**3GPP TSG RAN WG1 #106-e**  **R1- 210xxxx**

e-Meeting, August 16th – 27th, 2021

**Agenda item:** 7.2.5

**Source:** Moderator (vivo)

**Title:** Summary of [106-e-NR-L1enh-URLLC-05] Issue#9: Remaining issues on UL prioritization and UL skipping

**Document for:** Discussion and Decision

# 1 Introduction

This document is to kick-off the following email discussion:

* [106-e-NR-L1enh-URLLC-05] Issue#9: Remaining issues on UL prioritization and UL skipping by August 20 - Lihui (vivo)

**Please provide your feedback by UTC 11:59 AM, August 18.**

# 2 Background

## 2.1 For collision between DG and CG

In RAN1#103-e meeting, RAN1 received LS from RAN2 to confirm the intended UE behavior as below:

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| **RAN2 LS on Intra UE Prioritization Scenario (R1-2007523)**   |  | | --- | | RAN2 has agreed in RAN2#107 that  For the case when no PDU has been generated at all yet, and there are two grants where one will be de-prioritized (and there is data available for both grants), one PDU is generated by MAC.  This agreement means that in the collision scenario between CG and DG with same/different PHY-priority index, and only one transport block is delivered to PHY, PHY transmit on the grant for which a transport block is delivered and skip the transmission on the other grant.  It is not clear from the wording in the LS R1-2005078 if the PHY behavior described above is consistent with RAN1 understanding.  RAN2 respectfully asks RAN1 to clarify if the mentioned scenario is supported or not. | |

RAN1 provided the corresponding reply LS as following:

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| **RAN1 Reply LS on Intra UE Prioritization Scenario (R1-2009680)**   |  | | --- | | RAN1 had a discussion and made following agreements:  **Agreement**   * 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. | |

In RAN2#113-e and RAN2#113bis-e meeting, RAN2 further discussed Rel-16 intra-UE prioritization with taking UL skipping agreement into account and achieved following agreements:

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| **Working assumption: When lch-BasedPrioritization is not configured and Rel-16 CG/DG PUSCH skipping is enabled, DG always overrides CG. This working assumption is not agreed until confirmed by RAN1.**  **Working assumption: The MAC entity does not generate a MAC PDU for a deprioritized uplink grant even when its associated PUSCH is overlapping with PUCCH. This working assumption is not agreed until confirmed by RAN1.**  **Confirm the WA that LCH based prio has higher priority than UL skipping still applies, and we expect that if there are issues, RAN1 will come-back.** |

## 2.2 For collision between SR and PUSCH

In RAN1#104-e meeting, RAN1 received LS from RAN2 to confirm the intended UE behavior as below:

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| **RAN2 LS on overlapped data and SR are of equal L1 priority (R1-2100026)**   |  | | --- | | 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. | |

RAN1 provided the corresponding reply LS as following:

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| **RAN1 Reply LS on overlapped data and SR are of equal L1 priority (R1-2102244)**   |  | | --- | | Assumption: LCH based prioritization is configured. Rel-16 UL skipping is possible.  RAN1 respectfully asks RAN2 to provide their views on which understanding (understanding 1 or 2) is the intended MAC layer behavior or to provide an alternate understanding, for case 2-1, case 2-2, case 3 and case 4. | |

In RAN2#114-e meeting, RAN2 send the Reply LS on overlapped data and SR with equal L1 priority as follows.

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| RAN2 would like to appreciate the LS on overlapped data and SR are of equal L1 priority (R1-2102244). RAN2 has discussed and concluded the following.  For case 2-1 and case 4, RAN2 has made the following agreement in RAN2#114-e:   |  | | --- | | * We go with Understanding 1: MAC does not use knowledge of UCI multiplexing when MAC executes LCH based prioritization and deciding when to transmit SR |   For case 2-2 and case 3, RAN2 has made the following working assumption in RAN2#113-e:   |  | | --- | | * Working assumption: The MAC entity does not generate a MAC PDU for a deprioritized uplink grant even when its associated PUSCH is overlapping with PUCCH. This working assumption is not agreed until confirmed by RAN1. |   It was further confirmed in RAN2#113bis-e:   |  | | --- | | * Confirm the WA that LCH based prio has higher priority than UL skipping still applies, and we expect that if there are issues, RAN1 will come-back. |   The intended MAC layer behaviour of the working assumption is Understanding 2. |

# 3 Discussions

Continue the discussion in the last RAN1 meeting for the following three Scenarios for intra-UE prioritization/multiplexing:

* Scenario #2: lch-basedPrioritization is NOT configured, and TWO PHY priorities for UL transmission
* Scenario #3: lch-basedPrioritization is configured, and SINGLE PHY priorities for UL transmission
* Scenario #4: lch-basedPrioritization is configured, and TWO PHY priorities for UL transmission

Note that UE behavior for Scenario #1 of lch-basedPrioritization is NOT configured, and SINGLE PHY priorities for UL transmission is already finalized in the last RAN1 meeting.

## 3.1 Discussion on Scenario#2 without LCH based prioritization

### 1st Round

For Scenario#2, the main issue is whether to confirm RAN2’s WA. The concerns raised in the last meeting for not confirming the WA were that it may create some PHY layer issues if the L1 priority is not visible in MAC layer in case *lch-BasedPrioritization* is not configured. However, some companies think that the UE behavior is the same as scenarios 1 and proper gNB’s configuration/scheduling can avoid the undesirable cases. Based on the submitted contributions, there are two options proposed.

