3GPP TSG RAN WG1 #105-e R1-21xxxxx

e-Meeting, May 10th – 27th, 2021

Source: Moderator (vivo)

Title: Summary of discussion on remaining issues on UL skipping for PUSCH (Rel16)

Agenda Item: 7.1

Document for: Discussion and Decision

# Introduction

The document provides a summary for the email discussion thread [xxx] Discussion on PUSCH skipping with UCI overlapping for Rel-16 only. To make the discussion more efficient, following check points are planned. **Note that the deadline for the discussion for the email thread is 5/27.**

* 1st check point: **5/20 UTC 23:59 pm. Please provide your comment on the discussion point 1 in session 2.1, which is high priority. After that, possible proposals will be made based on the input.**
* 2nd check point: 5/24. To focus on the possible proposals in 1st check point and the discussion points 2 in session 2.2.
* 3rd check point: 5/27. Final check.

# Discussions

## Discussion point 1 (1st round)

### DG PUSCH skipping with repetitions

Regarding the issue of PUSCH skipping with repetitions, we already have intensive discussions for two meetings. Unfortunately we have not achieved consensus for this issue yet. Among the above options, there are both pros and cons for each option. It may be difficult to find out a perfect solution. In principle, the goal is to figure out a solution that lead to a deterministic behavior in terms of PUSCH transmissions from the UE and avoid any additional blind detection efforts at the gNB.

In RAN1 #105-e, [1-12] discussed the issue of PUSCH skipping with repetitions.

The proposals and views from companies are summarized as below, including the options in the summary of last meeting (R1-2104073) and the new proposals in this meeting.

* **Option 1:** When there’s a UCI to be multiplexed on any of the repetitions of the DG PUSCH, MAC generates MAC PDU for the DG PUSCH and delivers the MAC PDU(s) to PHY and the UCI can be multiplexed on the DG PUSCH.
  + MAC generate MAC PDU for all DG PUSCH repetitions
  + Note: the UCI multiplexing timeline condition for the first repetition of DG PUSCH should be ensured
  + *Supported by:*
* **Option 2:** 
  + When there’s UCI overlapping with the first PUSCH repetition of the DG PUSCH, 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 UCI is overlapping with the repetitions other than the first PUSCH repetition.
  + *Supported by:*
* **Option 3:** 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.
  + *Supported by: Spredtrum, CATT, Apple, DCM*
* **Option 3’**: When a PUCCH is overlapped with the first **X** 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 X PUSCH repetition, if there is no PDU including data delivered from MAC, the DG PUSCH can be skipped. UCI is transmitted on the PUCCH.
  + The value of X can be 1 or 2
  + *Supported by: CATT (FFS the value of X), Huawei, DCM (configurable X)*
* **Option 4:** Rel-16 PUSCH skipping and PUSCH repetitions are not allowed to be enabled together (error case is defined).
  + *Supported by:*
* **Option 5:** When PUSCH repetition is configured,
  + if a PUSCH repetition overlaps with PUCCH, MAC generates PDU for the repetition,
  + otherwise, MAC does not generate PDU for the repetition if there is no data for the DG PUSCH.
  + *Supported by: ZTE*
* **Updated Option 6:** When PUSCH repetition is configured,
  + MAC layer behavior: For a PUSCH configured with repetitions, MAC always generate a PDU. If MAC has data in buffer, MAC generate a real PDU; otherwise, MAC generate a dummy PDU. MAC use 1-bit to indicate PHY that the PDU is a dummy PDU or a real PDU.
  + PHY layer behavior: Each PUSCH repetition independently check whether it overlaps with a PUCCH or not.
    - If it overlaps with a PUCCH, that PUSCH repetition cannot be skipped, and UCI is multiplexed on the PUSCH repetition.
    - If it does not overlap with any PUCCH,
      * if the 1-bit indication indicates a dummy PDU, this PUSCH repetition is skipped.
      * If the 1-bit indication indicates a real PDU, this PUSCH repetition is not skipped.
  + *Supported by: QC*
* **Option 7:** When a PUCCH is overlapped with any of the first X 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.
  + UE does not expect a UCI is overlapping with the repetitions other than the first X PUSCH repetition
  + The value of X is 2
  + *Supported by: QC~~, DCM (configurable X)~~*

**New proposals in RAN1 #105-e**

* **Option 8:** When a PUCCH is overlapped with any of the first X 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.
  + UE does not expect to be configured with K > X when UL skipping is configured.
    - X can be 2 or 4.
  + *Supported by: vivo*
* **Option 9:** When a UCI would be multiplexed on a slot of a PUSCH repetition bundle that would be skipped:
  + If the UCI trigger comes “early enough” for the UE to be able to generate the dummy PDU starting from the 1st instance of the PUSCH repetition bundle:
    - UE behaviour is as in option 1, i.e. a dummy PDU is generated and the UCI is transmitted on PUSCH
  + If the UCI trigger comes “too late” for the UE to be able to trigger the dummy PDU starting from the 1st instance of the PUSCH repetition bundle:
    - As the PUSCH was not triggered, the UE transmits UCI on PUCCH
  + The “early enough” vs. “too late” is determined by at least the minimum PUSCH processing time.
    - FFS additional UE processing time budget on top of the minimum PUSCH processing time is specified.
  + *Supported by: Nokia, Ericsson*

