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.
* 2nd round discussion: 2/4 (UTC). Second round discussion in the 2nd week to further discuss the remaining issues. **Please provide the comments for the first-round discussion by 2/2 UTC 23:59 am.**

# Discussion of 2nd round

## Remaining issues for Case 1-6

**Summary of discussion of 1st round**

Based on the input, Option 3 is agreed by most companies for Case 1-6.

To make it as a general solution to cover the Case 1-6 in non-CA and CA cases, the proposal is updated as follows.

**Proposal 1-a: In Rel-16, when timeline condition is met, for Case 1-6 in 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,**

* **When a CG PUSCH overlaps with a PUCCH on a same or different serving cell, a DG PUSCH overlaps with the CG PUSCH on one serving cell and the DG PUSCH does not overlap with the PUCCH, and there is no remaining CG PUSCH(s) on other serving cell(s) overlapping with the PUCCH, the UCI is transmitted on the PUCCH.**
	+ **This is for case 1-6a and 1-6b in Figure 1.**
	+ If there is data for the DG PUSCH, MAC generates PDU for the DG PUSCH. If there is no data for the DG PUSCH, MAC does not generate PDU for the DG PUSCH nor the CG PUSCH
* **When a CG PUSCH overlaps with a PUCCH on a same or different serving cell, a DG PUSCH overlaps with the CG PUSCH on one serving cell and the DG PUSCH does not overlap with the PUCCH, and there is remaining CG PUSCH(s) on other serving cell(s) overlapping with the PUCCH, the PUSCH from other serving cell for UCI multiplexing is determined following the existing UCI multiplexing rules, MAC generates MAC PDU for the PUSCH and delivers the MAC PDU to PHY and the UCI is multiplexed on the PUSCH.**
	+ **This is for case 1-6c in Figure 1.**
	+ If there is data for the DG PUSCH, MAC generates PDU for the DG PUSCH. If there is no data for the DG PUSCH, MAC does not generate PDU for the DG PUSCH
* **FFS the timeline condition and whether there is additional spec impact for the timeline condition.**
1. **Please share your views on the above proposal 1-a and whether there is spec impact for proposal 1-a**

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| **Company** | **Comment** |
| NTT DOCOMO | Thank you for update. Two comments from our side.* Important part of Opt-3 is dropped. If there is data for DG, MAC generates PDU for DG PUSCH; otherwise, MAC does not generate PDU for DG or CG PUSCH. This information is necessary for RAN2.
* Underline part is incorrect. ‘there is no remaining CG PUSCH(s) on any serving cell overlapping with the PUCCH’ ‘there is remaining CG PUSCH(s) on any serving cell overlapping with the PUCCH’ should be used. Two reasons: the first reason is, if there is other DG PUSCH overlapping the PUCCH, UCI in the PUCCH is multiplexed on the DG PUSCH. DG PUSCH should be excluded from the underline part. The second reason is, the other CG PUSCH can be on the same cell. The other CG PUSCH is not overlapped with the DG PUSCH, then UCI in the PUCCH can be multiplexed on the CG PUSCH in the same cell.
 |
| ZTE | It seems we are keeping complicate the use cases with different implementing methods. For us, the case like case 1-6c is rather a corner case. We prefer to only consider case 1-6a and 1-6b, while would be also ok with case 1-6c if majority companies prefer to support. We also agree with what DOCOMO commented.  |
| Samsung | Agree with updated version.  |
| Intel | We are fine with the latest version, including suggestion to change “other serving cells” to “any serving cells”. |
| Apple | For the first sub-bullet, we think it should be:” **there is no remaining DG/CG PUSCH(s) on other serving cell(s) overlapping with the PUCCH**”. Otherwise it is an incomplete description of the case.A separate question: should we assume that the Rel-16 DG skipping and Rel-16 CG skipping are always enabled together? |

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| **Case 1-6a** | **Case 1-6b** |
|  |
| **Case 1-6c** |

**Figure 2: Case 1-6a/1-6b/1-6c for non-CA and CA case**

Regarding the timeline condition, it can be observed that a timeline condition is required from companies’ input for Case 1-6 as in the figure 1. For Case 1-6, the time condition that needs to be met is as follows.

* + The ending symbol of UL grant for the DG PUSCH should be at least symbols before the first symbol of the earliest PUCCH or PUSCH among the overlapping group of PUCCH/PUSCH channels.



**Figure 1: timeline condition for Case 1-6**

The key question is whether the existing timeline condition is sufficient or a new timeline condition is needed.

It is understood by some companies that for Case 1-6 the PUCCH, CG PUSCH and DG PUSCH are considered as an overlapping group of PUCCH/PUSCH channels. With such understanding, the timeline condition for UCI multiplexing in Subclause 9.2.5 of 38.213 should be satisfied for the UL grant associated with the DG PUSCH in the overlapping group. Meanwhile, it is specified that 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) in 38.214.

1. **For Case 1-6, the time condition that needs to be met is as follows.**
* **The ending symbol of UL grant for the DG PUSCH should be at least symbols before the first symbol of the earliest PUCCH or PUSCH among the overlapping group of PUCCH/PUSCH channels.**

**Is it the common understanding that for Case 1-6 the PUCCH, CG PUSCH and DG PUSCH are considered as an overlapping group of PUCCH/PUSCH channels? If yes, whether there is additional spec impact for the time condition for Case 1-6?**

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| **Company** | **Comment** |
| NTT DOCOMO | First question: YesSecond question: No spec impact is assumed. Current spec covers this case as Intel kindly captured in 1st round. |
| ZTE | The fundamental issue is whether these channels are considered as one group of overlapping channels. This should be clarified first. According to the spec text of TS 38.213 below, UCI multiplexing is only performed when the PUCCH overlaps with the PUSCH. Thus, when we consider to apply UCI multiplexing timeline for a group of overlapping PUCCH and PUSCH, our understanding is **only the PUSCH overlapping with PUCCH are considered in the UCI multiplexing timeline**. An example is given in the following figure, where the PUSCH are all DG PUSCH and no UL skipping is configured. In our view, the PUCCH will be multiplexed on DG PUSCH #1, and UCI multiplexing timeline would not take DG PUSCH#2 into account (it seems no reason to consider it). So, we would like to first clarify the legacy behavior for the example we provided.*If a UE* *- would multiplex UCI in a PUCCH transmission that overlaps with a PUSCH transmission, and* *- the PUSCH and PUCCH transmissions fulfill the conditions in Clause 9.2.5 for UCI multiplexing,* *the UE* *- multiplexes only HARQ-ACK information, if any, from the UCI in the PUSCH transmission and does not transmit the PUCCH if the UE multiplexes aperiodic or semi-persistent CSI reports in the PUSCH;**- multiplexes only HARQ-ACK information and CSI reports, if any, from the UCI in the PUSCH transmission and does not transmit the PUCCH if the UE does not multiplex aperiodic or semi-persistent CSI reports in the PUSCH.* |
| Samsung | Not clear whether this is included in current specification or not. Note that the following sentence is the first sentence under 9.2.5 in TS 38.213. Hence, it is understood that 9.2.5 only considers overlapping in time and it is possible that some specification impact might be necessary without defining additional new timeline. We prefer that 9.2.5 could be updated by including the case 1-6.

