q1-2: Do you agree with above on UCI handling for case 1-3-1, 1-3-2 and case 1-3-3?

* If you do not agree, please elaborate the reason and the preferred UCI handling solution.

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| Company | Comments |
| Apple | If MAC does not deliver MAC PDU for the hypothetical PUSCH in Stage 1, then UCI is dropped. |
| ZTE | Agree.  According to RAN1 spec, the UCI should be multiplexed in the PUSCH if the PUCCH and PUSCH overlaps in the time domain. The prerequisite is there is MAC PDU delivered from MAC layer for the PUSCH. |

For Case 1-4,

* 1-4-1: When only one grant (either DG or CG) has available data, it is expected that MAC should generate and deliver the MAC PDU for which there is data available.
* 1-4-2: When both grants have available data, it is expected that MAC should generate and deliver the MAC PDU for which the grant has higher priority of the associated LCH(s)
* 1-4-3: When there is no available data for either grant, (it is similar as Case 1-1 without LCH priority configured), it is expected that MAC should generate the MAC PDU for the DG PUSCH.

Q1-3: Do you agree with above expected MAC layer behavior for case 1-4-1, 1-4-2 and 1-4-3?

* If you do not agree, please elaborate the reason and the expected MAC layer behavior.

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| Company | Comments |
| ZTE | Agree  In our understanding, this is also in line with the current MAC spec for case 1-4-1 and case 1-4-2. For case 1-4-3, we think it is reasonable since it allow UCI multiplexing, which is also aligned with UE behavior the case 1-1. |
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For case 1-4-1, 1-4-2, handling of UCI,

* If the MAC PDU is delivered for the DG PUSCH, PHY will multiplex the UCI on the DG PUSCH and transmit the DG PUSCH including the UCI;
* If the MAC PDU is delivered for the CG PUSCH, this case will result in the similar situation as for Case 1-6 without LCH priority by interchanging CG and DG. The same handling (e.g, option 3-1: UCI is dropped or option 3-2: UCI is transmitted on PUCCH or option 3-3: depending on timeline, the PUCCH can be transmitted or dropped etc.) should be applied as for Case 1-6 without LCH priority.

Q1-4: Do you agree with above on UCI handling for case 1-4-1, case 1-4-2?

* If you do not agree, please elaborate the reason and the preferred UCI handling solution.

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| Company | Comments |
| Apple | To have a unified design as for Case 1-6 with LCH priority can be something nice to have as an outcome, but not a design goal.  For Stage 1, PUSCH selection for UCI multiplexing is applied to hypothetical PUSCHs (over a single CC or multiple CCs for CA) |
| ZTE | Agree  According to RAN1 spec, the UCI should be multiplexed in the PUSCH if the PUCCH and PUSCH with MAC PDU overlaps in the time domain. For case 1-4-2, the PUCCH should be transmitted as far as possible to avoid resource waste due to PUCCH dropping and accordingly PDSCH retransmission. Therefore, the PUCCH should be transmitted if the timeline is satisfied. |

For case 1-4-3, the UCI should be multiplexed on the DG PUSCH.

Q1-5: Do you agree with above on UCI handling for case 1-4-3?

* If you do not agree, please elaborate the reason and the preferred UCI handling solution.

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| Company | Comments |
| ZTE | Agree. This is similar as case 1-4-1 |

For case 1-6:

* 1-6-1: When only one grant (either DG or CG) has available data, it is expected that MAC should generate and deliver the MAC PDU for which there is data available.
* 1-6-2: When both grants have available data, it is expected that MAC should generate and deliver the MAC PDU for which the grant has higher priority of the associated LCH(s)
* 1-6-3: When there is no available data for either grant, (it is the same case as Case 1-6 without LCH priority configured), it is expected that MAC should generate the MAC PDU for the CG PUSCH.

Q1-6: Do you agree with above expected MAC layer behavior for case 1-6-1, 1-6-2 and 1-6-3?

* If you do not agree, please elaborate the reason and the expected MAC layer behavior.

