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

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

Source: Moderator (vivo)

Title: Summary of [104-e-NR-7.1CRs-01] Discussion on UL skipping for PUSCH for Rel-16

Agenda Item: 7.1

Document for: Discussion and Decision

# Introduction

The document provides a summary for the email discussion thread [104-e-NR-7.1CRs-01] Discussion on UL skipping for PUSCH for Rel-16 only. **Note that the deadline for the discussion for the email thread and the corresponding TP is set to be Feb. 5.**

[104-e-NR-7.1CRs-01] Discussion on UL skipping for PUSCH – Xiaohang (vivo) by Feb 5

* For Rel-16 only

In order to make use of the email thread for discussion efficiently, two check points are planned as follows.

* 1st check point: 1/29 (UTC). First round discussion in the 1st week to focus on the important issues and target at reaching the first set of agreements. **Please provide the comments for the first-round discussion by 1/28 UTC 1:59 am.**
* 2nd round discussion: 2/4 (UTC). Second round discussion in the 2nd week to further discuss the remaining issues.

# Email discussion outcomes

# Discussions on PUSCH overlapping with UCI

In RAN1 #103-e meeting, there were some discussions on DG/CG PUSCH overlapping with PUCCH. Following conclusions were made for DG/CG PUSCH overlapping with UCI.

**Agreement:**

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**

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 GG 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:**

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.

In this meeting, the remaining issues for UL skipping for PUSCH are discussed in the contributions provided in [1][2][3][4][5][6][7][8][9].

## Issue 1: Remaining issues for Case 1-6 and Case 1-5

### Remaining issues for Case 1-6

* **UE behavior for Case 1-6**

[1][2][3][4][5][6][7][8][9] discussed the UE behaviour for Case 1-6.

Regarding the option 3 and option 4 from the working assumptions, the views based on the contributions are quite converged. Option 3 provides benefit for ensuring UCI transmission. It is also mentioned that the DG PUSCH overriding CG PUSCH is deterministic behaviour such that the CG PUSCH would be considered as unavailable for UCI multiplexing. Therefore, option 3 is proposed to be adopted for Case 1-6.

On the other hand, for Case 1-6 in CA case, when CG PUSCH and DG PUSCH are on the same serving cell, it is the same as Case 1-6 in non-CA case where the CG PUSCH is overridden by the DG PUSCH. When CG PUSCH and DG PUSCH are on the different serving cells, they can be transmitted separately such that the handling is the same as Case 1-2. So, the unified solution for Case 1-6 for non-CA and CA cases can be adopted.

In addition, the potential conditions for Case 1-6 for UCI transmission are discussed in [1][2][3] [7]. At least when the time condition is met, option 3 is proposed to be adopted for Case 1-6. So, following proposal is proposed in principle and the detailed time condition will be further discussed.

**Proposal 1: In Rel-16, at least when time condition is met, support option 3 in principle for Case 1-6 for non-CA and CA cases, 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.**

* **Further discuss the time condition and whether there is additional behaviour if the condition is not met in proposal 2.**
1. **Please share your views on the above proposal.**

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| **Company** | **Comment** |
| Ericsson | We support Proposal 1. |
| Apple | We agree with the intention of Proposal 1, but feel that the formulation should be improved. The reason is that option 3 is the description of the behavior for a very specific non-CA case as shown in the figure, and it is not a generic description of the solution that is also suitable for the case with CA. The principle of Option 3 can be extended to cover CA, which is that in case CG and DG overlap on the same serving cell, CG is excluded from the UCI multiplexing determination.Also note that case 1-6 is when DG PUSCH and CG PUSCH are overlapping on a serving cell. Even though in case of CA there can be DG PUSCH and CG PUSCH on different serving cells overlapping, it is not the focus of case 1-6. (But we agree that case can be handled in the same way as case 1-2.)To give an example of what we consider as a generic description of the solution, our proposal is copied as below. This by no means suggests that we have/need to follow the formulation here. But it shows what our understanding of the generalized Option 3 is, and it would be good to understand if companies share the same understanding.“Proposal 2: In Rel.16, 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, for both CA and non-CA cases, in case a CG PUSCH overlaps with a PUCCH and a DG PUSCH overlaps with the CG PUSCH on the same CC and does not overlap with the PUCCH, UCI multiplexing decision is made following the UCI multiplexing rules without considering the CG PUSCH. That is, UCI is not to be multiplexed on the CG PUSCH. If the decision is that UCI is to be multiplexed on a PUSCH, MAC generates MAC PDU for this PUSCH and delivers the MAC PDU(s) to PHY and the UCI is multiplexed on this PUSCH.” |

* **Time condition for Case 1-6**

For Case 1-6, [1][2][3] [7] discussed the potential timeline conditions for Case 1-6 for UCI transmission.