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| This Clause is applicable to the case that a UE has resources for PUCCH transmissions or for PUCCH and PUSCH transmissions that overlap in time and each PUCCH transmission is over a single slot without repetitions. |

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| Intel | Thanks to ZTE’s example and the quoted text by Samsung, it seems some clarification for this case may be necessary. In this regard, it would be good to clarify whether such optimization (saving the UCI in this case) is only considered for the case in 1-6, and not expected to be extended to other more general cases, e.g., the example from ZTE (or other cases wherein the CG PUSCH in 1-6 may get dropped after UCI mux; e.g., due to max Tx power constraints and inter-CC UL channel prioritization, etc.).  |
| Apple | Our understanding is that this is not covered in Rel-15, or at least it is unclear. |

## Remaining issues for Case 1-5

**Summary of discussion of 1st round**

It can be observed that understanding 2 is the supported by most of companies. Besides, it is also mentioned by some companies that the further clarification on Case 1-5 on the behaviour is not needed. Therefore, I suggest we can make a conclusion for Case 1-5 as follows.

**Conclusion on Case 1-5: for Case 1-5 DG PUSCH and CG PUSCH are non-overlapping, both DG/CG PUSCH are overlapping with PUCCH, the understanding 2 is the RAN1 understanding, i.e. PUCCH, CG PUSCH and DG PUSCH are considered as an overlapping group of PUCCH/PUSCH channels.**

* **No spec change is needed**
1. **Please provide your comments if you have concern on the above conclusion for Case 1-5, if any.**

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| **Company** | **Comment** |
| NTT DOCOMO | Support |
| ZTE | Support |
| Samsung | Agree. If the above conclusion’s intention is to capture in chairman’s note. We would like to suggest following sentence by removing redundant texts. Conclusion on Case 1-5: for Case 1-5 DG PUSCH and CG PUSCH are non-overlapping, both DG/CG PUSCH are overlapping with PUCCH, ~~the understanding 2 is the RAN1 understanding, i.e.~~ PUCCH, CG PUSCH and DG PUSCH are considered as an overlapping group of PUCCH/PUSCH channels.* No spec change is needed
 |
| Intel | Support, including the updates from Samsung. |
| Apple | Agree |

## PUSCH skipping in case of PUSCH with repetitions

According to the discussion in 1st round, it was mentioned by some companies that the implementation complexity on blind decoding for gNB and the implementation complexity on the UCI multiplexing for UE need to be considered. That is also the design principle for Rel-16 UL skipping. Besides, differentiating the UCI multiplexing behaviours for PUSCH with repetitions in case of PUCCH overlapping with the first repetition or the other repetitions would require gNB to reliably detect the initial transmission of repetitions, which may be challenging for gNB especially when the number of repetitions is large or the number of allocated PRBs for PUSCH is small.

Considering these aspects, following options for PUSCH skipping in case of DG PUSCH repetitions are proposed.

* Option 1: When there’s a PUCCH overlapping with any of the repetitions, MAC generates MAC PDU for DG PUSCH and delivers the MAC PDU(s) to PHY and the UCI is multiplexed on the DG PUSCH.
* Option 2: 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. UE does not expect when a PUCCH is overlapped with the repetitions other than the first PUSCH repetition.

It should be noted that for both options, the UCI multiplexing timeline condition should be met for first repetition for DG PUSCH with repetitions according to the following descriptions in spec.

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| **38.213**9 UE procedure for reporting control informationA UE does not expect to detect a DCI format scheduling a PDSCH reception or a SPS PDSCH release, or a DCI format including a One-shot HARQ-ACK request field with value 1, and indicating a resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot if the UE previously detects a DCI format scheduling a PUSCH transmission in the slot and if the UE multiplexes HARQ-ACK information in the PUSCH transmission. |

For DG PUSCH with repetitions, the DL grant scheduling a PUCCH overlapping with the DG PUSCH including repetitions needs to be received before the UL grant for the DG PUSCH with repetitions. Therefore, the UCI multiplexing timeline condition for the first repetition of DG PUSCH is always met, even though the timeline condition is defined with the reference of each repetition based on current spec.



For option 1 or option 2, there will be no blind detection issue for gNB since UE will multiplex the UCI on the PUSCH regardless there is data or not.

Hence, the proposal is updated as follows.

**Proposal 3-a: 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, down-select from the following options,**

* + **Option 1: When there’s a PUCCH overlapping with any of the repetitions, MAC generates MAC PDU for DG PUSCH and delivers the MAC PDU(s) to PHY and the UCI is multiplexed on the DG PUSCH.**
	+ **Option 2: 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. UE does not expect when a PUCCH is overlapped with the repetitions other than the first PUSCH repetition.**

**Note: the UCI multiplexing timeline condition for the first repetition of DG PUSCH is always met according to current spec.**