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| Company | Comments |
| Apple | Don’t agree with 1-6-3. Depending on PUSCH selection outcome, if CG PUSCH is not selected for UCI multiplexing in Stage 1, no MAC generation for CG PUSCH is necessary. |
| ZTE | Agree  In our understanding, this is also in line with the current MAC spec for case 1-6-1 and case 1-6-2. For case 1-6-3, we think it is reasonable since it allow UCI multiplexing, which is also aligned with UE behavior the case 1-2. |

For case 1-6-1, 1-6-2, handling of UCI,

* If the MAC PDU is delivered for the CG PUSCH, PHY will multiplex the UCI on the CG PUSCH and transmit the CG PUSCH including the UCI;
* If the MAC PDU is delivered for the DG PUSCH, this case will result in the same situation as for Case 1-6 without LCH priority. The same handling should be applied as for Case 1-6 without LCH priority.

Q1-7: Do you agree with above on UCI handling for case 1-6-1 and 1-6-2?

* If you do not agree, please elaborate the reason and the preferred UCI handling solution.

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| Company | Comments |
| Apple | No. It all depends on the rule RAN1 is going to develop for selection among hypothetical PUSCHs for UCI multiplexing. Case 1-6 may not arise. |
| ZTE | Agree  According to RAN1 spec, the UCI should be multiplexed in the PUSCH if the PUCCH and PUSCH with MAC PDU overlaps in the time domain. For case 1-6-2, the PUCCH should be transmitted as far as possible to avoid resource waste due to PUCCH dropping and accordingly PDSCH retransmission. Therefore, the PUCCH should be transmitted if the timeline is satisfied. |

For case 1-6-3, the UCI should be multiplexed on the CG PUSCH.

Q1-8: Do you agree with above on UCI handling for case 1-6-3?

* If you do not agree, please elaborate the reason and the preferred UCI handling solution.

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| Company | Comments |
| Apple | No. It all depends on the rule RAN1 is going to develop for selection among hypothetical PUSCHs for UCI multiplexing. Case 1-6 may not arise. |
| ZTE | Agree. This is similar as case 1-6-1 |

* + 1. UL skipping with LCH prioritization and two PHY priorities

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| Case 2-1a | Case 2-1b |

Case 2-1a and Case 2-1b is similar, the only difference is for Case 2-1a, the starting symbol of LP DG PUSCH is earlier than that of HP CG PUSCH. In the following, we will use the case 2-1a for discussion. The same discussion results are also applied to case 2-1b.

For case 2-1a:

* 2-1a-1: When only one grant (either DG or CG) has available data, it is expected that MAC should generate and deliver the MAC PDU for which there is data available.
* 2-1a-2: When both grants have available data, it is expected that MAC should generate and deliver the MAC PDU for which the grant has higher PHY priority.
* 2-1a-3: When there is no available data for either grant, (it is the same case as Case 1-6 without LCH priority configured), it is expected that MAC should generate the MAC PDU for the DG PUSCH.

Q2-1: Do you agree with above expected MAC layer behavior for case 2-1a-1, 2-1a-2 and 2-1a-3?

* If you do not agree, please elaborate the reason and the expected MAC layer behavior.

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| --- | --- |
| Company | Comments |
| ZTE | Agree.  In our understanding, this is also in line with the current MAC spec for case 2-1a-1 and case 2-1a-2. For case 2-1a-3, we think it is reasonable since PUCCH and PUSCH have the same PHY priority and it allow UCI multiplexing, which is also aligned with UE behavior the case 1-1. |
|  |  |

For case 2-1a-1, 2-1a-2 and case 2-1a-3, handling of UCI,

* When both grants have available data or only CG has available data, it is expected the MAC PDU should be delivered for the CG PUSCH, this case will result in the same situation as for Case 1-4 with LCH priority and a single PHY priority. The same handling should be applied as for the Case 1-4 with LCH priority and a single PHY priority.
* When only DG has available data, it is expected the MAC PDU should be delivered for the DG PUSCH, and PHY will multiplex the UCI on the DG PUSCH and transmit the DG PUSCH including the UCI
* When neither grant has available data, it is expected the MAC PDU should be delivered for the DG PUSCH, so that PHY will multiplex the UCI on the DG PUSCH and transmit the DG PUSCH including the UCI.

Q2-2: Do you agree with above on UCI handling for Case 2-1a-1, 2-1a-2 and case 2-1a-3?

* If you do not agree, please elaborate the reason and the preferred UCI handling solution.