The arguments for these options are summarized as below. If there is anything missing or misunderstanding, please point it out.

|  |  |
| --- | --- |
| **Options** | **Arguments** |
| Option 1 | * option 1 would be predictable and work the same way as when no PUSCH repetition is used. * Option 1 is not feasible in case of CG PUSCH since UE cannot be aware of the collision before the transmission of the first repetition. * Option 1 introduces complexity for UE implementation. |
| Option 2 | * Option 2 would bring large restrictions to the network scheduling * Option 2 is friendly for UE implementation |
| Option 3 | * UE has to implement two different alternatives depending on where the UCI is multiplexed, and the gNB (potentially) has to blindly detect whether it should receive PUSCH and PUCCH. * Option 3 requires gNB to perform blind detection on PUCCH or PUSCH due to unreliable detection for the first repetition. |
| Option 3’ | * when PUCCH dynamic scheduled by a DCI is overlapped with the 2nd CG-PUSCH repetition, UCI multiplexing timeline in Rel-15, the UE expects the first symbol of the earliest PUCCH or PUSCH, among a group overlapping PUCCHs and PUSCHs in the slot, satisfies the timeline conditions. However, if Option 3’ is adopted for CG-PUSCH too, the UCI multiplexing timeline should be changed. E.g. UE expects the first symbol of the earliest PUCCH or PUSCH repetition 1 satisfies the conditions. It implies the timeline is changed compared with Rel-15. |
| Option 4 | * Option 4 would bring large restrictions to the network scheduling |
| Option 5 | * with the network not knowing if the transmitted PUSCH is a dummy PDU or information carrying PDU it would try to combine the different PUSCH instances and fail with the decoding of the PUSCH. This would not only lead to (potentially several) retransmission attempt(s) for the dummy TB, but also lead to confusion for the outer loop link adaptation and uplink power control algorithms. * Option 5 need to change MAC spec and complicate UE implementation. |
| Option 6 | * with the network not knowing if the transmitted PUSCH is a dummy PDU or information carrying PDU it would try to combine the different PUSCH instances and fail with the decoding of the PUSCH. This would not only lead to (potentially several) retransmission attempt(s) for the dummy TB, but also lead to confusion for the outer loop link adaptation and uplink power control algorithms. * Option 6 need to change MAC spec and complicate UE implementation. |
| Option 7 | * option 7 was brought in as a possible bridge between option 1 and option 3, but it still has the timeline issue of option 1 * option 7 has the same drawbacks with option 1 and option 2. |
| Option 8 | * UL skipping and large number of repetitions do not need to be configured simultaneously. To avoid too much increased UE implementation complexity, gNB can configure small number of repetitions when UL skipping is enabled. |
| Option 9 | * Option 1 behaviour maintains commonality with the non-repetition case and does not require blind decoding in the gNB * The fall-back behaviour when the UCI trigger comes too late eliminates the concern of being able to schedule DL and the related UL without having to delay the UCI when not knowing if the CG-PUSCH will be present or not. * This fall-back behaviour is the same as if the PUSCH is not triggered and should maintain UE implementation commonality. |

Since these options have been discussed intensively, including the pros and cons of each options, please indicate your views on these options in the following table. It is quite understandable that each company has preference over their schemes. However, I hope we can be more constructive and flexible because we’re at a point that we have to make decision.

**Q1-1: Please indicate your views on the options.**

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| --- | --- | --- | --- |
| **Company** | **Which option(s) is your 1st preference?** | **Which option(s) is acceptable?** | **Which option(s) is NOT acceptable?** |
| NTT DOCOMO | 3, 3’ | 1, 9 | 2, 4, 5, 6, 7, 8 |
| Ericsson | 9 | 1,3,3’,8,7 | 4,5,6,2 |
| Apple | 3 | 2, 4, 5, 6,  3’, 7 and 8 with timeline relaxation only | 1, 9 |
| OPPO | 4 | 2,3 | 1, 5, 6, 9 |
| QC | 6 | 2,7,1,4 | 3,3’,9 |
| Spreadtrum | 3 | 2, 3’,4, 7 | 1 |
| ZTE | 5, 6 | 1, 8 | 2, 3, 3’, 4, 7, 9 |
| Samsung | 3 | 4, 1 | 2, 5, 6, 7, 9 |
| Huawei, HiSilicon | 3 | 3’ | 2, 4, 5, 6, 7, |
| CATT | 3, 3’ | 1, 4 | 2, 5, 6, 7, 8, 9 |