**Figure 1. Potential timeline issue for Case 1-6**

An example is shown in the figure. When the UL grant for DG PUSCH comes after the time point for determining UCI multiplexing on CG PUSCH based on the timeline in TS 38.213 Clause 9.2.5, UE may have already decided and started preparation for multiplexing the UCI on the CG PUSCH. According to current specification (no Rel-16 intra-UE prioritization), the DG PUSCH will override the overlapping CG PUSCH. It is quite challenging for the UE that it may not have sufficient time to revert previous decision and re-process PUCCH to transmit the UCI.

It should be noted that in Rel-15 there is the similar timeline issue in Case 1-6. The timeline issue is not specific for Rel-16 DG/CG PUSCH skipping. It would be good to clarify the timeline condition for Case 1-6 in Rel-16 to ensure no ambiguity for UCI transmission.

The timeline conditions for Case 1-6 should include:

* **Condition 1**: the ending symbol of UL grant for DG PUSCH is at least 𝑁2 symbols before the first symbol of the overlapping CG PUSCH (i.e. Rel-15 DG overriding CG timeline).
	+ Note the condition 1 should be satisfied otherwise it is an error case.
* **Condition 2**: the DL grant for PUCCH (if any) needs to receive before $T\_{proc,2}^{mux}$ (multiplexing timeline) before the first symbol of *S*0 of the earliest PUCCH or PUSCH (i.e. fulfills the UCI multiplexing timeline conditions in 38.213, i.e. Rel-15 multiplexing timeline $T\_{proc,i}^{mux}$).
	+ Note the condition 2 should be satisfied otherwise it is an error case.
* **Condition 3**: the ending symbol of UL grant for DG PUSCH is at least $T\_{proc,i}^{mux}$ symbols before the first symbol of the earliest PUCCH or PUSCH.
	+ That means the UL grant for DG PUSCH should satisfy the UCI multiplexing timeline conditions.

From UE perspective, if the above condition 3 are not fulfilled, UE may not have sufficient time to revert previous decision and re-process PUCCH to transmit the UCI. UE may have to drop both the CG PUSCH and UCI.

From network perspective, it may be reasonable for gNB to avoid scheduling a DG PUSCH that override a CG PUSCH but would result in UCI dropping.

In this sense, the timeline requirements for Case 1-6 should be satisfied. Otherwise, it can be deemed as error case.

**Proposal 2: In Rel-16, for 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,**

* + **UE does not expect the ending symbol of UL grant for the DG PUSCH is not at least** $T\_{proc,i}^{mux}$ **symbols before the first symbol of the earliest PUCCH or PUSCH.**
		- **Note:** $T\_{proc,i}^{mux}$ **is as specified in Clause 9.2.5 of TS 38.213.**
1. **Please share your views on the above proposal.**

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| **Company** | **Comment** |
| Ericsson | In our understanding there are 2 timelines getting involved in this scenario. One is DG PUSCH override CG, which has been defined in 38.214; the other one is PUCCH timeline, that sufficient time should be ensured to send UCI on PUCCH. |
| Apple | We support the proposal in principle. We also think SP-CSI PUSCH should be treated in the same way as CG PUSCH, so we propose to add SP-CSI PUSCH into the proposal for completeness (i.e. replace “CG PUSCH” with “CG PUSCH or SP-CSI PUSCH”). |

### Remaining issues for Case 1-5

[2] discussed the potential behavior for case 1-5 where DG PUSCH and CG PUSCH are non-overlapping, both DG/CG PUSCH are overlapping with PUCCH, and DG PUSCH is later than CG PUSCH.

For Case 1-5, following conclusion was made.

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| **Conclusion**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 GG 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
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Since there was no explicit time relationship of DG PUSCH and CG PUSCH for Case 1-5, it would be better to clarify whether there is additional behavior for Case 1-5 with different time relationship of DG PUSCH and CG PUSCH.

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| **Case 1-5a** | **Case 1-5b** |

* **Case 1-5a:** DG PUSCH and CG PUSCH are non-overlapping, both DG/CG PUSCH are overlapping with PUCCH, and DG PUSCH is earlier than CG PUSCH
	+ The UE behaviour is the same as the conclusion in RAN1 #103-e, i.e. MAC generates MAC PDU for the DG PUSCH and the UCI is multiplexed on the DG PUSCH.
* **Case 1-5b**: DG PUSCH and CG PUSCH are non-overlapping, both DG/CG PUSCH are overlapping with PUCCH, and DG PUSCH is later than CG PUSCH
	+ it is needed to clarify the UE behavior based on the existing UCI multiplexing rules/conditions.