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| Company | Comments |
| ZTE | Agree  According to RAN1 spec, the UCI should be multiplexed in the PUSCH if the PUCCH and PUSCH with MAC PDU overlaps in the time domain. For the PUCCH overlapping with the PUSCH without MAC PDU (case 2-1a-1), it should be transmitted as far as possible to avoid resource waste due to PUCCH dropping and accordingly PDSCH retransmission. Therefore, the PUCCH should be transmitted if the timeline is satisfied. |
|  |  |

Below are Case 2-2 and Case 2-3. The difference between Case 2-2 and Case 2-3 is for Case 2-2, the PUSCH collision is between DG and CG PUSCH; while for Case 2-3, the PUSCH collision is between CG and CG PUSCH. It is noted that for Case 2-2, PHY expects MAC only deliver one MAC PDU. But for Case 2-3, MAC can deliver two CG PUSCHs, it is up to UE implementation to make sure that the low priority CG PUSCH transmission can be cancelled before the start of the high priority CG PUSCH.

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| Case 2-2 | Case 2-3 |

For Case 2-2,

* 2-2-1: When only HP CG has available data, it is expected that MAC should generate and deliver the HP CG PUSCH.
* 2-2-2: When only LP DG has available data, it is expected that MAC should generate and deliver the LP DG PUSCH.
* 2-2-3: When both grants have available data, it is expected that MAC should generate and deliver the HP CG PUSCH.
* 2-2-4: When there is no available data for either grant, discuss what the expected behavior is in MAC.

Q2-2: Do you agree with above expected MAC layer behavior for case 2-2-1, 2-2-2 and 2-2-3?

* If you do not agree, please elaborate the reason and the expected MAC layer behavior.

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| --- | --- |
| Company | Comments |
| ZTE | Agree  In our understanding, this is also in line with the current MAC spec for these three cases. |
|  |  |

Q2-3: for Case 2-2-4,

* Q2-3-a: What is the expected MAC layer behavior from PHY perspective and why?
* Q2-3-b: based on your replies to Q2-3-a, what is the preferred PHY layer on handling of the HP PUCCH and LP PUCCH?

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| --- | --- |
| Company | Comments |
| ZTE | We prefer the MAC layer should generate MAC PDU for the HP CG PUSCH to align with the UE behavior in case 2-2-1 and case 2-2-3 since the latter two cases are normal cases. |
|  |  |

For case 2-2-1, 2-2-2 and case 2-2-3, handling of UCI,

* For case 2-2-1 and case 2-2-3, HP CG is delivered and PHY will multiplex the HP-UCI on the HP-CG PUSCH; for LP-PUCCH, the same handling (e.g, UCI is dropped or UCI is transmitted on PUCCH or whether to drop or transmit the UCI depends on the timeline, etc.) should be applied as for the Case 2-1a with LCH priority and two PHY priorities.
* For case 2-2-2, LP DG is delivered and PHY will multiplex the LP-UCI on the LP-DG PUSCH; for HP-PUCCH, the same handling (e.g, UCI is dropped or UCI is transmitted on PUCCH, or whether to drop or transmit the UCI depends on the timeline etc.) can be considered to apply as for the Case 2-2-1.

Q2-4: Do you agree with above on UCI handling for Case 2-2-1, 2-2-3 and case 2-2-2?

* If you do not agree, please elaborate the reason and the preferred UCI handling solution.

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| --- | --- |
| Company | Comments |
| ZTE | Agree  According to RAN1 spec, the UCI should be multiplexed in the PUSCH if the PUCCH and PUSCH with MAC PDU overlaps in the time domain. For the PUCCH overlapping with the PUSCH without MAC PDU, it should be transmitted as far as possible to avoid resource waste due to PUCCH dropping and accordingly PDSCH retransmission. Therefore, the PUCCH should be transmitted if the timeline is satisfied. |
|  |  |

For Case 2-3,

* 2-3-1: When only HP CG has available data, it is expected that MAC should generate and deliver the HP CG PUSCH.
* 2-3-2: When only LP CG has available data, it is expected that MAC should generate and deliver the LP CG PUSCH.
* 2-3-3: When both grants have available data, it is possible that MAC generates and delivers both HP CG PUSCH and LP CG PUSCH, then it is up to UE implementation to make sure that the low priority CG PUSCH transmission can be cancelled before the start of the high priority CG PUSCH.
* 2-3-4: When there is no available data for either grant, it is similar as Case 2-2, we can discuss what the expected behavior is in MAC.

Q2-5: Do you agree with above expected MAC layer behavior for case 2-3-1, 2-3-2 and Case 2-3-3?