**Q1-2: Please provide your comment if any.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| NTT DOCOMO | Sorry, I misunderstood Option 7 as Option 3’ in our contribution. I corrected our preference as above with Red color. |
| Ericsson | The reason we are objecting for 5 and 6 is because when repetition is enabled at gNB, usually the UE is at cell edge or bad radio condition, the detection of omitted PUSCH is not feasible. Option 2 and 4 are extremely limiting the usage of ULSkipping and therefore not acceptable.  Our second preference is: 1,3, 3’,8  Acceptable: 7 |
| Apple | Our first preference is option 3, but we are open to consider some of the other options.  Option 1 and 9 are not acceptable to us due to the significant burden on UE processing to check all repetitions for UCI multiplexing.  Option 3’, 7 and 8 has similar impact on UE processing as option 1 and 9, but given that the number of repetitions to check is small, it becomes feasible for us if some timeline relaxation is provided. On the other hand, we feel Option 3’, 7 and 8 with timeline relaxation may not be the most desirable approach because it brings additional complexity to the already complicated timeline consideration in NR. |
| OPPO | We prefer to Option 4, because it is so-far the only settlement (though not from performance perspective) that always exists there to end this long-time debate.  We share the concern from Apple on Options 1 and 9. The new Option 9 does not solve the concern on UE implementation complexity which has to deal with the worst case – Option 9 seems to just try to identify a condition for that worst case, rather than to simplify the worst case. |
| QC | We cannot accept option 3,3’ and 9. Option 3/3’ creates unified behavior between with and without PUSCH repetition, that double UE implementation effort to support the UL skipping feature. Option 9 requires UE to check timeline. If timeline is satisfied, do behavior A; otherwise do behavior B. This timeline check dependent behavior is not acceptable to us. In Rel-15/16, UE is not required to check timeline and it is gNB’s responsibility to check timeline and make sure timeline is satisfied. Proposal 9 will have huge impact to UE implementation, while with little or zero benefit.  Regarding option 2 or 7, I think there is a misunderstanding. The restriction of option 2 or 7 to NW scheduler is not that large as we thought before. Take option 2 as an example, if there is already a UCI overlap with the first repetition, other/future UCI of course can overlap with the non-first repetitions. Therefore, NW could schedule a dummy PUCCH or intentionally put P-CSI overlap with first repetition of CG PUSCH, then there is no restriction for NW’s future scheduling. I am not saying option 2/7 has no restriction to scheduling. But in my view, there is a way to bypass the restriction, with some effort/cost, of course.  Based on above, we think option 2 and 7 should be updated as following.   * **Option 2:**    + When there’s UCI overlapping with the first PUSCH repetition of the DG PUSCH, 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 UCI is overlapping with the repetitions other than the first PUSCH repetition, if there is no UCI overlapping with the first PUSCH repetition. * **Option 7:** When a PUCCH is overlapped with any of the first X 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.   + UE does not expect a UCI is overlapping with the repetitions other than the first X PUSCH repetition, if there is no UCI overlapping with the first X PUSCH repetitions.   + The value of X is 2   For option 8, we have a question for clarification, what is K in the sub-bullet? Is it the number of repetitions? What is the difference between option 8 and option 1? To me, they seem the same. Please let me know if missed anything. |
| Spreadtrum | Our first choice is still Option 3.  However, we are will to accept Option 2, 3’, 4, 7. The main concern for Option 3’ is when same solution applies to DG and CG PUSCH, there is a multiplexing timeline change as shown in our paper for CG-PUSCH, while there is no such timeline issue for DG-PUSCH since UL grant is always the last DCI among the other related DL DCIs. Thus for DG-PUSCH, Option 3’ is acceptable, however, is not a good choice for CG-PUSCH.  We cannot accept Option 1 due to unlimited UCI multiplexing check. |
| ZTE | Our preferences are option 5 and option 6 because there is no network configuration restriction or blind detection issue at the gNB. In addition, for the operation for a repetition, the UE does not need to check the overlapping between the PUCCH and the other repetitions since each repetition is operated independently.  For option 2, 4, 7, there is a big network configuration restriction. For option 3 and 3’, the network needs to determine the UE behavior according to the detection of the first PUSCH repetition. It is not acceptable since the detection may not be reliable under a bad radio condition as pointed out by Ericsson. For option 9, many details need to be discussed, which is not acceptable at this stage. |
| Samsung | Option 3 is preferable.  For option 2 and 7, it provides a limited scheduling flexibility to gNB side. For option 5, it is understood that MAC should be changed, accordingly. Considering very late stage of Rel-16 CR, it should not be pursued. For option 6, we share the view such that this can increase unnecessary retransmission because gNB doesn’t know whether this is dummy TB or not. For option 9, timing check may bring another UE implementation burden, especially, if we consider CG PUSCH together since initial transmission of CG PUSCH is not fixed as DG PUSCH. |
| Huawei, HiSilicon | Our first preference is option 3, and option 3’ is the second priority.  For option 2 and option 7, they introduce more scheduling restrictions on gNB which are not necessary. We do not understand the meaning of dummy PUCCH explained by QC either, and it should be always avoided to have redundant scheduling for an efficient system.  Option 5 and 6 rely on the UE judgement (by MAC or PHY layer) of overlapping to transmit a padding MAC PDU which is unknown for gNB, so UL-SCH decoding failure may high likely happen due to less number of repetitions, and further retransmission will be indicated by gNB. On the other hand, option 5 redefines a MAC PDU generation procedure and generate PDUs repetition by repetition. More standard efforts and research are needed in both RAN1 and RAN2, which is not preferred in such late CR stage of Rel-16.  We do not totally understand the K meaning in option 8, FL may make it clearer.  For option 9, we think it does not fix the issue in the end. The MAC PDU is generated due to the UCI will be multiplexed on the PUSCH, and multiplexing should satisfy the timeline condition. However, it does not mean MAC PDU has to be generated when the grants come enough early. |
| CATT | Our preference is option 3 and 3’.  It seems that the concern for option 3 and 3’ is that the UE behavior is different for PUSCH with and without repetition. But it is not a problem in our view. For example, the UE behavior in terms of multiplexing/dropping is different for PUCCH with and without repetition. In addition, in case LCH-based prioritization is enabled, the UE behavior is also different from the case when LCH-based prioritization is not enabled.  In addition, no additional timeline is needed for Option 3 so that we can have a unified solution for both DG and CG PUSCHs. |