**Proposal 3.1-1: When *lch-BasedPrioritization* is not configured and PHY is configured with two L1 priorities, down-select from following two options:**

* **Option 1: RAN1 confirms RAN2’s working assumption that DG always overrides CG.**
* **Option 2: RAN1 confirms RAN2’s working assumption that DG always overrides CG for the case that the DG and CG has the same L1 priority and the case that the DG has higher L1 priority than the CG.**
  + **UE does not expect to receive DG PUSCH with priority index 0 if it overlaps with CG PUSCH with priority index 1 when *lch-BasedPrioritization* is not configured and PHY is configured with two L1 priorities.**

**Question 3.1-1:**

1. **Which option do you prefer?**
2. **Can you accept the option 2 if we cannot converge on option 1?**

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| Company | View |
| HW/HiSi | Option 1 is preferred.  For the sub-bullet under Option 2, could you please clarify if it means that the UE shall not receive LP DG PUSCH if it overlaps with HP CG, or does it mean that the gNB should ensure that a LP DG PUSCH should not overlap with a HP CG?  **Moderator’s reply: Yes, it means gNB should ensure that a LP DG PUSCH should not overlap with a HP CG.** |
| CATT | We prefer Option2 |
| OPPO | We are ok with both option 1 and option 2 with slight preference to option 2, since it can protect HP data as much as possible. |
| Nokia/NSB | We prefer Option 2 in principle.  But we are not sure we need the restriction below.   * + **UE does not expect to receive DG PUSCH with priority index 0 if it overlaps with CG PUSCH with priority index 1 when *lch-BasedPrioritization* is not configured and PHY is configured with two L1 priorities.**   As there is still the issue of buffer status of different priorities. MAC should select the overlapping DG or CG PUSCH grant of higher LCH priority having data available in the buffer (i.e. from MAC perspective, LCH based prioritization has higher priority than PHY priority).  **Moderator’s reply: Scenario 2 is the case that LCH based prioritization is not configured.** |
| Samsung | Both options are fine to us. |
| vivo | We are fine with both options. |
| Qualcomm | We support Option 2. |
| Ericsson | Option 1.  We don’t think it’s necessary to have the scheduling restriction in Option 2.  If it does not make sense to schedule LP DG to overlap with HP CG, then gNB wouldn’t do it.  On the other hand, if it makes sense to schedule LP DG to overlap with HP CG, then gNB is allowed to do it. For example, CG is intentionally over-provisioned (e.g., multiple CG configurations with short periodicities) to address the use case that TSN traffic periodicity is not integer multiple of CG periodicity. Scheduler is aware that most CG occasions are empty and can choose to schedule an overlapping DG.  **Moderator’s reply: thanks a lot for your views. For the mentioned case, it is better and can be achieved by configuring the LCH-based prioritization, and also two L1 priorities in PHY.**  In addition to Question 3.1-1, another issue needs to be discussed:  For Scenario#2: the UE behavior is unclear if Rel-16 UL skipping is enabled. We suggest that moderator add this as a discussion point, so that RAN1 can resolve this open issue. In Ericsson [2], the following is proposed to address this:  *Proposal:*  *When Rel-16 UL skipping is enabled and lch-basedPrioritization is not configured, for a given PHY priority, the same procedure agreed for single PHY priority applies so that MAC generates a PDU for a PUSCH which expected to multiplex with UCI of same priority, except the LP grant that overlaps with a HP PUCCH or a HP PUSCH.*  **Moderator’s reply: OK, I will add this proposal to collect companies’ views.** |
| Intel | Option 2. |
| ZTE | We are fine with option 1. And we understand the intention of option 2 is to introduce the restriction to cater for the the RAN2’s working assumption. We are also fine with this option. |
| DOCOMO | We prefer Option 1 for flexible scheduling while configuring HP CG with short periodicity for e.g., TSN traffic. |

### 2nd Round

Summary for the 1st round

**Proposal 3.1-1: When *lch-BasedPrioritization* is not configured and PHY is configured with two L1 priorities, down-select from following two options:**

* **Option 1: RAN1 confirms RAN2’s working assumption that DG always overrides CG.**
* **Option 2: RAN1 confirms RAN2’s working assumption that DG always overrides CG for the case that the DG and CG has the same L1 priority and the case that the DG has higher L1 priority than the CG.**
  + **UE does not expect to receive DG PUSCH with priority index 0 if it overlaps with CG PUSCH with priority index 1 when *lch-BasedPrioritization* is not configured and PHY is configured with two L1 priorities.**

Companies’ preference on the two options for Proposal 3.1-1 is added as below:

* Option 1 is supported by HW/HiSi, OPPO, Samsung, vivo, Ericsson, ZTE, DCM
* Option 2 is supported by CATT, OPPO, Nokia/NSB (prefer in principle, not sure for the sub-bullet), Samsung, vivo, QC, Intel, ZTE

As already discussed in several meetings, and many companies share the view that the undesirable cases can be handled by proper scheduling or configuration. I think no one object to confirm RAN2’s working assumption for the case that the DG and CG has the same L1 priority and the case that the DG has higher L1 priority than the CG. The controversial part is whether to confirm RAN2’WA for the case that the DG has smaller L1 priority than the CG. So, the original Proposal 3.1-1 is split into two proposals i.e., Proposal 3.1-1a and Proposal 3.1-1b.

**Proposal 3.1-1a: When *lch-BasedPrioritization* is not configured and PHY is configured with two L1 priorities, RAN1 confirms RAN2’s working assumption that DG always overrides CG for the case that the DG and CG has the same L1 priority and the case that the DG has higher L1 priority than the CG.**

**Q1: anyone object proposal 3.1-1a?**

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| Company | View |
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**Proposal 3.1-1b: When *lch-BasedPrioritization* is not configured and PHY is configured with two L1 priorities, RAN1 conclude that UE does not expect to receive DG PUSCH with priority index 0 if it overlaps with CG PUSCH with priority index 1.**

**Some additional notes for proposal 3.1-1b, some companies have strong concern to confirm RAN2’s WA for the case that the DG has smaller L1 priority than the CG. Proposal 3.1-1b from my perspective is a good way to move forward, otherwise, we may end like there is no consensus to confirm RAN2’s WA for the case where DG PUSCH with priority index 0 overlaps with CG PUSCH with priority index 1.**

**Q2: anyone object proposal 3.1-1b?**

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| Company | View |
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Based on Ericsson’s comments, following proposal is added to collect companies’ views