* If you do not agree, please elaborate the reason and the expected MAC layer behavior.

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| --- | --- |
| Company | Comments |
| ZTE | Agree  In our understanding, this is also in line with the current MAC spec for case 2-3-1 and case 2-3-3. For 2-3-3, it is also possible that MAC layer only generates and delivers the HP CG PUSCH. For example, when the high priority data arrives before the MAC generates the MAC PDU for the LP CG PUSCH. |

Q2-6: for Case 2-3-4,

* Q2-6-a: What is the expected MAC layer behavior from PHY perspective and why?
* Q2-6-b: based on your replies to Q2-6-a, what is the preferred PHY layer on handling of the HP PUCCH and LP PUCCH?

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| --- | --- |
| Company | Comments |
| ZTE | We prefer the MAC layer should generate MAC PDU for the HP CG PUSCH to align with the UE behavior in case 2-3-1 and case 2-3-3 (only HP CG PUSCH delivered as mentioned in Q2-5) since the latter two cases are normal cases |

Handling of UCI for case 2-3-1, 2-3-2 and case 2-3-3,

* For case 2-3-1, HP CG is delivered and PHY will multiplex the HP-UCI on the HP-CG PUSCH; for LP-PUCCH, FFS UCI can be dropped or UCI can be transmitted on PUCCH, etc.
* For case 2-3-2, LP CG is delivered and PHY will multiplex the LP-UCI on the LP-CG PUSCH; for HP-PUCCH, FFS UCI can be dropped or UCI can be transmitted on PUCCH, etc.
* For case 2-3-3,
  + if only HP CG is delivered, it becomes the same case as case 2-3-1;
  + if only LP CG is delivered, it becomes the same case as case 2-3-2;
  + if both CGs are delivered, it is up to UE implementation to make sure that the LP CG PUSCH with the LP UCI multiplexed on it can be cancelled before the start of the HP CG PUSCH, and the HP UCI is multiplexed on HP CG PUSCH.

Q2-7: Do you agree with above on UCI handling for Case 2-3-1, 2-3-2 and case 2-3-3?

* If you do not agree, please elaborate the reason and the preferred UCI handling solution.

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| --- | --- |
| Company | Comments |
| ZTE | Agree  According to RAN1 spec, the UCI should be multiplexed in the PUSCH if the PUCCH and PUSCH with MAC PDU overlaps in the time domain. For the PUCCH overlapping with the PUSCH without MAC PDU, it should be transmitted as far as possible to avoid resource waste due to PUCCH dropping and accordingly PDSCH retransmission. Therefore, the PUCCH should be transmitted if the timeline is satisfied.  For case 2-3-3, we do not think only LP CG PUSCH is delivered since the HP CG PUSCH has data for transmission. We think the other two behaviors are possible. |
|  |  |

**Q2-8: Based on your views for section 2.1 and 2.2, which high-level option as provided in the section 2.2.1 General views do you prefer?**

* **Option 1: Handled by gNB scheduling or configuration restrictions**
* **Option 2: PHY selects and indicates to MAC the PUSCH that cannot be skipped and the MAC layer can skip other PUSCHs except the one indicated by the PHY layer.**
* **Option 3: MAC layer decide which MAC PDU should be delivered (based on LCH based priority and data availability and the resource overlapping between the PUSCH and PUCCH of the same L1 priority).**

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| Company | Comments |
| ZTE | Option 3  In our understanding, the MAC layer should decide which MAC PDU should be deliver based on  LCH based priority and data availability if there is available data for either grant, or  the resource overlapping between the PUSCH and PUCCH of the same L1 priority if there is no available data for the two grants. |
|  |  |

**Q2-9: for the MAC PDU not delivered by MAC layer, if it overlaps with the PUCCH of the same PHY priority, do you prefer to have the same solution should be adopted as for the case 1-6 without LCH priority?**

* **If your answer is No, please share your reasons.**

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| --- | --- |
| Company | Comments |
| ZTE | Yes. We think the same solution should be used.  In general, the UCI should be multiplexed in the PUSCH if the PUCCH and PUSCH with MAC PDU overlaps in the time domain. For the PUCCH overlapping with the PUSCH without MAC PDU, it should be transmitted as far as possible to avoid resource waste due to PUCCH dropping and accordingly PDSCH retransmission. Therefore, the PUCCH should be transmitted if the timeline is satisfied. The timeline requirement is the time interval between the PUCCH and the PDCCH scheduling the PUSCH is not less than Tproc,1, where the PUSCH is transmitted finally. |
|  |  |