## Discussion point 2 (2nd round)

### DG PUSCH skipping with repetitions

To be updated after discussion in 1st round

### Clarification on time restriction for DG PUSCH repetitions overlapping with PUCCH

Regarding the time restriction for DG PUSCH repetition with overlapping PUCCH, it should be pointed out that, in Rel-15, the time restriction of DCI triggering UCI overlapping with PUSCH is specified, i.e. the DCI triggering the UCI should be before the DCI scheduling the PUSCH overlapping with the UCI. For all the above options, such restriction should be followed. Therefore, the DCI triggering UCI will come “early enough” in case of PUSCH repetitions, which will ensure sufficient time for UCI multiplexing on any of the PUSCH repetitions. If deemed necessary, we can further discuss whether additional UE processing time budget is needed.

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| **38.213**  9 UE procedure for reporting control information  A 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. |

**Proposed clarification: When DG PUSCH repetitions and UL skipping are configured, the DCI triggering the UCI should be before the DCI scheduling the PUSCH (with repetitions) overlapping with the UCI, according to the Rel-15 defined time restriction of DCI triggering UCI overlapping with PUSCH in clause 9 of 38.213.**

**Q2: Do you agree on the above clarification on the time restriction for PUSCH repetitions. Please provide your comment if any.**

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| **Company** | **Comment** |
| Apple | We raised one question in our RAN1#104b-e contribution on the quoted spec text: whether a case in the figure is allowed by the spec. We agree that if the DL DCI indicates HARQ-ACK overlapping with PUSCH, the DL DCI needs to come before the UL DCI. However, it is not completely clear whether there could be a DL DCI that overrides a previous overlapping HARQ-ACK and makes it no longer overlap. In the example below, DL DCI1 indicates HARQ-ACK overlapping with PUSCH rep#2, so DL DCI1 has to be before UL DCI according to the spec. However, is DL DCI2 allowed that indicates HARQ-ACK no longer overlapping with PUSCH? If this case is not precluded, we would have timeline issue with e.g. Option 1 for DG.  A screenshot of a computer  Description automatically generated with medium confidence |
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### CG PUSCH skipping with repetitions

It is proposed by companies that unified solution is adopted for DG PUSCH skipping with repetitions and CG PUSCH skipping with repetitions. Some companies propose that the definition of first PUSCH repetition can be different for CG PUSCH, i.e. the first PUSCH repetition is defined as any of the transmission occasions of the (actual) repetitions that are associated with RV=0 for initial transmission.

**Possible proposal: For CG PUSCH skipping with repetitions, same solution is adopted as DG PUSCH skipping with repetitions, with the following exception.**

* **the first PUSCH repetition is defined as any of the transmission occasions of the (actual) repetitions that are associated with RV=0 for initial transmission.**

**Q3: Please provide your comment if any.**

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| **Company** | **Comment** |
| Apple | We prefer to defer this discussion after DG is concluded. Given the different options on the table for DG, this proposal may no longer be generally applicable for all the options. |
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In [9], it was discussed that for CG PUSCH, there is no time restriction of gNB scheduling as DG PUSCH case in current spec. So for CG with repetitions, a timeline would be needed to ensure the DCI triggering UCI comes “early enough” to trigger PDU generation for PUSCH for UCI multiplexing. In order to ensure the UCI multiplexing on the CG PUSCH Tx occasion, follow timeline can be defined for the CG PUSCH with repetitions when there’s UCI overlapping with any of the CG PUSCH repetitions.

* When UE is scheduled a PUCCH overlapping with a CG PUSCH transmission occasion corresponding to any transmission opportunity, the DCI scheduling the PUCCH needs to be received before before the CG PUSCH transmission occasion corresponding to an initial transmission opportunity

**Q4: Please provide your comment if any.**

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| **Company** | **Comment** |
| Apple | Similar as Q3, we prefer to defer this discussion after DG is concluded |
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### Potential spec change for PUSCH skipping with repetitions

The potential spec change due to UL skipping with PUSCH repetitions will be discussed after there is conclusion on the issue of UL skipping with repetitions. Following draft CR can be the starting point once the corresponding behaviour would be agreed.

For option 8, [10] provides a draft CR as below.