According the following description in current specification and the agreements/conclusions made in previous RAN1 meeting. There may be the following understandings on the definition of the overlapping group PUCCH and PUSCH(s) in the slot for Case 1-5b.

* **Understanding 1**: CG PUSCH and DG PUSCH belong to different overlapping groups
	+ Group 1: the overlapping PUCCH and CG PUSCH in the slot
	+ Group 2: the DG PUSCH
* **Understanding 2:** CG PUSCH and DG PUSCH belong to the same overlapping group
	+ PUCCH, CG PUSCH and DG PUSCH are in the same overlapping group

Based on Understanding 1, for the overlapped PUCCH and CG PUSCH in group 1, the UCI multiplexing timeline conditions for CG PUSCH should be satisfied. Since only DG PUSCH is included in group 2, the DG PUSCH is not considered for UCI multiplexing if the UCI is decided to be multiplexed on CG PUSCH.

In Rel-15, if there is data for CG PUSCH, UCI will be multiplexed on the CG PUSCH. If there is no data for CG PUSCH, UCI will be multiplexed on the DG PUSCH. The group definition is depending on whether there is data for CG PUSCH.

In Rel-16 with CG PUSCH skipping behavior, according to the UCI multiplexing rule, the CG PUSCH will be selected for UCI multiplexing and MAC generates PDU for the CG PUSCH. Hence, the UCI multiplexing timeline requirement may be not needed for the DG PUSCH.

Based on Understanding 2, the DG PUSCH will be selected for UCI multiplexing following the UCI multiplexing rules. UE behaviour is the same as the conclusion in RAN1 #103-e, i.e. MAC generates MAC PDU for the DG PUSCH and the UCI is multiplexed on the DG PUSCH.

**Question: for determining a group overlapping PUCCHs and PUSCHs in the slot in Case 1-5b, which is the common understanding according to current specification?**

* **Understanding 1: CG PUSCH and DG PUSCH belong to different overlapping groups, i.e.**
	+ **Group 1: the overlapping PUCCH and CG PUSCH in the slot**
	+ **Group 2: the DG PUSCH**
* **Understanding 2: CG PUSCH and DG PUSCH belong to the same overlapping group, i.e.**
	+ **PUCCH, CG PUSCH and DG PUSCH are in the same overlapping group**
1. **Please share your views on the above question.**

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| **Company** | **Comment** |
| *Moderator’s comment* | *Based on current specification, understanding 2 seems the behaviour for determining a group overlapping PUCCHs and PUSCHs in the slot in Case 1-5b* |
| Ericsson | We are not sure if the discussion is still within the UL-skipping scope or rather a general time line discussion. The preferred outcome would be DG get transmitted. But we don’t see the association of Understanding 1 and Understanding 2. |
| Apple | We also think understanding 2 is the behavior. Our understanding is that the overlapping group is determined based on which PUSCHs overlap with the PUCCH(s). |

Based on the above understandings, the behavior for Case 1-5b can be clarified as follows

**Proposed clarification for Case 1-5b in Rel-16:**

* **Case 1-5b: DG PUSCH and CG PUSCH are non-overlapping, both DG/CG PUSCH are overlapping with PUCCH, and DG PUSCH is later than CG PUSCH**
	+ **If Understanding 1 is the common understanding, the CG PUSCH is selected for UCI multiplexing, MAC generates MAC PDU for the CG PUSCH and the UCI is multiplexed on the CG PUSCH.**
	+ **If Understanding 2 is the common understanding, UE behaviour is the same as the conclusion in RAN1 #103-e, i.e. the DG PUSCH will be selected for UCI multiplexing and MAC generates MAC PDU for the DG PUSCH and the UCI is multiplexed on the DG PUSCH.**
1. **Please share your views on the above clarification.**

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| **Company** | **Comment** |
| Ericsson | From gNB perspective the UCI shall be multiplexed on DG PUSCH. But we are not sure how useful this scenario is. From spec impact perspective, at the same time aiming for a simple solution for most of the scenarios, we would like to get other companies view. |
| Apple | As mentioned earlier, we think it is understanding 2 and we are fine with the corresponding clarification. |