**Proposal 3.1-2: When Rel-16 UL skipping is enabled and lch-basedPrioritization is not configured and PHY is configured with two L1 priorities, for a given PHY priority, the same procedure agreed for single PHY priority applies so that MAC generates a PDU for a PUSCH which expected to multiplex with UCI of same priority, except the L1 LP grant that overlaps with a L1 HP PUCCH or a L1 HP PUSCH.**

**Q3: Do you agree with Proposal 3.1-2?**

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| Company | View |
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## 3.2 Discussion on Scenario#3 and #4 with LCH based prioritization

### 3.2.1: 1st Round for Actual PUSCH or Hypothetical PUSCH

For scenario#3 and scenario#4 where the MAC entity is configured with *lch-basedPrioritization*, and there is collision between CG and DG with the same/different L1 priority, and there is also collision between PUCCH and the CG or DG with the same L1 priority, RAN2 made the WAs that the MAC entity does not generate a MAC PDU for a deprioritized uplink grant even when its associated PUSCH is overlapping with PUCCH. The main concern for not confirming the working assumption is that it is likely to increase gNB blind detection probability.

Some companies proposed to not configure the lch-basedPrioritization and UL skipping at the same time [2], [6]. They observed that in current specification of PHY layer multiplexing/prioritization procedure, when UL skipping function is NOT enabled, the selection of PUSCH for UCI multiplexing is performed after PHY receives PDU from MAC. However, when UL skipping function is enabled, physical layer multiplexing/prioritization procedure is based on hypothetical PUSCH, i.e., PHY performs the multiplexing without waiting for MAC’s delivering result.

Some companies observed that in Rel-15, the selection of PUSCH for UCI multiplexing is based on the actual PUSCH which is clarified in the chairman’s notes of RAN1 #97; For Rel-16 without physical layer priority or lch-basePrioritization, the selection of PUSCH for UCI multiplexing is based on the hypothetical PUSCH, aligned with the RAN1 #102-e UL skipping agreement [9].

Some companies think gNB can control blind detection complexity by proper configure the lch-basedPrioritization and UL skipping function, no need to restrict the high-capable gNB [4], [8];

Some companies think that gNB blind detection is still not reduced for some cases even if the two features are not configured simultaneously, e.g., the case with multiple overlapping CG PUSCHs in same/different serving cells, the Case 4 in Annex that no resource overlapping between SR and PUSCH, but the final PUCCH resource after UCI multiplexing overlaps with the PUSCH, given MAC does not use knowledge of UCI multiplexing and not aware of the final PUCCH resource with the SR [4], [8] (with details in following section 3.3).

To have a better understanding, one point needs to be clarified first.

**Question 3.2-1: What is your understanding of PUSCH that selected for physical layer multiplexing/prioritization in Rel-16 specification of TS 38.213 section 9? Based on your selected options, any spec update is necessary?**

* **Option 1: Actual PUSCH that delivered by MAC** 
  + **Any spec update is needed for option 1?**
* **Option 2: Hypothetical PUSCH, that may or may not be delivered by MAC**
  + **Any spec update is needed for option 2?**
* **Option 3: If UL skipping feature is NOT enabled, actual PUSCH; Otherwise, hypothetical PUSCH.** 
  + **Any spec update is needed for option 3?**

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| Company | View |
| HW/HiSi: | Option 1 without spec update.  If any option involving the hypothetical PUSCH would be selected, then it needd to be clarified whether the UCI is dropped or not if no PDU is received. Option 2 and Option 3 would therefore need a spec change. |
| Apple | Option 3 (we provide discussion on that in Section 2 and Section 3 in our contribution R1-2107714). |
| CATT | In principal, we are fine with Option 1.  In addition, for below case, we propose that UE starts the preparation of PUCCH#0 before UE knows there is PDU for PUSCH#0 to ensure UCI successful transmission.    **Moderator’s reply: thanks a lot for the comment. But when UE starts the preparation is UE internal processing procedure, seems no need to define the time.** |
| OPPO | If UL skipping has higher priority than lch-basedPrioritization, then it’s hypothetical PUSCH. Otherwise, it’s actual PUSCH. |
| Nokia/NSB | Option 1 without specs update (agree with HW/HiSi).  Having some hypothetical PUSCH there, would mean that overlapping UCI will be dropped (as it cannot be mapped on the hypothetical PUSCH) |
| Samsung | Option 1.  - Current specification has been same text regardless of UL skipping.  - “PUSCH transmission” means actual transmission. |
| vivo | At this stage, we prefer option 1 and share HW’s views. |
| Qualcomm | In the context of UL skipping, PHY could select a PUSCH that cannot be skipped; UCI will be multiplexed on this PUSCH. If this PUSCH is referred to as hypothetical PUSCH in the proposal, then we support Option 3. |
| Ericsson | First, it should be clarified if the PHY procedure needs to be applied twice when *lch-basedPrioritization* is configured, Rel-16 UL skipping is enabled. See our 5-step description provided in the table for “other issues to discuss”, at the end of section 3.  If PHY procedure is applied twice, then:   * + - * Step 3 uses hypothetical PUSCH (i.e., Option 2);       * Step 5 uses actual PUSCH (i.e., Option 1);   On the other hand, in our view, Rel-16 UL skipping should not be enabled, if *lch-basedPrioritization* is configured. In this case, Step 3 is removed; only Step 5 is applied and it uses actual PUSCH (i.e., Option 1); |
| Intel | We share similar views as HW-HiSi and others, and support Option 1. |
| ZTE | We prefer option 3. If the Rel-16 UL skipping is enabled, under some conditions, the MAC layer shall generate a MAC PDU for the PUSCH with multiplexed UCI anyway. It means the hypothetical PUSCH can be selected. |
| DOCOMO | Option 3. If UL skipping is enabled, PHY selects the hypothetical PUSCH which cannot be skipped |

### 3.2.1: 2nd Round for Actual PUSCH or Hypothetical PUSCH

For Question 3.2-1, companies’ views are summarized below:

**The PUSCH that selected for physical layer multiplexing/prioritization in Rel-16 specification of TS 38.213 section 9 is based on:**