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| When a UE is configured with *enhancedSkipUplinkTxDynamic* with value *true* or *enhancedSkipUplinkTxConfigured* with value *true*,   * If a UE would transmit a PUSCH with repetition Type A and the UE would transmit a PUCCH with HARQ-ACK and/or CSI information over a single slot that overlaps with one or more PUSCH repetitions of the PUSCH transmission in a slot, and the UE generates a transport block as described in [10, TS38.321], the UE multiplexes HARQ-ACK and/or CSI information in the one or more PUSCH repetitions of the PUSCH transmission. * If a UE would transmit a PUSCH with repetition Type B and the UE would transmit a PUCCH with HARQ-ACK and/or CSI information over a single slot that overlaps with one or more actual PUSCH repetitions of the PUSCH transmission in a slot, and the UE generates a transport block as described in [10, TS38.321], the UE multiplexes HARQ-ACK and/or CSI information in the one or more actual PUSCH repetitions of the PUSCH transmission. * For PUSCH repetition Type A, if *numberOfRepetitions* is present in the resource allocation table, the UE does not expect to be configured with any entry of *numberOfRepetitions* > 2; elseif *numberOfRepetitions* is not present in the resource allocation table, the UE does not expect to be configured with *pusch-AggregationFactor* > 2 for PUSCH scheduled by DCI format 0\_1 or 0\_2 in PDCCH with CRC scrambled with C-RNTI, MCS-C-RNTI, or CS-RNTI with NDI=1, or configured with *repK* > 2 for both Type 1 and Type 2 PUSCH transmissions with a configured grant [6, 38.214]. * For PUSCH repetition Type B, the UE does not expect to be configured with any entry of *numberOfRepetitions* > 2 in the resource allocation table [6, 38.214]. |

For option 9, [2] provides a draft CR as below.

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| If the UE is configured with *enhancedSkipUplinkTxDynamic* as *true*, and if the UE would multiplex UCI on a PUSCH slot of a PUSCH transmission over multiple slots,   * the UE multiplexes the UCI on PUSCH if the transmission of the PUSCH transmission over multiple slots would not start before after a last symbol of the corresponding PDCCH that triggered the UCI * The UE transmits the UCI on PUCCH otherwise. |

### Others

A TP for the timeline condition for Case 1-6 is provided [5].

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| 9.2.5 UE procedure for reporting multiple UCI types < Unchanged part is omitted >  If a UE would transmit a group of overlapping PUCCHs and PUSCHs including a first transmission set of multiple overlapping PUCCHs in a slot or overlapping PUCCH(s) and PUSCH(s) in a slot, and a second transmission set of PUCCH/PUSCH that overlaps with any transmission of the first transmission set when *enhancedSkipUplinkTxDynamic* is configured and *lch-basedPrioritization* is not configured 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 group of overlapping PUCCHs and 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], is selected based on the UE PDSCH processing capability of the i-th PDSCH and SCS configuration , where corresponds to the smallest SCS configuration among the SCS configurations used for the PDCCH scheduling the i-th PDSCH, the i-th PDSCH, the PUCCH with corresponding HARQ-ACK transmission for the i-th PDSCH, and all PUSCHs in the group of overlapping PUCCHs and PUSCHs.  - is not before a symbol with CP starting after after a last symbol of any corresponding SPS PDSCH release or of a DCI format 1\_1 indicating SCell dormancy as described in Clause 10.3, or of a DCI format 1\_1 indicating a request for a Type-3 HARQ-ACK codebook report without scheduling PDSCH. is given by maximum of where for the i-th PDCCH providing the SPS PDSCH release or the DCI format 1\_1 with corresponding HARQ-ACK transmission on a PUCCH which is in the group of overlapping PUCCHs and PUSCHs, , as described in Clause 10.2, or DCI format 1\_1 that requests Type-3 HARQ-ACK codebook report as described in Clause 10.2, or the DCI format 1\_1 indicating SCell dormancy without scheduling a PDSCH reception as described in Clause 10.3, where corresponds to the smallest SCS configuration among the SCS configurations used for the PDCCH providing the i-th SPS PDSCH release or the DCI format 1\_1, the PUCCH with corresponding HARQ-ACK transmission for the i-th SPS PDSCH release or the DCI format 1\_1, and all PUSCHs in the group of overlapping PUCCHs and PUSCHs.  - 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 PUSCH of the group of overlapping PUCCHs and PUSCHs, 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 PUCCH of the group of overlapping PUCCHs and PUSCHs in the slot  If 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.  If there is no PUSCH in the group of overlapping PUCCHs and PUSCHs, is given by maximum of where for the i-th PDSCH or the i-th SPS PDSCH release or the i-th SCell dormancy indication with corresponding HARQ-ACK transmission on a PUCCH which is in the group of overlapping PUCCHs, , is selected based on the UE PUSCH processing capability of the PUCCH serving cell if configured.   is selected based on the UE PUSCH processing capability 1, if PUSCH processing capability is not configured for the PUCCH serving cell. is selected based on the smallest SCS configuration between the SCS configuration used for the PDCCH scheduling the i-th PDSCH or providing the i-th SPS PDSCH release or providing the i-th SCell dormancy indication with corresponding HARQ-ACK transmission on a PUCCH which is in the group of overlapping PUCCHs, and the SCS configuration for the PUCCH serving cell.  - if there is an 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 PUSCH of the group of overlapping PUCCHs and PUSCHs, and  - any PDCCH scheduling a PDSCH, or SPS PDSCH release, or providing 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 PUCCH of the group of overlapping PUCCHs and PUSCHs in the slot  where corresponds to the smallest SCS configuration among the SCS configuration of the PDCCHs, the smallest SCS configuration for the PUSCHs of the group of overlapping PUCCHs and PUSCHs, and the smallest SCS configuration of CSI-RS associated with the DCI format scheduling the PUSCH with the multiplexed aperiodic CSI report, and for , for and for  - , , , , , and are defined in [6, TS 38.214], is applied only if of table 5.4-1 in [6, TS 38.214] is applied to the determination of , and and are defined in [4, TS 38.211].  If a UE would transmit the group of overlapping PUCCHs and PUSCHs in a slot, one of the PUCCHs includes HARQ-ACK information in response to an SPS PDSCH reception, and any PUSCH is not in response to a DCI format detection, the UE expects that the first symbol  of the earliest PUCCH or PUSCH satisfies the first of the previous timeline conditions with the exception that components associated to a SCS configuration for a PDCCH scheduling a PDSCH or a PUSCH are absent from the timeline conditions.  A UE does not expect a PUCCH or a PUSCH that is in response to a DCI format detection to overlap with any other PUCCH or PUSCH that does not satisfy the above timing conditions.  < Unchanged part is omitted > |