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| **38.213**9.2.5 UE procedure for reporting multiple UCI typesIf a UE would transmit multiple overlapping PUCCHs in a slot or overlapping PUCCH(s) and PUSCH(s) in a slot and, when applicable as described in Clauses 9.2.5.1 and 9.2.5.2, the UE is configured to multiplex different UCI types in one PUCCH, and at least one of the multiple overlapping PUCCHs or PUSCHs is in response to a DCI format detection by the UE, the UE multiplexes all corresponding UCI types if the following conditions are met. If one of the PUCCH transmissions or PUSCH transmissions is in response to a DCI format detection by the UE, the UE expects that the first symbol $S\_{0}$ of the earliest PUCCH or PUSCH, among a group overlapping PUCCHs and PUSCHs in the slot, satisfies the following timeline conditions |
| **Agreements in RAN1 #92bis**Working assumption:* When single-slot PUCCH overlaps with single-slot PUCCH or single-slot PUSCH in slot n for a PUCCH group,
	+ The UE multiplex all UCIs on either one PUCCH or one PUSCH, using the existing UCI multiplexing rule, if both following conditions are satisfied:
		- If the first symbol of the earliest PUCCH(s)/PUSCH(s) among all the overlapping channels starts no earlier than symbol N1+X after the last symbol of PDSCH(s)
		- If the first symbol of the earliest PUCCH(s)/PUSCH(s) among all the overlapping channels starts no earlier than N2+Y after the last symbol of PDCCHs scheduling UL transmissions including HARQ-ACK and PUSCH (if applicable) for slot n
	+ If at least one pair of overlapping channels does not meet the above timeline requirements, UE consider it is an error case for all UL channels in the group of overlapping channels. UE behavior is not specified.
* The definition of N1 and N2 follows the same definition in current NR spec.
* X and Y are non-negative integer values.
* FFS on values of X and Y
* FFS on timeline requirement for multiplexing UCIs on PUSCH with A-CSI.
* FFS how to handle one PUCCH overlap with multiple PUSCHs which satisfy timeline requirement.
* FFS: how to handle HARQ-ACK for semi-static PDSCH.
* FFS multiplexing rule when AN PUCCH resource with F1 overlaps with SR PUCCH resource with F0.
* FFS: how to handle semi-statically configured PUCCH overlap with semi-statically configured PUCCH or PUSCH.
* Note: The above proposal does not override the dropping rules defined for ACK/SR colliding with A-CSI-only on PUSCH without UL-SCH, or ACK/SR colliding with SP-CSI on PUSCH without UL-SCH.
* Note: Consider how to handle PUCCH colliding with other UL channels in NR Rel. 15 June drop when URLLC is taking into account.
 |
| **Agreements in RAN1 #93**Agreements:Within a group of overlapping PUCCH/PUSCH channels satisfying the timeline requirements, adopt the following procedure * For step 1, while there are overlapping PUCCH resources in a slot,
	+ The UE determines the PUCCH resource (resource A) that overlaps with at least another PUCCH resource with the priority order of earliest followed by largest duration (if applicable)
		- In case of multiple candidates for resource A, the UE can pick one (implementation-specific)
	+ The UE determines a set of PUCCH resources (resource set X) overlapping with PUCCH resource A.
	+ The UE determines a PUCCH resource and corresponding UCI for multiplexing the PUCCH resource A and PUCCH resources in set X in one shot.
	+ The determined PUCCH resource and the corresponding UCI replace resource set X and resource A
* For step 1, when there is no more overlapping PUCCH resources in the slot, the UE determines “the timeline requirements for overlapping UL channels”. If the requirement is met, the UE proceeds to Step 2.
* Note: the above is per PUCCH group
* The above agreements is to replace Step 1 in the agreements under 7.1.3.2.3
1. Step 2:
2. if the resulting PUCCH resource(s) in step 1 overlapping with PUSCH(s), multiplex UCIs on the overlapping PUSCH(s);
3. FFS: When UCI includes SR
4. Otherwise, multiplex UCI on the determined PUCCH resource(s)
 |
| **Conclusion in RAN1#97:**For the issue raised in the draft CR [R1-1906302](file:///C%3A%5CUsers%5Cqjiizhg%5CDocs%5CR1-1906302.zip), the intended UE behavior per specification is commonly understood as follows:* For UCI multiplexing, within a PUCCH group, on PUSCH, the following two steps are performed with step 1 first, then followed by step 2:
	+ Step 1: UCI in overlapped PUCCH transmissions is multiplexed into one PUCCH resource (resource Z) ~~on PCC~~. This step is done per PUCCH slot.
	+ Step 2: UCI, that doesn’t include SR, in Z is multiplexed into one PUSCH, if Z overlaps with at least one PUSCH, following the priorities (sequentially from high to low) as listed below.
		- First priority: PUSCH with A-CSI as long as it overlaps with Z
		- Second priority: earliest PUSCH slot(s) based on the start of the slot(s)
		- If there are still multiple PUSCHs overlap with Z in the earliest PUSCH slot(s), follow the following priorities (sequentially from high to low)
			* Third priority: Dynamic grant PUSCHs > PUSCHs configured by respective ConfiguredGrantConfig or semiPersistentOnPUSCH
			* Fourth priority: PUSCHs on ~~CC~~ serving cell with smaller ~~CC~~ serving cell index > PUSCHs on ~~CC~~ serving cell with larger ~~CC~~ serving cell index
			* Fifth priority: Earlier PUSCH transmission > later PUSCH transmission