* **Option 1: Actual PUSCH that delivered by MAC**
* **Option 2: Hypothetical PUSCH, that may or may not be delivered by MAC**
* **Option 3: If UL skipping feature is NOT enabled, actual PUSCH; Otherwise, hypothetical PUSCH.**
* Option 1 is supported by HW/HiSi, CATT, Nokia/NSB, Samsung, vivo, Intel.
  + Reason: no spec update is necessary and less remaining issues e.g. handle the PUCCH Tx that is expected to be multiplexed on the hypothetical PUSCH;
* Option 3 is supported by Apple, OPPO, QC, ZTE, DCM
  + Reason: align with the spirit of UL skipping agreement

**In addition, Ericsson suggest to align RAN1 understanding on MAC/PHY procedure in case *lch-basedPrioritization* is configured and Rel-16 UL skipping is enabled. Below please find Ericsson’s understanding and observations/views:**

**Step 1**: MAC takes as input PUSCH resources, SR resources, and information on if the resources overlap;

**Step 2 (MAC, LCH based prioritization)**: MAC decisions on SR, CG, DG, for both HP and LP if exist. The CG and DG may be allowed a PDU (prioritized grants), or not (deprioritized grants).

**Step 3 (PHY)**: As an intermediary step, PHY runs UL skipping related procedure in 38.213 based on actually delivered SR (positive or negative), and prioritized grants. Exclude deprioritized empty grants in this step. The procedure selects the PUSCH(s), among the prioritized grants, that are expected to have UCI multiplexing.

**Step 4 (MAC, UL skipping related)**: For prioritized grants that are expected to have UCI multiplexing, MAC generates a PDU even if there is no data in the buffer.

* For prioritized grants that are not expected to have UCI multiplexing, MAC may or may not generate a PDU depending on buffer status.

**Step 5 (PHY)**. PHY performs intra-UE multiplexing/prioritization procedure in 38.213, based on actually delivered SR, PDU for CG, PDU for DG, from MAC.

Ericsson provides following views: As discussed in our contribution, the complicated 5-step procedure above does not accomplish the goal of minimizing gNB blind detection of PUSCH-UCI multiplexing. Thus we proposed: “When lch-basedPrioritization is configured, Rel-16 UL skipping is never enabled in Rel-16.” We’d like to see if this proposal can be accepted. If this cannot be accepted, then

a) PHY performs multiplexing/prioritization procedure twice (Step 3 and Step 5), and Question 3.2-1 should be answered separately, one answer for Step 2 (e.g., use hypothetical PUSCH), another answer for Step 5 (e.g., use actual PUSCH).

b) Proposal 3.2-2 need to be revisited, e.g., for a PUSCH expected to have UCI multiplexing, MAC entity cannot deprioritize this PUSCH, and MAC has to generate a PDU for it.

c) Question 3.2-3 need to be revisited as well, e.g., if PUSCH#0 is the one expected to have UCI multiplexing, then MAC is not allowed to skip the PDU for PUSCH#0. Instead, MAC has to prioritize PUSCH#0, deprioritize PUSCH#1, deliver a PDU for PUSCH#0 only, and PUSCH#0 and PUCCH#0 are multiplexed for transmission.

d) Proposal 3.3-1 should be revisited as well, e.g., a PUSCH expected to have UCI multiplexing cannot be deprioritized by the SR.

Therefore, following questions are listed:

**Q1: Do you agree with Ericsson’s views on above 5-step MAC/PHY procedure in case *lch-basedPrioritization* is configured and Rel-16 UL skipping is enabled?**

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| Company | View |
| Nokia/NSB | Do not agree, as based on the RAN2 feedback of the MAC not being aware of the UCI multiplexing on PUCCH, we wonder how step 3 (PHY prioritization) could be done before step 4 (MAC UL skipping decision) |
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**Q2: Do you agree following proposal?**

**Proposal: When lch-basedPrioritization is configured, Rel-16 UL skipping is never enabled in Rel-16**

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| Company | View |
| Nokia/NSB | Disagree. There is no need for such limitation impacting URLLC performance (no UL skipping increases UL interference / network impact, no LCH based prioritization impacting single UE URLLC performance). |
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### 3.2.2: 1st Round for confirming RAN2’s WA for data vs. data with LCH based prioritization

As observed, even if the lch-basedPrioritization and UL skipping are not configured at the same time, when lch-basedPrioritization is configured without configuring the UL skipping, the BD at the gNB side still cannot be reduced. If gNB would like to reduce the BD, it should make proper scheduling, trying to avoid the undesirable collision cases. From moderator perspective, the gNB’s BD concern for not confirming RAN2’s working assumption is not really there. Hence, it is proposed to confirm RAN2’s WA.

**Proposal 3.2-2: RAN1 confirms RAN2’s following WA:**

* **Working assumption: The MAC entity does not generate a MAC PDU for a deprioritized uplink grant even when its associated PUSCH is overlapping with PUCCH.**

**Question 3.2-2: Do you agree above proposal?**

* **If you do not agree, please provide your reasons and compromised proposal is highly appreciated.**