1. **Please share your views and preference on the above options.**

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| **Company** | **Comment** |
| NTT DOCOMO | Option 2 seems not OK since this option restricts Rel-15 rule. In Rel-15, PUCCH can be overlapped with any of PUSCH repetitions. I’m not sure why the additional restriction is allowed.For option 1, let me ask for clarification; the generated MAC PDU is transmitted on the slot? or all slots? or from the slot to the last slot? If not only the slot, so many wasted PUSCH transmissions are performed. I do not think it is desirable from UE power consumption perspective.Regarding original proposal in 1st round, some companies do not prefer it, but is it impossible for gNB perspective? I think gNB can know whether the PUSCH is transmitted or not by power detection based on DM-RS reception. Once gNB knows the presence, no blind decoding is assumed in the remaining slot, which means that the approach is not against what we discussed in the previous meetings. |
| ZTE | We don’t support Option 2, which has strong limitation on gNB scheduling.Our preference is to do per repetition basis as we proposed in the first round. But we understand the prerequisite is the MAC PDU can be generated per repetition basis. Two companies think otherwise in the first round. While we’d like to check with FL and other companies’ view on this. Regarding the comments that it may cause unnecessary re-transmission due to only the overlapped PUSCH is transmitted, gNB could do DMRS detection/channel estimation based on other skipped DG PUSCHs, just like detection of CG PUSCH. Then, it could know whether MAC PDU is generated for non-overlapped PUSCH/whether it’s a padding PDU for overlapped PUSCH in most cases. Thus, unnecessary re-transmission can be avoided. On the other hand, it could save UE power for unnecessary initial PUSCH repetitions and could allow gNB to reschedule transmissions on the resources of skipped PUSCH repetitions.For Option 1, we might be also ok if MAC PDU cannot be generated per repetition basis. Because it is similar like the legacy case when UL skipping is not configured while UE has only padding PDU to transmit, though it is not very efficient and makes UL skipping less attractive.  |
| *Moderator* | After checking with RAN2 colleagues, our understanding is that MAC can only generate PDU at the initial transmission occasion for PUSCH with repetitions. The corresponding MAC behaviors are given by the following highlighted descriptions in MAC spec 38.321.

|  |
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| 5.4.2 HARQ operation5.4.2.1 HARQ EntityIf *REPETITION\_NUMBER* > 1, after the first transmission within a bundle, at most *REPETITION\_NUMBER* – 1 HARQ retransmissions follow within the bundle. For both dynamic grant and configured uplink grant, bundling operation relies on the HARQ entity for invoking the same HARQ process for each transmission that is part of the same bundle. Within a bundle, HARQ retransmissions are triggered without waiting for feedback from previous transmission according to *REPETITION\_NUMBER* for a dynamic grant or configured uplink grant unless they are terminated as specified in clause 6.1 of TS 38.214 [7]. Each transmission within a bundle is a separate uplink grant delivered to the HARQ entity.For each transmission within a bundle of the dynamic grant, the sequence of redundancy versions is determined according to clause 6.1.2.1 of TS 38.214 [7]. For each transmission within a bundle of the configured uplink grant, the sequence of redundancy versions is determined according to clause 6.1.2.3 of TS 38.214 [7].For each uplink grant, the HARQ entity shall:1> identify the HARQ process associated with this grant, and for each identified HARQ process:2> if the received grant was not addressed to a Temporary C-RNTI on PDCCH, and the NDI provided in the associated HARQ information has been toggled compared to the value in the previous transmission of this TB of this HARQ process; or2> if the uplink grant was received on PDCCH for the C-RNTI and the HARQ buffer of the identified process is empty; or2> if the uplink grant was received in a Random Access Response (i.e. in a MAC RAR or a fallback RAR); or2> if the uplink grant was determined as specified in clause 5.1.2a for the transmission of the MSGA payload; or2> if the uplink grant was received on PDCCH for the C-RNTI in *ra-ResponseWindow* and this PDCCH successfully completed the Random Access procedure initiated for beam failure recovery; or2> if the uplink grant is part of a bundle of the configured uplink grant, and may be used for initial transmission according to clause 6.1.2.3 of TS 38.214 [7], and if no MAC PDU has been obtained for this bundle:…3> if the previous configured uplink grant, in the BWP, for this HARQ process was not prioritized; and3> if a MAC PDU had already been obtained for this HARQ process; and3> if the uplink grant size matches with size of the obtained MAC PDU; and3> if none of PUSCH transmission(s) of the obtained MAC PDU has been completely performed:4> consider the MAC PDU has been obtained.3> else if the MAC entity is not configured with *lch-basedPrioritization*; or3> if this uplink grant is a prioritized uplink grant:4> obtain the MAC PDU to transmit from the Multiplexing and assembly entity, if any;3> if a MAC PDU to transmit has been obtained:4> if the uplink grant is not a configured grant configured with *autonomousTx*; or4> if the uplink grant is a prioritized uplink grant:5> deliver the MAC PDU and the uplink grant and the HARQ information of the TB to the identified HARQ process;…2> else (i.e. retransmission):3> if the uplink grant received on PDCCH was addressed to CS-RNTI and if the HARQ buffer of the identified process is empty; or3> if the uplink grant is part of a bundle and if no MAC PDU has been obtained for this bundle; or3> if the uplink grant is part of a bundle of the configured uplink grant, and the PUSCH duration of the uplink grant overlaps with a PUSCH duration of another uplink grant received on the PDCCH or an uplink grant received in a Random Access Response (i.e. MAC RAR or fallbackRAR) or an uplink grant determined as specified in clause 5.1.2a for MSGA payload for this Serving Cell; or:3> if the MAC entity is configured with *lch-basedPrioritization* and this uplink grant is not a prioritized uplink grant:4> ignore the uplink grant.3> else:… |

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| Samsung | Disagree both options. (1) option 1 is not aligned with MAC specification, as cited by FL. (2) option 2 is not aligned with PHY specification. If a DCI scheduling PUCCH is earlier than a DCI scheduling PUSCH repetition, it is understood that the PUCCH can be overlapped with the repetitions other than the first PUSCH repetition. We don’t understand how current specification only allows first PUCCH repetition for PUCCH multiplexing.  |
| Intel | Same view as Samsung. |
| Apple | We do not agree with either of the options. From the first round of discussion, Proposal 3 has support from many companies. It is unclear why it is dropped completely. The DMRS detection may not be 100% reliable, but the reliability should be fairly good. The UE complexity should be taken into account as well, which is why we do not support Option 1. Option 2 addresses UE implementation complexity issue, but it is quite restrictive from gNB scheduling point of view. Therefore, we still think the original Proposal 3 is a good option.In addition, we think we should not use the condition of whether a PUSCH repetition is overlapping with PUCCH. Instead, the condition should be whether there would be UCI multiplexed on a PUSCH repetition, which has always been the principle so far. Otherwise, we could have two PUSCHs with repetitions overlapping with PUCCH, and the proposals here would require both PUSCHs to generate PDU, which is certainly not the intention.If we change the condition to be whether there would be UCI multiplexed on a PUSCH repetition, Option 1 does not seem to work any more. To determine whether the UCI would be multiplexed on a PUSCH (repetition), the UE needs to know all the PUSCHs on all the CCs. When the UE tries to determine whether to generate MAC PDU for the first repetition, the UE does not know yet whether there will be more UL grants received on the other CCs that overlap with later repetitions, which can change the UCI multiplexing decision on the later repetitions. So the option seems to be broken. |

For CG PUSCH with repetitions, the same principle as DG PUSCH can be adopted. The difference is that for CG PUSCH, a timeline condition should be defined for first repetition for CG PUSCH. Besides, at least the the first repetition is the first transmission occasion is assumed to define the timeline condition.