In RAN1 #104b-e meeting, there was discussion on the possible spec change for Case 1-6. According to the previous discussion, some companies see the need for capturing the timeline condition for Case 1-6 in the spec due that spec is not clear and conclusion in the chairman notes is not sufficient, while other companies view no need to update the spec because the current spec and the conclusion are sufficient to address the timeline condition for Case 1-6.

**Q5: Please share your comments on whether additional clarification for Case 1-6 by updating the spec or drawing conclusion is needed.**

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| **Company** | **Comment** |
| Apple | We support capturing the timeline condition for case 1-6 in the spec. The proposed TP can be used as the starting point for discussion. |
|  |  |

# List of contributions

1. R1-2104299 Remaining issues with PUSCH skipping (without LCH and PHY prioritization) (Rel-16) Nokia, Nokia Shanghai Bell, Ericsson
2. R1-2104300 Draft CR on PUSCH skipping with repetition (Rel-16) Nokia, Nokia Shanghai Bell
3. R1-2104316 Discussion on UL skipping for PUSCH ZTE
4. R1-2104409 Discussion on UL skipping for PUSCH in Rel-16 Spreadtrum Communications
5. R1-2104471 Discussion on remaining issue of PUSCH skipping CATT
6. R1-2104646 Discussion on PUSCH skipping Qualcomm Incorporated
7. R1-2104809 Discussion on PUSCH skipping with UCI overlapping OPPO
8. R1-2105076 Discussions on PUSCH skipping in Rel-16 Apple
9. R1-2105458 Discussion on PUSCH skipping with overlapping UCI on PUCCH in Rel-16 vivo
10. R1-2105459 Correction on 38.213 for UL skipping with PUSCH repetitions in Rel-16 vivo
11. R1-2105520 Discussion on UL skipping Huawei, HiSilicon
12. R1-2105730 Discussion on UL skipping for PUSCH repetition NTT DOCOMO INC.

# 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:\Workspace\3GPP%20related\3GPP%20meeting\2020\2020.Q4\RAN1%23103e\Docs\R1-2007337.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.

|  |  |
| --- | --- |
| In Rel-15, for dynamic UL skipping, RAN1 discussed the LS [R1-2000015](file:///E:\Workspace\3GPP%20related\3GPP%20meeting\2020\2020.Q4\RAN1%23103e\Docs\R1-2000015.zip) from RAN2 and provided replies in [R1-2001376](file:///E:\Workspace\3GPP%20related\3GPP%20meeting\2020\2020.Q4\RAN1%23103e\Docs\R1-2001376.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:\Workspace\3GPP%20related\3GPP%20meeting\2020\2020.Q4\RAN1%23103e\Docs\R1-2005044.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:   |  | | --- | | 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. |   Based on above agreements, RAN1 in principle agreed the corrections for Rel-16 TS 38.214 (R1-200xxxx), assuming that RAN2 will update the Rel-16 sepcification TS 38.321 corresponding to the above agreement so that UE generates the MAC PDU for the PUSCH with UCI multiplexing.  In addition, RAN1 noticed that in Rel-15, dynamic UL skipping is an optional feature with capability signaling (*skipUplinkTxDynamic*). It is RAN1’s understanding the dynamic UL skipping cannot be implemented based on the Rel-15 specification. For Rel-16 with the defined UE behavior for dynamic UL skipping, RAN1 has discussed  following two options for the capability signaling handling. However, the final decision on the capability design for Rel-16 dynamic UL skipping should be decided by RAN2.   * Option 1: introduce a new UE capability for Rel-16 dynamic UL skipping * Option 2: Reuse Rel-15 UE capability with the understanding that Rel-15 dynamic UL skipping is not implementable therefore UEs indicating this capability should implement Rel-16 behavior. |

LS is approved in:

[**R1-2007338**](file:///E:\Workspace\3GPP%20related\3GPP%20meeting\2020\2020.Q4\RAN1%23103e\Docs\R1-2007338.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.