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| Company | View |
| HW/HiSi | Agree |
| CATT | We can confirm RAN2’s WA. |
| OPPO | We agree to confirm RAN2’s WA. If there is some concern on gNB’s blind decoding, the following compromised proposal which protect HP data/UCI as well as reducing gNB’s blind decoding to some acceptable level can be considered:   * ***If the PHY priority of the PUSCH with UCI overlapping is higher or equal to the PHY priority of the PUSCH without UCI overlapping, then UL skipping is prioritized over lch-basedPrioritization;*** * ***Otherwise, lch-basedPrioritization is prioritized over UL skipping.*** |
| Nokia/NSB | Agree to confirm the RAN2 WA.  It would also be good to inform RAN2, that this WA should be generically applicable including operation with and without LCH based prioritization as well as one & two UL PHY priorities. |
| Samsung | Agree |
| vivo | Agree |
| Qualcomm | We do not agree. When UL skipping is configured, PHY could select a PUSCH for UCI multiplexing first; this PUSCH should not be skipped by MAC. This is completely aligned with the updated Rel. 15 UL skipping discussions.  Before confirming the RAN2 WA, we think that RAN1 should discuss how the proposed behavior for Rel. 16 is different from the original behavior of Rel. 15 that later was concluded to be broken? Is it correct to assume that by confirming the WA, the Rel. 16 behavior would later be announced as broken by RAN1? |
| Ericsson | Do not confirm RAN2’s WA as is. Modified proposal:  *If Rel-16 UL skipping cannot be enabled when lch-basedPrioritization is configured, RAN1 confirm RAN2’s WA that “MAC entity does not generate a MAC PDU for a deprioritized uplink grant even when its associated PUSCH is overlapping with PUCCH.” Othewise, RAN2 WA cannot be confirmed.*  It is true that when {*lch-basedPrioritization* is configured, Rel-16 UL skipping disabled}, gNB blind decoding cannot be minimized, and we are fine to confirm RAN2 WA for this case.  However, when {*lch-basedPrioritization* is configured, Rel-16 UL skipping enabled}, the UL skipping procedure is applied to minimize gNB blind decoding. In this case, procedures are to be defined to ensure that MAC delivers PDU for those PUSCH that are expected to have UCI multiplexing, similar to the agreements made under Rel-15 maintenance. Then RAN2 WA contradicts with the design goal of Rel-16 UL skipping procedure, and cannot be accepted. |
| Intel | Agree. |
| ZTE | We tend to confirm RAN2’s working assumption if the overlapped PUSCH and PUCCH are both low priority in physical layer.  However, When the overlapped PUSCH and PUCCH are high priority in physical, if there is no available data to be multiplexed in the PUSCH and the MAC entity does not generate MAC PDU for the HP PUSCH, it may lead to the HP PUCCH is dropped as discussed in question 3.2-2. It is not acceptable to the URLLC service. So we think the MAC entity should generated the MAC PDU for the HP PUSCH anyway if it overlaps with PUCCH.  **Moderator’s reply: if the PUSCH for MUX is the actual PUSCH, then HP PUCCH will be transmitted on PUCCH, it will not be dropped. Even if it is Hypothetical PUSCH, option 2 in Question 3.2-3 will not drop the PUCCH.**  The details can be found in our contribution R1-2106731. |
| DOCOMO | We don’t agree with the proposal and share the same view with Qualcomm/Ericsson |

### 3.2.2: 2nd Round for confirming RAN2’s WA for data vs. data with LCH based prioritization

Companies views for Proposal 3.2-2 is summarized below.

**Proposal 3.2-2: RAN1 confirms RAN2’s following WA:**

* **Working assumption: The MAC entity does not generate a MAC PDU for a deprioritized uplink grant even when its associated PUSCH is overlapping with PUCCH.**
* **Confirm the WA: HW/HiSi, CATT, OPPO, Nokia/NSB, Samsung, vivo, ZTE**
* **Do not confirm the WA: QC, Ericsson, DCM**

In addition, Ericsson proposed one modified proposal, I would like to collect companies’ views.

**Proposal 3.2-2a: If Rel-16 UL skipping is NOT enabled when lch-basedPrioritization is configured, RAN1 confirm RAN2’s WA that “MAC entity does not generate a MAC PDU for a deprioritized uplink grant even when its associated PUSCH is overlapping with PUCCH.” Otherwise, RAN2 WA cannot be confirmed.**

**Q: Can you accept above proposal 3.2-2a to move forward?**

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| --- | --- |
| Company | View |
| Nokia/NSB | Sorry, but we cannot agree to this. Please note, that to our understanding UL skipping is still automatically enabled for CG PUSCH.  And what do we then do if it is configured?? |

### 3.2.3: 1st Round for PUCCH handling

Some companies discussed on how to handle the PUCCH that overlaps with a PUSCH of the same L1 priority if the PUSCH is not delivered by MAC. From moderator’s understanding, depending on the discussion results of **Question 3.2-1**, if the selected PUSCH for UCI multiplexing is the actual PUSCH, then we do not need to discuss this issue. On the other hand, if for some cases, the selected PUSCH for UCI multiplexing is the hypothetical PUSCH, we need to discuss this issue. Following options proposed in email summary R1-2106025 in the last meeting can be a good starting point:

**Question 3.2-3: In case LCH based prioritization is configured, for the case that a PUSCH i.e., PUSCH#0 overlaps with a PUCCH#0 with the same L1 priority on a same or different serving cell, a PUSCH i.e., PUSCH#1 overlaps with the PUSCH#0 on one serving cell with the same or different priorities and the PUSCH#1 does not overlap with the PUCCH#0, and if the PUSCH#0 is NOT delivered by MAC, which option do you prefer to handle the PUCCH#0?**

* **Option 1: Drop the PUCCH#0.**
* **Option 2: When timeline condition is met,** 
  + **If there is no other remaining PUSCH(s) on any serving cell(s) overlapping with the PUCCH#0 of the same L1 priority, the UCI is transmitted on the PUCCH.**
  + **Otherwise, the PUCCH#0 should be dropped.**

**Note: above timeline condition is ensured by gNB, i.e. the ending symbol of UL grant for the PUSCH#1 should be at least**  **symbols before the first symbol of the earliest PUCCH#0 or PUSCH#0.**