# References

1. [R1-2100091](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100091.zip), Remaining issues on intra-UE multiplexing in Rel-16 URLLC, ZTE
2. R1-2100265, Intra-UE Multiplexing and Prioritization for Rel-16 URLLC, Ericsson
3. [R1-2100336](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100336.zip), Discussion on overlapping between CG PUSCH and DG PUSCH, CATT
4. [R1-2100415](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100415.zip), Maintenance on intra-UE prioritization, vivo
5. [R1-2100632](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100632.zip), On remaining details for handling CG-DG PUSCH overlaps, Intel Corporation
6. [R1-2100756](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100756.zip), URLLC/IIoT PUSCH skipping (with LCH and/or PHY prioritization configured), Nokia, Nokia Shanghai Bell
7. [R1-2100793](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100793.zip), Remaining issues of CG-PUSCH enhancements for URLLC, Spreadtrum Communications
8. [R1-2100829](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100829.zip), PUSCH skipping, InterDigital, Inc.
9. [R1-2101264](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101264.zip), PHY prioritization/multiplexing with consideration of UL skipping, Huawei, BUPT, China Southern Power Grid, HiSilicon
10. [R1-2101348](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101348.zip), PUSCH skipping considering physical layer priority & LCH based prioritization, Apple
11. [R1-2101440](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101440.zip), Remaining issues on eCG enhancements for URLLC, Qualcomm Incorporated
12. [R1-2101586](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101586.zip), Corrections on enhanced configured grant transmission for Rel-16 URLLC, NTT DOCOMO, INC.
13. [R1-2100898](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100898.zip), PHR issues related to URLLC/IIOT WI, LG Electronics
14. R1-2100026 LS on overlapped data and SR are of equal L1 priority RAN2, Huawei
15. R1-2100088 [DRAFT] Reply LS on overlapped data and SR of equal L1 priority ZTE
16. R1-2100089 Discussion on overlapped data and SR of equal L1 priority ZTE
17. R1-2100318 Discussion on overlapped data and SR of equal L1 priority CATT
18. R1-2100727 [Draft] Reply LS on overlapped data and SR are of equal L1 priority Nokia
19. R1-2101154 Reply LS on overlapped data and SR with equal L1 priority vivo
20. R1-2101166 Draft reply LS on overlapped data and SR are of equal L1 priority Samsung
21. R1-2101276 Draft reply LS on overlapped data and SR with equal L1 priority for Rel-16 URLLC Huawei, HiSilicon
22. R1-2101277 Discussion on overlapped data and SR with equal L1 priority for Rel-16 URLLC Huawei, HiSilicon
23. R1-2101502 Discussion of Response LS on Overlapped Data and SR of Equal L1 Priority Ericsson Inc.
24. R1-2101528 Discussion on LS on overlapping data and SR with same L1 priority Intel Corporation

# Appendix

## RAN1 agreements related to Rel-16 uplink skipping

**Agreement (RAN1#102)**

For UL skipping of dynamic UL grant in non-CA and CA case, when there is PUCCH carrying UCI overlapping with a set of PUSCHs, the PUSCH with UCI multiplexing from the set cannot be skipped. MAC generates MAC PDU for the PUSCH and the UCI is multiplexed on the PUSCH.

**Agreement: (RAN1#103)**

For the case (Case 1-2) where only one or more CG PUSCHs overlapping with PUCCH

* In Rel.16, for CA and non-CA case, when Rel-16 LCH based prioritization is not configured and there is a single PHY priority for UL transmissions, and when PUSCH repetition is not applied, in case of one or more CG PUSCHs overlapping with UCI and there is no DG PUSCH overlapping with the UCI and there is no DG PUSCH overlapping with the one or more CG PUSCHs, the CG PUSCH with UCI multiplexing from the one or more CG PUSCHs cannot be skipped.  MAC generates MAC PDU for the CG PUSCH and delivers the MAC PDU to PHY and the UCI is multiplexed on the CG PUSCH.

**Conclusion (RAN1#103)**

For the following cases, for CA and non-CA, when DG PUSCH skipping is configured and Rel-16 LCH based prioritization is not configured and there is a single PHY priority for UL transmissions, MAC generates MAC PDU for the DG PUSCH and the UCI is multiplexed on the DG PUSCH. For the case 1-3 and 1-4, MAC does not generate a TB for the CG PUSCH(s) overlapping with the DG PUSCH on the same serving cell.  The ~~G~~CG PUSCH(s) is discarded and does not participate in subsequent physical layer procedure.