**Proposal 4-a: 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,**

* + **Option 1: When there’s a PUCCH overlapping with any of the repetitions, MAC generates MAC PDU for CG PUSCH and delivers the MAC PDU(s) to PHY and the UCI is multiplexed on the CG PUSCH.**
	+ **Option 2: 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. UE does not expect when a PUCCH is overlapped with the repetitions other than the first PUSCH repetition.**
* **The first PUSCH repetition is at least the first transmission occasion of the repetition bundle**
	+ - **FFS other transmission occasion, e.g. 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**
* **Timeline condition is defined for the first repetition of CG PUSCH as follows**
	+ **UCI multiplexing timeline condition should be met for the first repetition of CG PUSCH**
1. **Please share your views and preference on the above options.**

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| **Company** | **Comment** |
| NTT DOCOMO | Similar comment in Q4, but anyway CG case should be discussed after conclusion on DG case. After the conclusion, CG case discussion would be much easier. |
| ZTE | Similar principle as DG PUSCH should be considered. Whether we need the last two sub-bullets depends on which option will go with. So, it’s better to discuss CG case after concluding on CG case, as also proposed by NTT DOCOMO.  |
| Samsung | Same comment in Q4. |
| Intel | Same view as for Q4. |
| Apple | Agree it can follow the same principle as DG. |

## Other issues

In the first round discussion, Apple raised the issue of UCI multiplexing determination in case of multiple CG configurations for Rel-16. For the case of multiple CG configurations with the same starting time, how to choose CG configuration from multiple CG configurations is up to UE implementation according to current spec. For Rel-16 with UL skipping, it may need to clarify the understanding on the UCI multiplexing behavior for the following case.



In case of multiple CG with the same starting time

* Understanding 1: PHY first determine which CG PUSCH is used to multiplex UCI based on UCI multiplexing rule. MAC then generates PDU for the selected CG PUSCH for UCI multiplexing.
* Understanding 2: MAC first choose a CG PUSCH and generates PDU for transmission. PHY then multiplexes the UCI on the CG PUSCH with MAC delivered PDU.

In case of multiple CG with different starting time

* Understanding 1: PHY first determine which CG PUSCH is used to multiplex UCI based on UCI multiplexing rule. MAC then generates PDU for the selected CG PUSCH for UCI multiplexing.
* Understanding 2: MAC first choose a CG PUSCH and generates PDU for transmission. PHY then multiplexes the UCI on the CG PUSCH with MAC delivered PDU.

Note that this issue is a separate discussion and can be further discussed later.

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

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| **Company** | **Comment** |
| NTT DOCOMO | These cases were agreed as case 1-2, where understanding 2 is applied.The issue seems the case that multiple CGs are active in the same cell and with same starting symbol. In this case, as abovementioned, the current spec seems one of them is selected for multiplexing by UE implementation.We think this is good point and some rule will be necessary. For example, UE supporting two services with same priority and different payloads/periodicities need two CG configs and they could be overlapped with the above conditions. However, this is not related to CG skip function but discussions of URLLC agenda, where multiple active CGs were agreed. I do not think we need to discuss this issue here. |
| ZTE | Open to further discuss. But we don’t see much problem for now. Regardless UL skipping, gNB anyway needs to blindly detect all active CG PUSCH configurations. Thus, for above cases, it can still leave to UE implementation for selection of one CG and generation of MAC PDU, no matter which will perform first. gNB can first detect which CG is actually transmitted, and then decoding the CG and UCI.  |
| Samsung | For both cases, understanding 2. It is understood that LCH will select one grant based on L2-priority. If both grants have same L2-priority, it is up to UE implementation which grant will be selected based on MAC specification. With considering following agreement, we don’t think that there are additional issues to be resolved. **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.

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| Intel | Agree with Samsung. As mentioned by ZTE, for CG PUSCH, gNB BD is typically needed anyway. So, any dependency on UE implementation for the case of same starting symbol for the two CG PUSCH configurations should not impact the gNB’s BD requirements fundamentally.  |
| Apple | We would like to point out now we have the first step to determine which PUSCH the UCI would be multiplexed on before MAC delivers PDU to PHY. So we need to determine the set of PUSCHs for UCI multiplexing determination before MAC builds PDU. When there are multiple overlapping CGs on a serving cell, our current assumption is that all the CG occasions are included in the set of PUSCHs. If companies are making different assumptions, we would like to know what assumption it is.At least we think it is an issue that needs to be addressed, but we are open to discuss how to address the issue. |

# Discussions of 1st round

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.” |
| NTT DOCOMO | Agree with the direction.However, current option 3 is not accurate. If there is a remaining CG PUSCH overlapped with the PUCCH, UCI in the PUCCH is multiplexed on the CG PUSCH and the PUCCH is dropped. This situation should be reflected. |
| vivo | We support the proposal 1 as the principle for Case 1-6. |
| *(Moderator’s comment)* | *On Apple and DCM’s suggestion, this proposal 1 is mainly the principle based on option 3 that UCI should be transmitted. We can refine the proposal to be more generic once we have conclusion on the proposal 1 and proposal 2.*  |
| ZTE | Fine with the proposal, and agree that some timeline conditions should be met.  |
| QC | Agree with the principle of the proposal.  |
| Huawei, HiSilicon | Ok with the principle in general. However, we are already aware of the rules are only applied to the CA case where CG and DG PUSCHs are in the same carrier. So it is better to calcified this in the proposal and make it more accurate. Secondly, it seems ok to investigate the timeline conditions to implement the rule but it does not mean we need to specify any dedicate UE behaviours if the timeline is not satisfied. So we suggest to modify the proposal as following:**Proposal 1: In Rel-16, at least when time condition is met, support option 3 in principle for Case 1-6 for non-CA cases and CA cases where DG and CG PUSCHs in the same carrier, 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.**