* **Option 3: Transmit PUCCH#0 and the UE does not expect that there is other remaining PUSCH(s) on any serving cell(s) overlapping with the PUCCH#0 of the same L1 priority.**
* **Option 4: Other options?**

|  |  |
| --- | --- |
| Company | View |
| HW/HiSi | Our preference is Option 4 as given below, this option does not need a spec change.   * If there is no remaining PUSCH(s) on any serving cell overlapping with PUCCH#0 of the same priority, the UCI is transmitted on the PUCCH * Otherwise, the UCI is multiplexed in the PUSCH according to existing rules |
| Apple | We are fine with Option 2 and Option 1. |
| CATT | We are fine with Option 3.  For Option 1, dropping PUCCH#0 isn’t preferred because UCI dropping increases DL transmission latency.  For Option2, the PUCCH#0 will still be dropped if other remaining PUSCH(s) on any serving cell(s) overlapping with the PUCCH#0 of the same L1 priority.  For Option 3, some scheduling restrictions on gNB for PUSCH scheduling are introduced, the while PUCCH#0 dropping can be avoided.  For Option4, although the PUCCH#0 can be transmitted in other remaining PUSCH(s) on any serving cell(s) overlapping with the PUCCH#0 of the same L1 priority, it potentially increases the blind detection efforts at the gNB side. |
| OPPO | Since this discussion has some dependency on the above questions, we prefer to postpone the discussion until companies reach common understanding on Question 3.2-1. |
| Nokia/NSB | Option 2 is preferred:   * We agree with OPPO that there is a relation to Question 3.2-1. As in case we go for actual PUSCH there, to my understanding Option 2 and Option 4 basically become the same. * Compared to Option 1, there is at least the chance for the gNB to receive the UCI for Option 2. * Compared to Option 3, there is no PUSCH scheduling restriction (impacting UL throughput) for Option 2. * Compared to Option 4,   + We agree with OPPO that there is a relation to Question 3.2-1. As in case we go for actual PUSCH there, to my understanding Option 2 and Option 4 basically become the same in the end.   + If we go for hypothetical PUSCH, Option 2 will simplify the gNB implementation in the number of UCI hypothesis in terms of PUSCH RE mapping . |
| Samsung | It should be discussed after making common understanding on Question 3.2-1 |
| vivo | We are fine with option 2 and option 3. |
| Qualcomm | Option 4: PUSCH#0 cannot be skipped by MAC since it is the PUSCH chosen by PHY to carry UCI. |
| Ericsson | First, the condition should be clarified if Rel-16 UL skipping procedure is applied when *lch-basedPrioritization* is configured.  If UL skipping procedure is not applied, we prefer Option 4’, i.e., Option 4 by Huawei is paraphrased as a general rule:  Option 4’: When a PUSCH does not receive a PDU from MAC, then this PUSCH is removed before performing PHY multiplexing/prioritization procedure.  Applying the general rule to the example scenario, then PUSCH#0 is removed. Other channels (PUCCH#0, PUSCH#1, PUCCH#1) go through the existing procedure without change.  If UL skipping procedure is applied, then Question 3.2-3 description texts are not correct. Since PUSCH#0 is expected to be multiplexed with PUCCH#0, then: MAC has to prioritize PUSCH#0, deprioritize PUSCH#1, deliver a PDU for PUSCH#0 only. |
| Intel | We prefer Option 2 as it allows transmission of PUCCH in some cases, aiming to strike a balance between Options 1 and 3. |
| ZTE | We prefer option 2 since it can ensure the PUCCH transmission as possible. |
| DOCOMO | When UL skipping is enabled, Option 4 as Qualcomm. Otherwise, Option 4 as Huawei |

### 3.2.3: Summary for PUCCH handling

**In case LCH based prioritization is configured, for the case that a PUSCH i.e., PUSCH#0 overlaps with a PUCCH#0 with the same L1 priority on a same or different serving cell, a PUSCH i.e., PUSCH#1 overlaps with the PUSCH#0 on one serving cell with the same or different priorities and the PUSCH#1 does not overlap with the PUCCH#0, and if the PUSCH#0 is NOT delivered by MAC,**

* **Option 1: Drop the PUCCH#0.**
* **Option 2: When timeline condition is met,** 
  + **If there is no other remaining PUSCH(s) on any serving cell(s) overlapping with the PUCCH#0 of the same L1 priority, the UCI is transmitted on the PUCCH.**
  + **Otherwise, the PUCCH#0 should be dropped.**

**Note: above timeline condition is ensured by gNB, i.e. the ending symbol of UL grant for the PUSCH#1 should be at least**  **symbols before the first symbol of the earliest PUCCH#0 or PUSCH#0.**

* **Option 3: Transmit PUCCH#0 and the UE does not expect that there is other remaining PUSCH(s) on any serving cell(s) overlapping with the PUCCH#0 of the same L1 priority.**
* **Option 4:** 
  + **If there is no remaining PUSCH(s) on any serving cell overlapping with PUCCH#0 of the same priority, the UCI is transmitted on the PUCCH**
  + **Otherwise, the UCI is multiplexed in the PUSCH according to existing rules**
* **Option 5: PUSCH#0 cannot be skipped by MAC since it is the PUSCH chosen by PHY to carry UCI.**

Companies views are summarized below.

* **Option 1 is supported by Apple**
* **Option 2 is supported by Apple, Nokia/NSB, vivo, Intel, ZTE**
* **Option 3 is supported by CATT, vivo**
* **Option 4 is supported by HW/HiSi, (Ericsson and DCM if UL skipping procedure is not enabled)**
* **Option 5 is supported by QC, (Ericsson and DCM if UL skipping procedure is enabled)**

**As also some companies commented that this proposal can be discussed after the decision made for section 3.2.1.**

## 3.3 Collision between SR and Data

### 1st Round

[3], [4], [8], [9], [10] observed that the gNB’s blind detection is unavoidable and cannot be reduced for some cases given that MAC does not use knowledge of UCI multiplexing when MAC executes LCH based prioritization and decides when to transmit SR. In particular,

* [8] observed that for all the identified cases in terms of PUSCH and SR in the RAN1/RAN2 LSs, requiring MAC to deliver a PDU for an UL grant overlapping with a PUCCH carrying AN/CSI also for LCH based prioritization operation is not reducing the maximum number of transmission hypothesis the gNB needs to be accounting for (as the maximum is determined by case 4 where there is not overlap of PUCCH with AN/CSI and PUSCH). Case 4 is also the most complex in terms of gNB operation, as two different RE mapping hypothesis of UL-SCH on PUSCH need to be considered. There are four possibilities:



**Figure 1: Case 4**

* + (i) PUCCH carrying AN/CSI only on the green resource (no SR, PUSCH skipped since no any overlapping PUCCH with PUSCH)
  + (ii) PUCCH with SR/AN/CSI on the beige resource (SR delivered, PUSCH not delivered)
  + (iii) PUCCH carrying AN/CSI (on the green resource) and PUSCH without UCI if PUSCH is delivered but SR is not delivered
  + (iv) PUSCH carrying AN/CSI if both PUSCH and SR have been delivered since MAC is not aware of the final PUCCH resource with the SR
* [9] observed that such uncertainty does not incur complexity on the UE side, as the UE PHY performs all the processing with information on SR status from MAC, the PHY is never tasked to track all the alternative outcomes.