Note: The clarification applies to both cases with the same (except the second priority part) and different numerologies among PUCCH and PUSCHs. |

## Issue 2: PUSCH skipping in case of PUSCH with repetitions

[1][2][3] [5] [8][9] discussed the PUSCH skipping with PUSCH repetitions.

* **DG PUSCH with repetitions**

For DG PUSCH with repetitions, UE starts the initial transmission from the first repetition. When DG PUSCH skipping is not configured, if there is data, MAC generates PDU and UE transmits all the repetitions, while if there is no data, no PDU will not be generated such that UE does not transmit the repetitions at all.

When there is PUCCH overlapping with the first repetition, according to DG skipping behavior, a MAC PDU needs to be generated and the UCI is multiplexed on the overlapped PUSCH repetition. For DG, since the UCI multiplexing timeline should be satisfied with respect to the first PUSCH repetition, it is feasible for MAC to generate PDU for the UCI multiplexing if there is no data. If MAC delivered a PDU for UCI multiplexing, UE needs to transmit all the remaining repetitions since UE does not know the PDU includes the actual data or the padding bits. This may cause unnecessary transmissions of the padding TB.

When there is PUCCH overlapping with the other repetition than the first repetition, if MAC does not generate a PDU for the repetitions, UE does not need to transmit the repetitions. In such case, UCI can be transmitted on PUCCH.



Figure 2. PUCCH vs DG PUSCH with repetition [8].

**Proposal 3: For DG PUSCH with repetitions,** **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,**

* + **When a PUCCH is overlapped with the first PUSCH repetition, MAC generates MAC PDU for DG PUSCH and delivers the MAC PDU(s) to PHY and the UCI is multiplexed on the DG PUSCH. All of the PUSCH repetitions are not skipped.**
	+ **When a PUCCH is overlapped with the repetitions other than the first PUSCH repetition, if there is no PDU including data delivered from MAC, the DG PUSCH can be skipped. UCI is transmitted on the PUCCH.**

**Note for DG PUSCH with repetitions, the first PUSCH repetition is the first transmission occasion of the actual repetitions among the repetition bundle.**

1. **Please share your views on the above proposal.**

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| **Company** | **Comment** |
| Ericsson | To simplify the implementation complexity on blind decoding, our preferred solution would be: If a PUCCH is overlapped with any PUSCH repetition, MAC generates MAC PDU for that DG PUSCH and the remaining PUSCH repetitions. |
| Apple | We are generally fine with the principle of the proposal. However, we think the proposal should be formulated in a generic way to cover all cases. 1. It currently says MAC generates MAC PDU for DG PUSCH, but it is only true if UCI would be multiplexed on the first PUSCH repetition.
2. For the 2nd bullet, it is not accurate to say “the DG PUSCH can be skipped”. Basically it has been skipped already because no PDU has been generated. Also, UCI is not necessarily transmitted on PUCCH because there may be other overlapping PUSCH(s).

Here is the suggested modification (in blue):**For DG PUSCH with repetitions,** **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,*** + **When a PUCCH is overlapped with the first PUSCH repetition and UCI would be multiplexed on the first PUSCH repetition, MAC generates MAC PDU for DG PUSCH and delivers the MAC PDU(s) to PHY and the UCI is multiplexed on the DG PUSCH. All of the PUSCH repetitions are not skipped.**
	+ **When a PUCCH is overlapped with the repetitions other than the first PUSCH repetition, ~~if there is no PDU including data delivered from MAC, the DG PUSCH can be skipped. UCI is transmitted on the PUCCH.~~**
		- **If there was no MAC PDU generated for the DG PUSCH (for the first repetition), the repetitions other than the first PUSCH repetition is not considered in UCI multiplexing determination.**
		- **Otherwise, the repetitions other than the first PUSCH repetition is considered in UCI multiplexing determination.**

In addition, the meaning of the note is not exactly clear to us. Could you please elaborate which case(s) it tries to cover? Is it about PUSCH repetition Type B where the first nominal repetition may be segmented into actual repetitions? Does the note mean that we consider the first actual repetition after segmentation, regardless of whether it is dropped or not due to conflict?  |

* **CG PUSCH with repetitions**

For CG PUSCH with repetitions, MAC determines whether to generate a PDU for the PUSCH at any transmission occasion that may be used for initial transmission of a TB. When there is no data for CG PUSCH, MAC will not generate PDU for the CG PUSCH with repetitions. The similar solution can be adopted as DG PUSCH with repetition.