Another question is for the proposal from Apple, may I kindly ask why the CG PUSCH is ignored? In the current design for UCI multiplexing, it is no different handling between CG and DG transmission. |
| CATT | We are fine with the proposal in principle and open to refine the wording. |
| Samsung | Agree in principle. Regarding timeline, we share same view with Huawei/HiSilicon. Since this is Rel-16 CR, we need to minimize additional new UE behaviour as much as possible.  |
| Nokia, NSB | Agree in principle, and support the Huawei rewording. |
| Apple 2 | **To the moderator**: even though we understand the intention, we should be accurate on the proposal formulation before agreeing to it. Given that Option 3 explicitly says “UCI is transmitted on PUCCH”, it is not generally applicable to all cases. Given that now we already have consensus on the principle, it could be a good time to refine the proposal now.**To Huawe/HiSilicon**: I am not sure I understand the question. Our understanding of the principle of Option 3 is that in the example case 1-6, because CG is always overridden by DG on MAC, UCI is not multiplexed on CG. This is what I mean by ignoring CG when determine which PUSCH UCI would be multiplexed on. Not sure what “In the current design for UCI multiplexing, it is no different handling between CG and DG transmission” means exactly (i.e. no difference in what sense). We know that DG overrides overlapping CG on MAC, and also in UCI multiplexing on PHY, DG has higher priority than CG.  |
| OPPO | Agree with proposal in principle |
| Intel | Agree in principle. |

* **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 (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 ).
	+ 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 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 symbols before the first symbol of the earliest PUCCH or PUSCH.**
		- **Note: 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”). |
| NTT DOCOMO | 9.2.5 of 38.213 is saying that ‘If a UE would transmit multiple overlapping PUCCHs in a slot or overlapping PUCCH(s) and PUSCH(s) in a slot and, …’. This part seems to include this proposal. In that sense, we think this discussion is not necessary. Note that even if DG PUSCH skip is not configured, CG PUSCH is dropped, i.e. DG PUSCH will be included in the timeline constraints. |
| vivo | We support the proposed time condition for Case 1-6. We think it is necessary to clarify the condition in the spec. |
| ZTE | Condition 1: Agree with condition 1 should be satisfied as in Rel-15.Condition 2: Agree the intention. It should be noted that, the overlapping channels only includes PUCCH and CG PUSCH, i.e., the multiplexing timeline should not take DG PUSCH into account. Condition 3: In addition to the legacy overriding timeline and multiplexing timeline in Condition 1 and 2 respectively, what gNB needs to ensure is the transmission of PUCCH. That is, the timeline between the ending of UL grant and the starting of PUCCH should be larger than *Tproc,1.* Thus, defining a following timeline is sufficient.* + **UE does not expect the ending symbol of UL grant for the DG PUSCH is not at least** *Tproc,1* **symbols before the first symbol of the earliest PUCCH ~~or PUSCH~~.**
 |
| QC | We agree with the spirit of FL proposal. Timeline condition 3 is needed to make sure UE can take the action due the scheduled DG PUSCH. The exactly wording can be fine-tuned a little. For example, we might want to clarify like this: …**earliest PUCCH or PUSCH among the overlapping group of PUCCH/PUSCH channels.**To ZTE and Ericsson: the timeline FL proposed is needed. Other timeline may not work. Essentially, what FL proposal says is that, we view the three channels as a group of overlapping channels (although the CG is cancelled by DG. But it is part of the group before it is cancelled). With such a group of overlapping channel, according to Rel-15 UCI multiplexing timeline, UL grant should arrive at least T\_proc2^mux time before the earliest channel among all the channels in the overlapping group. So the reference cannot just consider the earliest PUCCH. It has to consider all channels in the group, following Rel-15 principle. Another comment is that, if we agree with the above principle on timeline. The same principle should be applied to all cases – meaning check the timeline with respect to all channels in the overlapping group.  |
| Huawei, HiSilicon | Actually, two timelines have been specified in the current spec: the DG overriding CG timeline, N2, and PUCCH multiplexing timeline . Based on these two timelines, Case 1-6 can be handled without considering the possible skipping of PUSCH, and as does it considering UL skipping. Therefore, it is no need to introduce another timeline for Case 1-6. |
| Ericsson | Thanks to QC for the discussion. The is define as timeline when PDCCH scheduling PDSCH is received, how that can be used as UL grant timing restriction? Do we need to change the 38.214 description of DG override CG timing? |
| CATT | We agree with the proposal and also agree with Apple to add SP-CSI PUSCH in addition to CG PUSCH in the timeline consideration. |
| Samsung | Agree in principle. But, we realized that figure 1 can be seen as the same situation which is being discussed in [104-e-NR-7.1CRs-08] if we assume that PUCCH 🡪 PUSCH, CG/DG PUSCH 🡪 HARQ-ACK. So, same principle should be applied to all cases including figure 1 and other cases. Actually, although it is understood that the intention of current specification text (which is quoted by DCM) may not consider figure 1 well, it would be good to have a discussion if current specification text could include more general cases as well as figure 1. If needed, it’s fine to have a relevant conclusion for it.  |
| Nokia, NSB | Agree in principle. The **“UE does not expect the ending symbol … is not at least xxx symbols before…”** phrasing makes the wording unclear. perhaps **“…is less than xxx symbols before…”** |
| Apple 2 | To respond to some companies’ comments, the multiplexing timeline needs to be satisfied for the UL DCI of the DG PUSCH even though it does not overlap with the PUCCH. The reason is that the multiplexing timeline is the latest time when the UE needs to make the decision on the multiplexing of PUCCH and CG PUSCH. If the UL DCI of the DG does not arrive before the time, the UE would not take the DG into consideration when determining UCI multiplexing.In addition, we think this should be applied to Rel-15 also. |
| OPPO | Agree with proposal in principle |
| Intel | We have similar understanding as Ericsson, Huawei, DCM, et al. that the third condition listed, while necessary, is already covered by the PUCCH multiplexing timeline in Subclause 9.2.5 of 38.213.To Apple, QC, our understanding is that the phrase “group of overlapping PUCCHs and PUSCHs” in the following already cover the third condition “*the multiplexing timeline needs to be satisfied for the UL DCI of the DG PUSCH even though it does not overlap with the PUCCH*”. It is not necessary for a PUSCH in the group to necessarily overlap with another PUCCH. On the other hand, the behavior of using the PUCCH in this case to carry the UCI (content of Proposal 1) could be captured in Clause 9 (top level clause) of 38.213.