Based on the contribution, there is no one proposed to NOT to support the intended UE behavior mentioned in RAN2’s LS R1-2100026 on overlapped data and SR are of equal L1 priority. Therefore, following is proposed:

**Proposal 3.3-1: RAN1 confirms that the following intended UE behavior can be supported:**

* **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.**

**Question 3.3-1: Do you agree above proposal?**

* **If you do not agree, please provide your reasons and compromised proposal is highly appreciated.**

|  |  |
| --- | --- |
| Company | View |
| HW/HiSi | Agree |
| CATT | We are fine with FL proposal. |
| Nokia/NSB | Agree / support |
| Samsung | Agree |
| vivo | Agree |
| Qualcomm | We do not agree. Whether PUSCH can be skipped or not is dependent on whether it should carry UCI or not.  In response to the argument about ambiguity at the gNB due to SR, a simple solution is to always assume a positive state for SR when determining a UCI carrying PUSCH by PHY. Of course, the actual state of SR could then be positive or negative. |
| Ericsson | First, the condition should be clarified if Rel-16 UL skipping procedure is applied when *lch-basedPrioritization* is configured.  If UL skipping procedure is not applied, then proposal above is fine.  If UL skipping procedure is applied, then proposal above is incorrect. If a PUSCH is expected to have UCI multiplexed, then MAC cannot prioritize the SR. Instead, the PUSCH should be prioritized and MAC provides a PDU for it. The SR should be deprioritized. |
| Intel | Agree. |
| ZTE | If RAN1 does not confirm the intended UE behavior, it may violate the RAN2 principle. However, if RAN1 confirm the intended UE behavior, it may violate the RAN1 agreement on UL skipping in some cases, for example, when the final PUCCH overlaps with the PUSCH. To avoid such violation in RAN1 and RAN2, maybe we can make the following updates.   * **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 in case there is no UCI to be multiplexed in the PUCH; MAC shall instruct PHY for SR transmission and generate the MAC PDU for the PUSCH in case there is UCI to be multiplexed in the PUSCH.** |
| DOCOMO | We have the same understanding as Ericsson |

In addition, [9] discussed that in case LCH-based prioritization is configured, since gNB cannot control the SR status at a UE, it may cause much complexity at the gNB side. One example is shown in Figure 2 where the PUCCH resource for HARQ-ACK, SR1 of SR configuration#1 and SR2 of SR configuration#2 are all configured with PUCCH format 1. Depending on SR status for the two SR configurations, 4 cases can arise:

1. Both SR1 and SR2 are negative, HARQ-ACK is sent on PUCCH-0
2. SR1 is positive and SR2 is negative, HARQ-ACK is sent on PUCCH-1
3. SR2 is positive and SR1 is negative, HARQ-ACK is sent on PUCCH-2
4. Both SR1 and SR2 are positive, HARQ-ACK is sent on PUCCH-1, and SR2 is sent over PUCCH-2.

Timeline

Description automatically generated

Figure 2 Resource selection for PUCCH format 1 from [9]

Therefore, [9] proposed following to avoid the uncertainty created by overlapping PUCCH resources for HARQ-ACK/SR at PUCCH format 1:

**Proposal 3.3-2: To mitigate the uncertainty in UCI multiplexing, the occurrence of HARQ-ACK PUCCH resource at PUCCH format 1 and SR PUCCH resource at PUCCH format 1 should be avoided. One of the following alternatives is selected:**

* **Alt. 1: HARQ-ACK PUCCH resource and SR PUCCH resource cannot be both configured with PUCCH format 1**
* **Alt. 2: If HARQ-ACK PUCCH resource and SR PUCCH resource overlap, then they won’t be both at PUCCH format 1.**
* **Alt. 3: SR is assumed to be negative for UCI multiplexing.**
* **Alt. 4: SR is assumed to be positive for UCI multiplexing.**

Above issue was discussed in the last meeting, and there were views that the proposal is not necessary since the configuration and UCI multiplexing is under gNB’s control. While there were also views that this proposal is needed and beneficial, more time should be given for companies to check. To proceed, following question is asked:

**Question 3.3-2: What is your views on above proposal?**

* **Whether it is needed and if it is needed, which is your preferred Alternative?**