* (Case 1-3) DG PUSCH and CG PUSCH are overlapping and both DG/CG PUSCH are overlapping with PUCCH
* (Case 1-4) DG PUSCH and CG PUSCH are overlapping and DG PUSCH is overlapping with PUCCH, and CG PUSCH is non-overlapping with the PUCCH
* (Case 1-5) DG PUSCH and CG PUSCH are non-overlapping and both DG/CG PUSCH are overlapping with PUCCH

**Working Assumption: (RAN1#103)**

For the case (Case 1-6) when DG PUSCH and CG PUSCH are overlapping on a serving cell and CG PUSCH is overlapping with PUCCH, and DG PUSCH is non-overlapping with the PUCCH

* In Rel.16, for non-CA case, when DG PUSCH skipping is configured and Rel-16 LCH based prioritization is not configured and there is a single PHY priority for UL transmissions, and when PUSCH repetition is not applied, in case of one or more CG PUSCHs overlapping with UCI and there is DG PUSCH overlapping with the CG PUSCHs on a serving cell and not overlapping with the UCI
  + Opt-3:
    - If there is data for DG, MAC generates PDU for DG PUSCH
      * UCI is transmitted on PUCCH.
    - If there is no data for DG, MAC does not generate PDU for DG or CG PUSCH
      * UCI is transmitted on PUCCH.
  + Opt-4:
    - If there is data for DG, MAC generates PDU for DG PUSCH
      * UCI is dropped together with CG PUSCH.
    - If there is no data for DG, MAC does not generate PDU for DG or CG PUSCH.
      * UCI is dropped together with CG PUSCH.

Note: In RAN1#104-e, aim to resolve case 1-6 using above options as a starting point, other options are not precluded.

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| **Case 1-2** | **Case 1-3** |
|  |  |
| **Case 1-4** | **Case 1-5** |
|  | |
| **Case 1-6** | |

## RAN1 agreements from Rel-16 URLLC

**Agreement (RAN1#103)**

* For the collision scenario between CG and DG with same/different PHY-priority index, if there is no collision between PUCCH and the CG and there is no collision between PUCCH and the DG, the behaviour mentioned in the LS is consistent with RAN1’s understanding if taking into account the TP to Rel-16 TS 38.214, i.e., revision CR in R1-2008655.
* When the MAC entity is configured with *lch-basedPrioritization*, for the collision scenario between CG and DG with same/different PHY-priority index, and when there is collision between PUCCH and the CG with the same priority and/or there is collision between PUCCH and the DG with the same priority, RAN1 is still discussing the related PHY layer behaviour.

## RAN1 agreements related to collision handling for PUSCH of different PHY priorities in Rel-16

1. Overlapping HP DG PUSCH and LP DG PUSCH is not supported
   * Related RAN1#99 Conclusion: In Rel. 16 URLLC, the UE is not expected to be scheduled with two DG-PUSCH overlap in the time domain on the same carrier.
2. HP CG PUSCH and LP CG PUSCH can be overlapping and MAC may deliver more than one PDU, it is up to UE implementation to make sure that the low priority CG PUSCH transmission can be cancelled before the start of the high priority CG PUSCH.
   * Related RAN1#101-e Agreement: For collision handling between CG and CG with different priorities - If MAC delivers two MAC PDUs, it is up to UE implementation to make sure that the low priority CG PUSCH transmission can be cancelled before the start of the high priority CG PUSCH
3. Overlapping of DG PUSCH and CG PUSCH of different PHY priority is supported, if the Rel-15 overriding timeline is satisfied (i.e. only a single MAC PDU will be delivered, no PHY cancelation)
   * Related RAN1#101-e Conclusion:There is no consensus in RAN1 for the support of the following
     + - high priority DG cancel the transmission of low priority CG in the physical layer
       - high priority CG cancel the transmission of low priority DG in the physical layer

No further discussion for Rel-16.

* + Related RAN1#102-e Conclusion: For the collision between DG PUSCH and CG PUSCH with different priorities, the DG PUSCH can be scheduled overlapping in time with CG PUSCH occasion if Rel-15 timeline satisfies.