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| If a UE would multiplex CSI reports that include Part 2 CSI reports in a PUCCH resource, the UE determines the PUCCH resource and a number of PRBs for the PUCCH resource or a number of Part 2 CSI reports assuming that each of the CSI reports indicates rank 1. If 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 of the earliest PUCCH or PUSCH, among a group overlapping PUCCHs and PUSCHs in the slot, satisfies the following timeline conditions- is not before a symbol with CP starting after after a last symbol of any corresponding PDSCH, is given by maximum of where for the i-th PDSCH with corresponding HARQ-ACK transmission on a PUCCH which is in the group of overlapping PUCCHs and PUSCHs, , is selected for the i-th PDSCH following [6, TS 38.214], ….- if there is no aperiodic CSI report multiplexed in a PUSCH in the group of overlapping PUCCHs and PUSCHs, is not before a symbol with CP starting after after a last symbol of - any PDCCH with the DCI format scheduling an overlapping PUSCH, and - any PDCCH scheduling a PDSCH or SPS PDSCH release, or a DCI format 1\_1 indicating SCell dormancy, or a DCI format 1\_1 indicating a request for a Type-3 HARQ-ACK codebook report without scheduling PDSCH, with corresponding HARQ-ACK information in an overlapping PUCCH in the slotIf there is at least one PUSCH in the group of overlapping PUCCHs and PUSCHs, is given by maximum of where for the i-th PUSCH which is in the group of overlapping PUCCHs and PUSCHs, , , and are selected for the i-th PUSCH following [6, TS 38.214], is selected based on the UE PUSCH processing capability of the i-th PUSCH and SCS configuration , where  corresponds to the smallest SCS configuration among the SCS configurations used for the PDCCH scheduling the i-th PUSCH, the PDCCHs scheduling the PDSCHs or providing the SPS PDSCH releases or providing the SCell dormancy indication with corresponding HARQ-ACK transmission on a PUCCH which is in the group of overlapping PUCCHs/PUSCHs, and all PUSCHs in the group of overlapping PUCCHs and PUSCHs. |

 |
| QC2 | To moderator and Ericsson: I was assuming there is a typo in the proposal,  **should be ?** |

### 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
 |

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). |
| NTT DOCOMO | We are not sure why this discussion is necessary. Case 1-5a and 1-5b should be handled by unified way as agreed. |
| vivo | We think understanding 2 is the behavior. |
| ZTE | We don’t see a need to differentiate Case 1-5a and Case 1-5b. Understanding 2 can be applied for both. That is, when determining the multiplexing timeline, all the three channels should be considered. If the timeline is not satisfied, it is an error case, otherwise UE shall follow the behavior agreed in the last meeting. |
| QC | Understanding 2 should be the reasonable way to go. It simplifies things and keep unified behavior among the cases.  |
| Huawei, HiSilicon | We do not know why we open this issue for discussion which had been understood commonly in Rel-15. RAN1 does not have a stringent definition of the overlapping group, but it is accepted all the channels including scheduled and demined resource overlapping each other would belong to same overlapping group. So it is understanding 2, but we do not why this is related for UL skipping discussion. |
| CATT | Fine with understanding 2. |
| Samsung | Understanding 2. No need to make a proposal for the question. It is noted that current specification is clear for both cases 1-5a/b as following. If a UE transmits multiple PUSCHs in a slot on respective serving cells that include first PUSCHs that are scheduled by DCI formats and second PUSCHs configured by respective *ConfiguredGrantConfig* or *semiPersistentOnPUSCH*, and the UE would multiplex UCI in one of the multiple PUSCHs, and the multiple PUSCHs fulfil the conditions in Clause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in a PUSCH from the first PUSCHs. |
| Nokia, NSB | Not sure why this discussion is relevant. |
| OPPO | Fine with understanding 2 |
| Intel | Understanding 2. Also, in response to the following statement from the Moderator:“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.”*For Rel-15, the “group definition” is still as per Understanding 2 (i.e., includes all three channels in these examples), irrespective of whether MAC has data for the CG PUSCH grant.  |

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. |
| NTT DOCOMO | In the conclusion in RAN1#103-e, UCI shall be multiplexed on the DG PUSCH. No need to have different behavior. |
| Vivo | We support the clarification based on understanding 2. |
| ZTE | We are not sure why we need to discuss Understanding 1, which is against the agreements achieved in the last meeting. |
| QC | We don’t see the need for this proposal by further partition case 1-5 to 1-5a and 1-5b. If clarification is need, I think we should clarify understanding 2 is the definition of a group of overlapping channels.  |
| Huawei, HiSilicon | Same as the conclusion in RAN1 #103-e. |
| CATT | Another issue we brought up in [2] is that for CA case with different numerology, for case 1-5b, UE does not multiplex UCI in DG PUSCH according to current rule if CG PUSCH is in an earlier slot as shown below.Given that the agreement in the last meeting was to deliver PDU to the PUSCH which is used for UCI multiplexing, we propose to update the agreement to consider the above mentioned case.Proposal: For case 1-5, for CA and non-CA, when there is a single PHY priority for UL transmissions and PUSCH repetition is not applied, MAC generates PDU for the PUSCH selected for UCI multiplexing based on the PUSCH selection rule in PHY and the UCI is multiplexed on the selected PUSCH. |
| Samsung | No need to make a proposal for clarification. Current specification is already clear.  |
| Nokia, NSB | Concluded already, no need to make a proposal for clarification. |
| Apple 2 | Regarding the case mentioned by CATT, we are still quite struggling to figure out which part of the specs describes that the PUSCH in the earliest slot should be prioritized in UCI multiplexing, even though it was captured in the agreements. It is unclear whether UE implementation would actually do this or not if the specs do not reflect it.With this said, CATT’s proposal seems to well reflect the spirit of the agreements that had been made. |
| OPPO | Agree to go to understanding 2. |
| Intel | With understanding 2 in response to previous question; we do not see any need for further clarifications.  |