## RAN1 #104-e

**Agreement**

Send an LS to RAN2 to convey the latest RAN1 agreement on PUSCH skipping (Rel-16). LS is endorsed in R1-2102249.

**Agreement**

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, 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 one or more CG PUSCH(s) overlap with a PUCCH on a same or different serving cell, a DG PUSCH overlaps with the one or more CG PUSCH(s) on one serving cell and the DG PUSCH does not overlap with the PUCCH, and there is no remaining PUSCH(s) on any 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.
    - MAC does not generate PDU for the one or more CG PUSCH(s)
    - 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
  + When one or more CG PUSCH(s) overlap with a PUCCH on a same or different serving cell, a DG PUSCH overlaps with the one or more CG PUSCH(s) on one serving cell and the DG PUSCH does not overlap with the PUCCH, and there is remaining PUSCH(s) on any serving cell(s) overlapping with the PUCCH, the PUSCH from the remaining PUSCH(s) 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.
    - Note the remaining CG PUSCH(s) are not overlapping with any DG PUSCH on the same serving cell
    - This is for case 1-6c in Figure 1.
    - MAC does not generate PDU for the one or more CG PUSCH(s)
    - 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

**Conclusion**

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,

* The time condition is ensured by gNB, i.e. 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.
* RAN1 understands that for Case 1-6 the PUCCH, the CG PUSCH and the DG PUSCH are considered as an overlapping group of PUCCH/PUSCH channels for which the multiplexing timeline needs to be satisfied.
  + The overlapping group of PUCCH/PUSCH channels for Case 1-6 is defined in the way such that a PUCCH/PUSCH would be included in a group if it overlaps with any channel in that group, regardless of whether multiplexing between these channels occurs or not.
* FFS whether or not additional spec change is needed

**Conclusion**

For Case 1-5, i.e. when DG PUSCH and CG PUSCH are non-overlapping and both DG/CG PUSCH are overlapping with PUCCH, PUCCH, CG PUSCH and DG PUSCH are considered as an overlapping group of PUCCH/PUSCH channels.

* No spec change is needed

## RAN1 #104b-e

**Conclusion**

For Rel-16, In case of UCI overlapping with multiple CG with the same starting time on a serving cell, it is up to UE implementation to determine the CG resource for UCI multiplexing from multiple CG configurations.

* No spec change is needed

## RAN1 #105-e

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| [**R1-2105459**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105459.zip) | Correction on 38.213 for UL skipping with PUSCH repetitions in Rel-16 | vivo |
| R1-2104646 | Discussion on PUSCH skipping | Qualcomm Incorporated |
| [**R1-2105458**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105458.zip) | Discussion on PUSCH skipping with overlapping UCI on PUCCH in Rel-16 | vivo |
| R1-2104809 | Discussion on PUSCH skipping with UCI overlapping | OPPO |
| R1-2105587 | Discussion on PUSCH with ULSkipping and repetition | Ericsson |
| R1-2104471 | Discussion on remaining issue of PUSCH skipping | CATT |
| R1-2105520 | Discussion on UL skipping | Huawei, HiSilicon |
| R1-2104316 | Discussion on UL skipping for PUSCH | ZTE |
| [**R1-2104409**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104409.zip) | Discussion on UL skipping for PUSCH in Rel-16 | Spreadtrum Communications |
| R1-2105730 | Discussion on UL skipping for PUSCH repetition | NTT DOCOMO INC. |
| R1-2105076 | Discussions on PUSCH skipping in Rel-16 | Apple |
| [**R1-2104300**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104300.zip) | Draft CR on PUSCH skipping with repetition (Rel-16) | Nokia, Nokia Shanghai Bell |
| R1-2104886 | On UL skipping and PUSCH repetitions | Intel Corporation |
| R1-2104942 | On UL skipping and PUSCH repetitions | Intel Corporation |
| R1-2104999 | On UL skipping and PUSCH repetitions | Intel Corporation |
| [**R1-2104299**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104299.zip) | Remaining issues with PUSCH skipping (without LCH and PHY prioritization) (Rel-16) | Nokia, Nokia Shanghai Bell, Ericsson |

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| [**R1-2104409**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104409.zip) | Discussion on UL skipping for PUSCH in Rel-16 | Spreadtrum Communications |

Considering the strong concern of Option 3 from some companies, we are willing to consider Option 3’ which is a compromise between Option 1 and 3. However, there is still some timeline problem of Option 3’. As show in Figure 1 below, when PUCCH dynamic scheduled by a DCI is overlapped with the 2nd CG-PUSCH repetition, UCI multiplexing timeline in Rel-15, the UE expects the first symbol of the earliest PUCCH or PUSCH, among a group overlapping PUCCHs and PUSCHs in the slot, satisfies the timeline conditions. However, if Option 3’ is adopted for CG-PUSCH too, the UCI multiplexing timeline should be changed. E.g. UE expects the first symbol of the earliest PUCCH or PUSCH repetition 1 satisfies the conditions. It implies the timeline is changed compared with Rel-15. So we think Option 3’ still has some problems according to UCI multiplexing, if we adopt the same option for DG-PUSCH and CG-PUSCH.