If PUCCH is overlapping with CG PUSCH repetitions for initial transmission, the CG PUSCH overlapping with PUCCH cannot be skipped. MAC generates PDU for the CG PUSCH for UCI multiplexing. The remaining repetitions need to be transmitted as well. If PUCCH is overlapping with CG PUSCH repetitions for non-initial transmission and no PDU for the CG PUSCH repetitions is not delivered from MAC for the latest PUSCH transmission occasion for initial transmission, UE can skip the CG PUSCH and UCI is transmitted on the PUCCH.

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| **38.214**6.1.2.3 Resource allocation for uplink transmission with configured grant6.1.2.3.1 Transport Block repetition for uplink transmissions of PUSCH repetition Type A with a configured grantThe procedures described in this clause apply to PUSCH transmissions of PUSCH repetition Type A with a Type 1 or Type 2 configured grant. The higher layer parameter *repK-RV* defines the redundancy version pattern to be applied to the repetitions. If *cg-RetransmissionTimer* is provided, the redundancy version for uplink transmission with a configured grant is determined by the UE. If the parameter *repK-RV* is not provided in the *configuredGrantConfig* and *cg-RetransmissionTimer* is not provided, the redundancy version for uplink transmissions with a configured grant shall be set to 0. If the parameter *repK-RV* is provided in the *configuredGrantConfig* and *cg-RetransmissionTimer* is not provided, for the *n*th transmission occasion among *K* repetitions, *n*=1, 2, …, *K*, it is associated with *(mod(n-1,4)+1)th* value in the configured RV sequence. If a configured grant configuration is configured with *startingFromRV0-r16* set to *'off'*, the initial transmission of a transport block may only start at the first transmission occasion of the *K* repetitions. Otherwise, the initial transmission of a transport block may start at - the first transmission occasion of the *K* repetitions if the configured RV sequence is {0,2,3,1},- any of the transmission occasions of the *K* repetitions that are associated with RV=0 if the configured RV sequence is {0,3,0,3},- any of the transmission occasions of the *K* repetitions if the configured RV sequence is {0,0,0,0}, except the last transmission occasion when *K≥8*. 6.1.2.3.2 Transport Block repetition for uplink transmissions of PUSCH repetition Type B with a configured grantThe procedures described in this Clause apply to PUSCH transmissions of PUSCH repetition type B with a Type 1 or Type 2 configured grant.For PUSCH transmissions with a Type 1 or Type 2 configured grant, the nominal repetitions and the actual repetitions are determined according to the procedures for PUSCH repetition Type B defined in Clause 6.1.2.1. The higher layer configured parameters *repK-RV* defines the redundancy version pattern to be applied to the repetitions. If the parameter *repK-RV* is not provided in the *configuredGrantConfig*, the redundancy version for each actual repetition with a configured grant shall be set to 0. Otherwise, for the *n*th transmission occasion among all the actual repetitions (including the actual repetitions that are omitted) of the *K* nominal repetitions, it is associated with *(mod(n-1,4)+1)th* value in the configured RV sequence. If a configured grant configuration is configured with *startingFromRV0-r16* set to *'off'*, the initial transmission of a transport block may only start at the first transmission occasion of the actual repetitions. Otherwise, the initial transmission of a transport block may start at - the first transmission occasion of the actual repetitions if the configured RV sequence is {0,2,3,1},- any of the transmission occasions of the actual repetitions that are associated with RV=0 if the configured RV sequence is {0,3,0,3},- any of the transmission occasions of the actual repetitions if the configured RV sequence is {0,0,0,0}, except the actual repetitions within the last nominal repetition when *K≥8*.  |



Figure 3. PUCCH vs CG PUSCH with repetition [8].