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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 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?  |
| NTT DOCOMO | Agree with principle and Apple’s update seems good.Regarding ‘any PUSCH’ instead, we think it is not aligned with the current spec. gNB knows that the DG PUSCH is not transmitted due to lack of DG PUSCH at the initial slot, so blind decoding would not the issue. |
| vivo | We support the proposal.For DG PUSCH with repetitions, in case of PUCCH overlapping with the repetitions other than the first repetition, it is beneficial for UE to reduce the power consumption and avoid unnecessary transmissions for a padding TB on the non-overlapped PUSCH repetitions if UCI is transmitted on the PUCCH. |
| *(Moderator’s comment)* | *On Apple’s question, the note is to clarify the first PUSCH repetition for DG PUSCH case is the first actual repetition. To make it clear, the note can be revised as follows***Note for DG PUSCH with repetitions, the first PUSCH repetition is the first ~~transmission occasion of the~~ actual repetition~~s among the repetition bundle~~** |
| ZTE | Do not support the proposal.For both PUSCH repetition type A and type B, our understanding is the UCI multiplexing timeline check is only for the repetitions that overlap with PUCCH, and the UCI is only multiplexed on the overlapping repetitions. Similarly, if UL skipping is configured, MAC PDU generation and also UCI multiplexing is only for the overlapping repetitions. In brief, **when a PUCCH is overlapped with one or more PUSCH repetitions of a DG PUSCH, MAC generates MAC PDU for the one or more repetitions of the DG PUSCH and delivers the MAC PDU(s) to PHY and the UCI is multiplexed on the the one or more repetitions of the DG PUSCH. All of the remaining PUSCH repetitions are skipped.** Note that, according to RAN2 spec, the repetitions after the first repetition is regarded as a retransmission, each repetition is a separate UL grant. Thus, MAC layer generates MAC PDU based on each repetition. Thus, it can only generates the MAC PDU for the overlapping repetition while not for other repetitions.

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| *If REPETITION\_NUMBER > 1, after the first transmission within a bundle, at most REPETITION\_NUMBER – 1 HARQ retransmissions follow within the bundle. For both dynamic grant and configured uplink grant, bundling operation relies on the HARQ entity for invoking the same HARQ process for each transmission that is part of the same bundle. Within a bundle, HARQ retransmissions are triggered without waiting for feedback from previous transmission according to REPETITION\_NUMBER for a dynamic grant or configured uplink grant unless they are terminated as specified in clause 6.1 of TS 38.214 [7]. Each transmission within a bundle is a separate uplink grant delivered to the HARQ entity.* |

In addition, HARQ-ACK can only be multiplexed in a PUSCH if the DL grant scheduling PDSCH corresponding to the HARQ-ACK is before the UL grant scheduling the PUSCH. Thus, when receives UL grant for DG PUSCH, it already knows whether would be PUCCH overlapping. If one repetition overlaps PUCCH, MAC PDU should be generated for that repetition. This could also save UE power for unnecessary transmissions and could allow gNB to reschedule transmissions on the resources of skipped PUSCH repetitions.  |
| QC | We Support the first sub-bullet but not the second sub-bullet. The reason is that the second sub-bullet is against the principle we had to handle Rel-15 UL skipping. gNB does not know UCI will be transmitted on PUCCH or PUSCH. Following the principle of UL skipping, UE should always multiplex the UCI on PUSCH, as if the UL skipping feature is disabled. Then we need make a change on the UCI multiplexing timeline. Rel-15 UCI mux timeline for PUSCH repetitions is defined with respect to the actual PUSCH overlap with the PUCCH. We need change the timeline definition to push the reference of timeline to the beginning of the PUCCH repetition (i.e., the first PUSCH in the repetitions).  |
| Huawei. HiSilicon | We prefer the solution that the MAC PDU generation is determined the overlapping between first PUSCH repetition and PUCCH. If the overlapping exists, a MAC PDU is generated for UCI multiplexing in the first PUSCH repetition and all the repetitions cannot be skipped. Otherwise, all repetitions are dropped and UCI is transmitted on PUCCH. So the proposal 3 seems fine in principle and Apple’s update is also acceptable. |
| Ericsson | We agree with QC there’s implementation complexity for gNB and UE with the proposal 3. On ZTE’s proposal, if gNB cannot decode that single PUSCH correctly, which is most likely to occur when gNB configured repetition, retransmission for the dummy may happen, and the gNB may also fail to decode UCI. Our first proposal is aiming to optimize the timeline situation when repetition is being used.Maybe the simple approach is more acceptable: MAC always generates MAC PDU for the DG if there’s PUCCH overlapping with any of the repetitions. The timeline for multiplexing shall consider all repetitions, start from the first repetition, despite of if the PUCCH overlapping with the first PUSCH repetition. |
| CATT | We are fine with the intention of the proposal and agree with Apple’s update. |
| Samsung | Agree in principle. Need to check whether ZTE’s understanding is aligned with RAN2 group. At least, our understanding is that MAC cannot generate MAC PDU per each repetition.  |
| Nokia, NSB | The ZTE proposal to transmit only those PUSCH instances that overlap with the UCI is attractive. the gNB can still combine the PUSCH over the full set of slots and combine some noise to the PUSCH, but it doesn’t matter as the PUSCH is dummy PDU anyway, while it knows the slots in which the UCI is multiplexed and can extract them normally.Qualcomm proposal would seem to effectively result with a lot of timeline violations due to the UCI trigger not being sufficiently early before the PUSCH start. This would either lead to the UCI dropping (which we definitely do not want), or transmitting UCI on PUCCH, which would be the same as the moderator proposal. Not sure which of these two behaviours Qualcomm had in mind. |
| Apple 2 | We do not think MAC can generate MAC PDU on a per-repetition basis. The PDU would be generated for the first repetition, and all the remaining repetitions are simply retransmissions. So we do not think ZTE’s proposal would work. In addition, when the UE transmits just a few repetitions and gNB fails the decoding, gNB has no idea that the PUSCH contains only padding and it would schedule retransmission for the PUSCH. This does not bring any benefit.From UE perspective, it is strongly preferred the determination is based on the first repetition only, because current specs would not require the UE to check all the repetitions in the future (which can be complicated) and it allows each repetition to be processed independently.On QC’s comments, the idea here is that the gNB (if it wants to avoid multiple hypothesis) would need to determine which PUSCH UCI is multiplexed based on whether the first repetition has been transmission or not. This determination can be done e.g. using DMRS detection. This had been extensively discussion in URLLC and had been considered reliably enough for URLLC. (Alternatively, gNB can avoid scheduling too complicated overlapping cases with repetitions.) |
| OPPO | Agree with proposal in principle |
| Intel | We are supportive of the proposal and the updates from Apple, and agree with the reasoning from Apple on why BD at gNB should not be an issue. If timeline needs to consider the first PUSCH repetition and then multiplex, in addition to making the constraint rather strict in most cases, this also leads to unnecessary UL transmissions.  |
| QC | To Apple’s comment about gNB can do blind detection based on DMRS: 1) I am not sure how reliable it is. Whether gNB implemented this feature or not. I will let gNB vendors to comment 2) this seems against the principle we had since day 1 on this issue. The reason that we had this problem to begin with is gNB does not do multiple blind hypothesis test. 3) If we consider CA, the PUCCH overlap with a set of parallel PUSCH with repetitions, then gNB needs to do quite a few hypothesis test (based on DMRS detection) to figure out where the PUCCH goes…  |
| Intel2 | On the issue of reliability raised by QC, we now realize that, *in the context of repetitions*, reliability may indeed be an issue if relying on detection based on the first PUSCH (including its DMRS). Thus, we acknowledge that, depending on link conditions, such may not always be feasible, especially if the number of repetitions is large. Considering this, we would also err on the side of robustness and practicality over efficiency, and would be supportive of defining the timeline w.r.t. first PUSCH repetition for the second sub-bullet.  |
| Huawei, HiSilicon 2 | We have a sympathy with Apple 2’s explanation. From UE implementation perspective, it will regard the non-initial repetitions as the retransmissions of the first repetition. As the first PUSCH repetition has no data to transmit and no overlapping with PUCCH either, the MAC PDU is not received by the PHY layer. That means there is no initial transmission, so there is no retransmission as well. From the gNB perspective, the repetition of PUSCH is enabled for the UEs at cell edge, the undesirable channel conditions will lead to detection failure of PUSCH if only the ones overlapping with PUCCH are received. However, gNB has no idea about the TB is containing padding bits or actual data. gNB may schedule another retransmission which is unnecessary.For the point from QC that the multiplexing timeline is shifted to the starting PUSCH, we do not think so. The timeline is related to the overlapping. If there is overlapping, the timeline applied, if no, no timeline is performed. So there is no change on multiplexing timeline definition.  |