Figure 1: UCI multiplexing on CG-PUSCH

Hence, PUSCH with repetition, including scheduled and configured grand PUSCH, Option 3 can be applied.

1. ***For UL skipping, PUSCH with repetition (including scheduled and configured grand PUSCH), Option 3 can be applied.***

* ***Option 3: 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.***

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| [**R1-2104299**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104299.zip) | Remaining issues with PUSCH skipping (without LCH and PHY prioritization) (Rel-16) | Nokia, Nokia Shanghai Bell, Ericsson |

**Observation 1:** Options 1, 2, 3 and 7 have the same behaviour if the UCI overlaps with the 1st instance of the PUSCH repetition bundle, while they lead to different behaviours if the UCI overlaps with any other instance of the PUSCH repetition bundle.

**Observation 2**: Option 7 behaves as option 1 or as option 2 depending on the PUCCH location

* If the PUCCH overlaps with the 1st PUSCH repetition: option 7 behaves the same as option 1, 2 and 3
* if the PUCCH overlaps with the 2nd PUSCH repetition: option 7 behaves the same as option 1
* if the PUCCH overlaps with the 3rd or later PUSCH repetition: option 7 is the same as option 2, i.e. undefined

**Observation 3:** Options 5 and 6 are behaviourally the same

**Issues with option 5/6**: with the network not knowing if the transmitted PUSCH is a dummy PDU or information carrying PDU it would try to combine the different PUSCH instances and fail with the decoding of the PUSCH. This would not only lead to (potentially several) retransmission attempt(s) for the dummy TB, but also lead to confusion for the outer loop link adaptation and uplink power control algorithms.

**Issues with option 1:** When looking at things from the receiver perspective the option 1 would be most preferrable as everything would be predictable and work the same way as when no PUSCH repetition is used. The one issue left is what happens if the DCI triggering the UCI comes too late for the UE to trigger the dummy PUSCH to multiplex the UCI with.

**Issues with option 3:** option 3 was motivated to answer the timeline issue of option 1, but there were concerns raised both on the UE having to implement two different alternatives depending on where the UCI lands, and the gNB (potentially) having to blindly detect whether it should receive PUSCH and PUCCH.

**Issues with Option 7:** option 7 was brought in as a possible bridge between option 1 and option 3, but it still has the timeline issue of option 1.

**Proposed way forward:** When a UCI would be multiplexed on a slot of a PUSCH repetition bundle that would be skipped:

* If the UCI trigger comes “early enough” for the UE to be able to generate the dummy PDU starting from the 1st instance of the PUSCH repetition bundle:
  + UE behaviour is as in option 1, i.e. a dummy PDU is generated and the UCI is transmitted on PUSCH
* If the UCI trigger comes “too late” for the UE to be able to trigger the dummy PDU starting from the 1st instance of the PUSCH repetition bundle:
  + As the PUSCH was not triggered, the UE transmits UCI on PUCCH
* The “early enough” vs. “too late” is determined by at least the minimum PUSCH processing time.
  + FFS additional UE processing time budget on top of the minimum PUSCH processing time is specified.

The proposed way forward is illustrated in figure 2 below for cases where the triggered UCI would overlap with the 1st, 2nd or 3rd PUSCH repetition instance, and with the UCI trigger coming “early enough” as well as “too late” to trigger the dummy TB on PUSCH .

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| **Fig 2a**:  DCI triggering the UCI is received “early enough” |  |
| **Fig 2b**:  DCI triggering the UCI is received “too late” |  |

Figure 2: Proposed way forward: If the UE has sufficient time to prepare the dummy TB on PUSCH for the full PUSCH repetition bundle, then the UCI is muxed in PUSCH, otherwise the UCI is sent on PUCCH.

The thinking behind the proposal is the following:

* Option 1 behaviour maintains commonality with the non-repetition case and does not require blind decoding in the gNB
* The fall-back behaviour when the UCI trigger comes too late eliminates the concern of being able to schedule DL and the related UL without having to delay the UCI when not knowing if the CG-PUSCH will be present or not.
* This fall-back behaviour is the same as if the PUSCH is not triggered and should maintain UE implementation commonality.

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| [**R1-2104300**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104300.zip) | Draft CR on PUSCH skipping with repetition (Rel-16) | Nokia, Nokia Shanghai Bell |

If the UE is configured with *enhancedSkipUplinkTxDynamic* as *true*, and if the UE would multiplex UCI on a PUSCH slot of a PUSCH transmission over multiple slots,

* the UE multiplexes the UCI on PUSCH if the transmission of the PUSCH transmission over multiple slots would not start before after a last symbol of the corresponding PDCCH that triggered the UCI
* The UE transmits the UCI on PUCCH otherwise.