**Proposal 4: For CG PUSCH with repetitions, adopt the same solution as DG PUSCH with repetitions in principle, i.e.**

**When CG PUSCH skipping is configured and Rel-16 LCH based prioritization is not configured and there is a single PHY priority for UL transmissions,**

* + **When a PUCCH is overlapped with the first PUSCH repetition, MAC generates MAC PDU for CG PUSCH and delivers the MAC PDU(s) to PHY and the UCI is multiplexed on the CG PUSCH. All of the PUSCH repetitions are not skipped.**
	+ **When a PUCCH is overlapped with the repetitions other than the first PUSCH repetition, if there is no PDU including data delivered from MAC, the CG PUSCH can be skipped. UCI is transmitted on the PUCCH.**
	+ **For CG PUSCH with repetitions, the first PUSCH repetition can be as follows**
		- **Option 1: the first repetition is the first transmission occasion of the actual repetitions among the repetition bundle**
		- **Option 2: the first repetition is any of the transmission occasions of the actual repetitions that are associated with RV=0 for initial transmission**

**Note for CG PUSCH with repetitions, the transmission occasions of the actual repetitions that are associated with RV=0 for initial transmission are as specified in TS 38.214.**

1. **Please share your views on the above proposal.**

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| **Company** | **Comment** |
| Ericsson | Same as the proposal for DG with repetition. Our preferred solution is that MAC generate PDU for any CG overlapping with PUCCH and continue the PUSCH transmission with remaining CG repetition. |
| Apple | We agree with the proposal in principle. But we have comments similar to those for Proposal 3. We suggest the following:**For CG PUSCH with repetitions, adopt the same solution as DG PUSCH with repetitions in principle, i.e.****When CG PUSCH skipping is configured and Rel-16 LCH based prioritization is not configured and there is a single PHY priority for UL transmissions,*** + **When a PUCCH is overlapped with the first PUSCH repetition and UCI would be multiplexed on the first PUSCH repetition, MAC generates MAC PDU for CG PUSCH and delivers the MAC PDU(s) to PHY and the UCI is multiplexed on the CG PUSCH. All of the PUSCH repetitions are not skipped.**
	+ **When a PUCCH is overlapped with the repetitions other than the first PUSCH repetition, ~~if there is no PDU including data delivered from MAC, the CG PUSCH can be skipped. UCI is transmitted on the PUCCH.~~**
		- **If there was no MAC PDU generated for the CG PUSCH (for the first repetition), the repetitions other than the first PUSCH repetition is not considered in UCI multiplexing determination.**
		- **Otherwise, the repetitions other than the first PUSCH repetition is considered in UCI multiplexing determination.**
	+ **For CG PUSCH with repetitions, the first PUSCH repetition can be as follows**
		- **Option 1: the first repetition is the first transmission occasion of the actual repetitions among the repetition bundle**
		- **Option 2: the first repetition is any of the transmission occasions of the actual repetitions that are associated with RV=0 for initial transmission**

Regarding Option 1 vs Option 2, we are open to consider both. But for Option 2, the initial transmission cannot start at the 5th repetition (which is RV=0) if RV sequence is {0, 2, 3, 1}. It may be better to reword it as “Option 2: the first repetition is any of the transmission occasions of the actual repetitions where the UE may start the initial transmission according to TS 38.214 Clause 6.1.2.3”. |

## Others

1. **Please share any other comments if any.**

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| **Company** | **Comment** |
| Apple | We think it is important to align the understanding on which PUSCHs are considered in the first step of determining which PUSCH would have UCI multiplexed on.Our understanding is that this is based on the DG and CG occasions being scheduled/configured, without considering which one(s) may or may not have data. Using all the scheduled DG PUSCHs and all the activated/configured CG PUSCH occasions and SP-CSI PUSCH as the starting point, we think the following pruning of the candidate set should be done for UCI multiplexing determination:* A CG PUSCH occasion that conflicts with a semi-static DL symbol is excluded
* A SP-CSI PUSCH that overlaps with a DG or CG occasion on the same serving cell is excluded
* In case there are multiple CG PUSCH occasions on the same serving cell with the same starting time for UCI multiplexing, define a rule to select only one of them (e.g. the one with smallest CG configuration index).
	+ Note that currently there is no rule for such a case because this case does not exist in Rel-15.
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# List of contributions

1. R1-2100082 Discussion on UL skipping for PUSCH ZTE

1. R1-2100321 Discussion on PUSCH skipping CATT

1. R1-2100405 Discussion on PUSCH skipping with overlapping UCI on PUCCH in Rel-16 vivo

1. R1-2100754 PUSCH skipping with UCI (without LCH and PHY prioritization) (Rel-16) Nokia, Nokia Shanghai Bell

1. R1-2100796 Discussion on UL skipping for CG PUSCH Spreadtrum Communications

1. R1-2101145 Discussion on CG collision with UCI and DG Ericsson

1. R1-2101341 Discussions on PUSCH skipping Apple

1. R1-2101580 Discussion on skipping vs UCI multiplexing on configured PUSCH NTT DOCOMO, INC.

1. R1-2101739 Discussion on remaining issues of UL skipping for CG PUSCH Huawei, HiSilicon

# Previous Agreements

## RAN1 #102-e

Agreement

* 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

The following text proposal for TS38.214 is endorsed. Final CR is agreed in [R1-2007337](file:///E%3A%5CWorkspace%5C3GPP%20related%5C3GPP%20meeting%5C2020%5C2020.Q4%5CRAN1%23103e%5CDocs%5CR1-2007337.zip) (TS 38.214, Rel-16, CR#0123, Cat F).