* **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”. |
| NTT DOCOMO | Agree with Apple’s update.We prefer option 2 with update as “…**the actual repetitions ~~that are associated with RV=0~~ available for initial transmission**”. Detailed condition is described in 38.214. As you know, “**that are associated with RV=0 for initial transmission**” is not accurate, so either only saying ‘available’ or adding detailed condition would be better. Rewording suggested by Apple is also fine for us. |
| vivo | We support the proposal.For CG PUSCH with repetitions, MAC can only be able to generate PDU for CG PUSCH on any of the transmission occasions of the actual repetitions where the UE may start the initial transmission according to TS 38.214. When a DL grant scheduling a PUCCH overlapping with the CG PUSCH repetitions comes after MAC decided not generating CG PUSCH due to no data, the UCI cannot be multiplexed on CG PUSCH. |
| ZTE | For the first two sub-bullets, we have similar comments as DG PUSCH repetition. Since there is no need to differentiate the first repetition. The last sub-bullets are not needed correspondingly.  |
| QC | We Support the first sub-bullet but not the second sub-bullet. The reason is that the second sub-bullet is against the principle we had to handle Rel-15 UL skipping. gNB does not know UCI will be transmitted on PUCCH or PUSCH. Following the principle of UL skipping, UE should always multiplex the UCI on PUSCH, as if the UL skipping feature is disabled. Then we need make a change on the UCI multiplexing timeline. Rel-15 UCI mux timeline for PUSCH repetitions is defined with respect to the actual PUSCH overlap with the PUCCH. We need change the timeline definition to push the reference of timeline to the beginning of the PUCCH repetition (i.e., the first PUSCH in the repetitions).The last bullet is low level detail. It can be decided later. Our preference is option 1.  |
| Huawei, HiSilicon | Ok with the proposal in principle, but we think another sub-bullet as option 3 should be added:* + **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**
		- **Option 3: the first repetition is the first transmission occasion of the actual repetitions that are associated with RV=0 for initial transmission**

The purpose to introduce MAC PDU generation for skipping PUSCH is avoiding the blind decoding in gNB side. So from the NW perspective, it has nearly no difference to use option 2 or option 3 as the first CG PUSCH repetition. However, for the UE perspective, it only needs to judge the multiplexing and MAC PDU generation once for option 3 comparing to check each possible occasion in option 2. The complexity of option 3 in UE is less. Therefore, we think option 3 should be added for further studied.  |
| Ericsson | Similar solution of DG and CG is preferred. We can decide on DG first. |
| CATT | Similar as proposal 3, we agree with the intention and the update from Apple.For the two options, we prefer option 2 with the update from Apple. |
| Samsung | Agree in principle. Considering that a UE would transmit actual CG PUSCH based on option 2, option 2 seems nature choice. Anyhow, if UE would have PDU generated from MAC, UE will transmit data on configured grant resource associated RV=0.  |
| Nokia, NSB | The same behaviour should be adopted as for the question 5. |
| OPPO | Agree with proposal in principle. For two options, we prefer option 2 updated by Apple. |
| Intel | Agree in principle, as for Question 5, including the rephrasing from Apple. |

## 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.
 |
| *Moderator’s comment* | On Apple’s comments, for the following candidate, at least from my understanding, it should be the common understanding for determining the PUSCH for UCI multiplexing.* 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

For the case of multiple CG configurations with the same starting time, how to choose CG configuration from multiple CG configurations is up to UE implementation, according to 38.321. Defining the rule to select the CG occasion in case of multiple CG configurations would be a new behavior for UE, which may have impact on the MAC spec. On the other hand, for gNB, if multiple CG configurations are configured with the same starting time, gNB should be able to do detection for CG with multiple hypotheses.

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| **38.321**5.4.1 UL Grant receptionNOTE 7: If the MAC entity is not configured with *lch-basedPrioritzation* and if there is overlapping PUSCH duration of at least two configured uplink grants, it is up to UE implementation to choose one of the configured uplink grants. |

 Furthermore, since these clarifications may not be associated with UL skipping only and seem to be general issue for UCI multiplexing, we can collect more views from companies on these aspects. |
| QC | We would like to understand the issue Apple raised is in Rel-15 or Rel-16? For Rel-15, we prefer not introducing any change to spec unless it is critical. If a spec has ambiguity for corner cases, it is fine. For Rel-16, it can be further discussed.  |
| Apple 2 | To clarify, the issues are for Rel-16, because now we are doing UCI multiplexing determination based on the grants, while in Rel-15, the determination is based on the actual PUSCH transmission after MAC delivers PDU to PHY. We agree these discussions can come later after we agree on the main aspects.Regarding the multiple CG configurations with the same starting time, we propose this to align with the spirit that the gNB would not need to do multiple hypotheses. All the agreements we have made have impact on MAC, and we think the extent of the impact from this one is similar to the impact from the agreements made. Moreover, this issue is specific to the new behavior we introduced for Rel-16 UL skipping, because now the UCI multiplexing decision is made considering all the grants (where we could have multiple overlapping CGs on a serving cell). But anyway, this can be discussed more later. |

# 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.
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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.