|  |  |
| --- | --- |
| Company | View |
| HW/HiSi | Our view is that the situation can be solved by gNB implementation. The proposal does not seem to be needed. |
| Apple | Maybe adding one point to the point FL captured on our observation: for the case with UL skipping, “(For scenarios treated in Section 2), note the uncertainty in the resource Z generation does not incur complexity on the UE side, as the UE PHY performs all the processing with information on SR status from MAC, the UE PHY is never tasked to track all the alternative outcomes, and the gNB takes all the burden to handle all possible outcomes. The situation changes drastically for the discussion in Section 3 (with UL skipping cases)”. For the case without UL skipping, it is indeed a gNB implementation issue, for the case with UL skipping, it can be a nightmare for UE implementation: as all the possible combinations need to be covered by UE implementation. Still with the example given above, then the UE PHY needs to track all the possible outcomes for UCI multiplexing, by assuming SR statuses for different SR resources. We don’t think that is reasonable to given such a job to UE when the overall design goal is to reduce gNB blind detection complexity.  **Moderator’s question: thanks a lot for your views. Would you explain what is the difference between UL skipping and non UL skipping case? The UL skipping agreements made for PUCCH carrying HARQ-ACK/CSI overlapping with the PUSCH, and LCH based prioritization is NOT configured, single PHY priority.**  If you look at the Alt. 1 to Alt. 4, they are just various ways to avoid tracking multiple hypotheses on SR statuses on the UE side. We would be fine with any of them.  In Section 5 of R1-2107714, we also provide one alternative design where the LCH based prioritization is split into data/data prioritization and data/SR prioritization, as long as data/SR prioritization is not configured, then actual SR statuses can be generated by UE MAC, so the problem to track multiple hypotheses due to SR statuses is avoided. Note RAN2 needs to change its specification (currently once LCH based prioritization is configured, it applies for data/data and data/SR).  **Moderator’s question: thanks a lot for your suggestion. My thinking is RAN2 should be the better place to discuss the whether and how to split the feature of LCH based prioritization into data and data and data and SR.** |
| CATT | In our understanding, this behavior of the occurrence of HARQ-ACK PUCCH resource at PUCCH format 1 and SR PUCCH resource at PUCCH format 1already exists in Rel-15 and it is not necessary to make any enhancement during Rel-16 maintenance. The UE behavior of maintaining Rel-15 will still work. In the case of combining with LCH, too much blind detection can be avoided by gNB scheduling and it belongs to gNB implementation. It should be noticed, no matter what gNB configuration or implementation is used, it already supported at the UE side in current specification.  Regarding the behavior for the overlapping of SR PUCCH and HARQ-ACK PUCCH, to our understanding, if there is no P-SR at the latest preparation time of A/N, UE will prepare for the A/N transmission according to N-SR, which then gives a guideline for MAC to decide the deadline to deliver P-SR to PHY.  So we think Proposal 3.3-2 isn’t necessary. |
| OPPO | In our understanding, the PHY UCI multiplexing procedure is performed based on actual SR status even with UL skipping. Seems this proposal is unnecessary. |
| Nokia/NSB | Alt. 1 and Alt. 2 can be done by gNB implementation / configuration without the need to specify that solution specifically. Thus, if we discuss any solution to the problem to be specified, then we should focus on Alt. 3 and Alt. 4 only (as the other can be done through gNB implementation). |
| Samsung | Not necessary  1) This can be controlled by gNB implementation.  2) Still don’t understand what this issue should be discussed in Rel-16 eURLLC. It’s not related to design of URLLC, even PUSCH skipping. |
| vivo | We agree with others that this issue can be avoided by proper configuration if gNB has BD concern. |
| Qualcomm | If this proposal is related to how to remove the UCI multiplexing ambiguity in the context of UL skipping as is explained by the text above proposal 3.3-1, we then support Alt3 or Alt4. |
| Ericsson | In our understanding, the example shown in Figure 2 already existed in Rel-15. It is not caused by LCH prioritization, since there is no SR-vs-PUSCH overlap to apply LCH prioritization.  We don’t think Proposal 3.3-2 need to be handled. |
| Intel | We do not see the need to address anything by specifications for this. Such configurations are entirely under gNB control, can occur even in REl-15, and can be managed/avoided with proper configuration depending on gNB capability and choice. |
| ZTE | We believe this issue can be resolved by the network implementation. This proposal is not necessary from our view. |
| DOCOMO | We share the view with Nokia that we should focus on Alt.3/4 |

### 2nd Round

**Proposal 3.3-1: RAN1 confirms that the following intended UE behavior can be supported:**

* **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.**

For proposal 3.3-1, companies’ views are summarized below.

* Support by: HW/HiSi, CATT, Nokia/NSB, Samsung, vivo, (Ericsson and DCM if UL skipping is NOT enabled), Intel,
* Do not support by QC, (Ericsson and DCM if UL skipping is enabled)

In addition, ZTE proposed on compromised proposal, I would like to check companies’ views on whether it is acceptable to move forward.

**Proposal 3.3-1a: 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 in case there is no UCI to be multiplexed in the PUSCH; MAC shall instruct PHY for SR transmission and generate the MAC PDU for the PUSCH in case there is UCI to be multiplexed in the PUSCH.**

|  |  |
| --- | --- |
| Company | View |
|  |  |

**Proposal 3.3-2: To mitigate the uncertainty in UCI multiplexing, the occurrence of HARQ-ACK PUCCH resource at PUCCH format 1 and SR PUCCH resource at PUCCH format 1 should be avoided. One of the following alternatives is selected:**

* **Alt. 1: HARQ-ACK PUCCH resource and SR PUCCH resource cannot be both configured with PUCCH format 1**
* **Alt. 2: If HARQ-ACK PUCCH resource and SR PUCCH resource overlap, then they won’t be both at PUCCH format 1.**
* **Alt. 3: SR is assumed to be negative for UCI multiplexing.**
* **Alt. 4: SR is assumed to be positive for UCI multiplexing.**

For proposal 3.3-2, companies’ views are summarized below.

* The proposal is not necessary: HW/HiSi, CATT, OPPO, Nokia/NSB?, Samsung, vivo, Ericsson, Intel, ZTE, DCM?
* The proposal is necessary: Apple, QC (prefer Alt.3 or Alt.4)

Since majority companies do not see the necessity, there is no further action for this proposal.

# References

1. [R1-2106487](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106487.zip) Remaining issues on UL prioritization and UL skipping Huawei, HiSilicon
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3. [R1-2106731](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106731.zip) Remaining issues on intra-UE multiplexing in Rel-16 URLLC ZTE
4. [R1-2106861](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106861.zip) Discussion on PUSCH skipping for URLLC Samsung
5. [R1-2106930](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106930.zip) Discussion on overlapping between CG PUSCH and DG PUSCH CATT
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10. [R1-2107984](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107984.zip) Maintenance on intra-UE prioritization and multiplexing vivo

Annex 1: RAN1 use cases for SR colliding PUSCH



Case 2-1: the final PUCCH resource after UCI multiplexing does not overlap with PUSCH



Case 2-2: the final PUCCH resource after UCI multiplexing overlaps with PUSCH



Case 3: other UCI(s) overlaps with a PUSCH, SR overlaps with the PUSCH, SR does not overlap with other UCI(s)



Case 4: other UCI(s) overlaps with SR of an equal L1 priority, but SR does not overlap with the PUSCH of an equal L1 priority