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| **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. When the UE is scheduled with multiple PUSCHs by a DCI, HARQ process ID indicated by this DCI applies to the first PUSCH, as described in clause 6.1.2.1, HARQ process ID is then incremented by 1 for each subsequent PUSCH(s) in the scheduled order, with modulo 16 operation applied. For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to transmit a PUSCH that overlaps in time with another PUSCH. For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH that ends later than symbol *i*. The UE is not expected to be scheduled to transmit another PUSCH by DCI format 0\_0, 0\_1 or 0\_2 scrambled by C-RNTI or MCS-C-RNTI for a given HARQ process until after the end of the expected transmission of the last PUSCH for that HARQ process. <unchanged part omitted> |

Agreement

Send an LS to RAN2 to inform them of the latest RAN1 agreement on uplink skipping.

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| In Rel-15, for dynamic UL skipping, RAN1 discussed the LS [R1-2000015](file:///E%3A%5CWorkspace%5C3GPP%20related%5C3GPP%20meeting%5C2020%5C2020.Q4%5CRAN1%23103e%5CDocs%5CR1-2000015.zip) from RAN2 and provided replies in [R1-2001376](file:///E%3A%5CWorkspace%5C3GPP%20related%5C3GPP%20meeting%5C2020%5C2020.Q4%5CRAN1%23103e%5CDocs%5CR1-2001376.zip) for Case 1 of dynamic PUSCH skipping without overlapping CSI/HARQ-ACK on PUCCH.Case 2 of dynamic PUSCH skipping with overlapping CSI/HARQ-ACK on PUCCH was further discussed in RAN1. In RAN1#101-e meeting, it was concluded that in Rel-15, the UE behavior is undefined for case 2 and case 2 can be addressed for Rel-16. Endorsed CR [R1-2005044](file:///E%3A%5CWorkspace%5C3GPP%20related%5C3GPP%20meeting%5C2020%5C2020.Q4%5CRAN1%23103e%5CDocs%5CR1-2005044.zip) (TS38.214, Rel-15, CR#0105, Cat. F) for Case 1 and Case 2 can be found in the attachment. In Rel-16, RAN1 continued the discussion for Case 2 and made following agreements in RAN1#102-e meeting:

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| AgreementFor 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. |

Based on above agreements, RAN1 in principle agreed the corrections for Rel-16 TS 38.214 (R1-200xxxx), assuming that RAN2 will update the Rel-16 sepcification TS 38.321 corresponding to the above agreement so that UE generates the MAC PDU for the PUSCH with UCI multiplexing. In addition, RAN1 noticed that in Rel-15, dynamic UL skipping is an optional feature with capability signaling (*skipUplinkTxDynamic*). It is RAN1’s understanding the dynamic UL skipping cannot be implemented based on the Rel-15 specification. For Rel-16 with the defined UE behavior for dynamic UL skipping, RAN1 has discussed  following two options for the capability signaling handling. However, the final decision on the capability design for Rel-16 dynamic UL skipping should be decided by RAN2. * Option 1: introduce a new UE capability for Rel-16 dynamic UL skipping
* Option 2: Reuse Rel-15 UE capability with the understanding that Rel-15 dynamic UL skipping is not implementable therefore UEs indicating this capability should implement Rel-16 behavior.
 |

LS is approved in:

[**R1-2007338**](file:///E%3A%5CWorkspace%5C3GPP%20related%5C3GPP%20meeting%5C2020%5C2020.Q4%5CRAN1%23103e%5CDocs%5CR1-2007338.zip) **LS on PUSCH with UL skipping RAN1, vivo**

## RAN1 #103-e

**Agreement**

**The text proposal in R1-2008655 is endorsed for TS38.214 as revision of R1-2007337. Endorsed in R1-2009687 (TS38.214, Rel-16, CR#0123, Cat. F). Add the following in the CR cover sheet.**

* **This CR is expected to submit to RAN plenary for approval together with the corresponding endorsed RAN2 CR.**
* **Other specs affected: TS 38.321**

**Agreement:**

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**

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 GG 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:**

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.

**Agreement**

Send an LS to RAN2 to convey the above RAN1 agreement, conclusion, and working assumption on PUSCH skipping (Rel-16). The LS is endorsed in R1-2009772.