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

e-Meeting, April 12th – 20th, 2021

Source: Moderator (vivo)

Title: Summary of [104b-e-NR-7.1CRs-05] discussion on PUSCH skipping with UCI overlapping (Rel16)

Agenda Item: 7.1

Document for: Discussion and Decision

# Introduction

The document provides a summary for the email discussion thread [104b-e-NR-7.1CRs-05] Discussion on PUSCH skipping with UCI overlapping for Rel-16 only. **Note that the deadline for the discussion for the email thread and the corresponding TP is set to be April 20.**

[104b-e-NR-7.1CRs-05] Issue#25: Discussion on PUSCH skipping with UCI overlapping – Xiaohang (vivo) by April 20

* 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: 4/15 (UTC). **Please provide the comments by 4/13 UTC 23:59 pm.**
* 2nd round discussion: 4/20 (UTC).

# Email discussion outcomes

# Discussions

1. **DG PUSCH skipping with PUSCH repetitions**

In [1][2][3][4][5][6][7][8][9][10], DG PUSCH skipping with PUSCH repetitions is discussed.

Following options are summarized based on companies’ contributions.

* Option 1: 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: DCM, vivo*

* 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: Nokia, Spreadtrum, CATT, Apple, Huawei*

* Option 4: Rel-16 PUSCH skipping and PUSCH repetitions are not allowed to be enabled together (error case is defined).

*Supported by: OPPO*

* 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.
  + Note: it requires the MAC layer can decide whether to generate a MAC PDU for the repetition depending on whether it overlaps with PUCCH, which is different from current MAC behaviour.

*Supported by: ZTE*

1. **For DG PUSCH skipping with repetitions, which option do you prefer? Please share your comment if any.**

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| --- | --- |
| **Company** | **Comment** |
| NTT DOCOMO | Option 3 if sufficient performance to detect existence of PUSCH is achievable at gNB;  Option 1 otherwise. |
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1. **if no consensus can be achieved, would that be acceptable that Rel-16 PUSCH skipping and PUSCH repetitions are not allowed to be enabled together, i.e. option 4.**

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| **Company** | **Comment** |
| NTT DOCOMO | No. This seems typical situation in URLLC case. Not support is too restrictive. |
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1. **CG PUSCH skipping with PUSCH repetitions**

In [1][2][3][4][5][6][7][8][9][10], CG PUSCH skipping with PUSCH repetitions is discussed.

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.**

1. **For CG PUSCH skipping with repetitions, please share your comment if any.**

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| **Company** | **Comment** |
| NTT DOCOMO | OK (maybe better to discuss after DG case is concluded). Note that the following is the intended behaviour.   * If option 1 is supported, when UCI in a PUCCH would be multiplexed on m-th repetition of CG PUSCH, MAC PDU shall be generated and the repetitions are transmitted from n-th occasion, where n-th occasion is the last one among occasions that can be first transmission and that is not later than m-th occasion (i.e. n ≤ m). * If option 3 is supported, when UCI in a PUCCH would be multiplexed on n-th repetition of CG PUSCH that can be first transmission, MAC PDU shall be generated and the repetitions are transmitted from n-th occasion. When a PUCCH is overlapped with m-th repetition of CG PUSCH that cannot be first transmission, any DG PUSCH repetition is not transmitted if no data. |
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1. **Potential specification modification for Case 1-6**

In [4][6], the potential specification modification for Case 1-6 for PUSCH skipping.

In [4], it is mentioned that only overlapping of multiple PUCCH transmissions or overlapping of PUCCH and PUSCH are considered in Clause 9.2.5 for timeline check, which means that in case 1-6, only overlapping of PUCCH and CG PUSCH is included in the procedure of timeline check, while overlapping of DG PUSCH and CG PUSCH is not included in the procedure of timeline check. Therefore, it is proposed that the specification should be modified to capture the overlapping of case 1-6 for timeline check, e.g. to give a clear definition of the group of overlapping PUCCHs and PUSCHs by considering not only the first UL channel of overlapping PUCCHs or overlapping PUCCH and PUSCH, but also a second PUCCH/PUSCH that overlaps with either one of the first UL channel.

For the case of PUSCH skipping without repetitions, following conclusion for case 1-6 was made. The overlapping group of PUCCH/PUSCH channels for Case 1-6 as well as the time condition that should be ensured by gNB is clarified. Therefore, in [], it is proposed that no additional spec change is needed for DG PUSCH skipping for Case 1-6

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| **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 |

1. **Please share your comments on whether and how to introduce additional spec change to reflect the conclusion for PUSCH skipping for Case 1-6. If additional spec change is deemed necessary, please provide the possible TP for spec change.**

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| **Company** | **Comment** |
| NTT DOCOMO | We think the current spec and the above conclusion are sufficient and no spec update is needed. Meanwhile, if majority prefers to update spec, it is also OK for us. |
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1. **Multiple CG with the same starting time**

In [6][7], UL skipping for CG in case of multiple CG with same starting time for Rel-16 is discussed.

Following options are proposed for this issue.

* Option 1: When determining whether there would be UCI multiplexing on a PUSCH, for selecting between CG PUSCHs on the same serving cell with the same starting time, the CG PUSCH with the smaller CG configuration index is prioritized.
* Option 2: In case of UCI overlapping with multiple CG with the same/different starting time, it is up to UE implementation to determine the CG resource for UCI multiplexing from multiple CG configurations.
  + no spec change is needed

1. **please share your comments on whether and how to address the issue for multiple CGs with the same starting time.**

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| **Company** | **Comment** |
| NTT DOCOMO | No spec update is necessary but option 2 is not aligned with current spec.  In current spec, when multiple CGs are overlapped with a PUCCH, CG in cell with the smallest ServCellIndex is selected. If there are two or more in the cell, the earliest CG is selected. Then, if there are two or more in the cell with the same starting symbol, then which CG is up to UE implementation.  In our understanding, this behaviour can be maintained and no update is necessary since this situation will be a corner case and it seems gNB can avoid this situation. Note that such a discussion should be done at eURLLC WI, where multiple active CGs are introduced. We think this feature is not only for UL skip. |
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1. **Clarification on UCI multiplexing rule for SP-CSI PUSCH and SR**

In [7], the UCI multiplexing rule in Rel.16 is discussed. It is mentioned that there are some unclear parts for UCI multiplexing in case of CG PUSCH vs. SP-CSI PUSCH and SR, and they need to be clarified.

* Issue 5-1: How to select PUSCH for UCI multiplexing in case of overlapping CG PUSCH and SP-CSI PUSCH on the same serving cell
* Issue 5-2: whether SR (positive SR or negative SR) is considered for UCI multiplexing

Following solutions to further clarify the UCI multiplexing rule are provided.

* Solution for issue 5-1: When determining whether there would be UCI multiplexing on a PUSCH, for selecting between overlapping CG PUSCH and SP-CSI PUSCH on the same serving cell, CG PUSCH has higher priority than SP-CSI PUSCH.
* Solution for issue 5-2:When determining whether there would be UCI multiplexing on a PUSCH, the actual SR status (positive SR or negative SR) is considered.

Although these issues could have impact on PUSCH skipping, they also affect the behaviour for UCI multiplexing without PUSCH skipping. So these issues seem to be general issues for UCI multiplexing. Since there is limited input for these issues, let’s collect more views from companies on whether and how to solve these issues.

1. **For the issue 5-1 on UCI multiplexing for SP-CSI PUSCH discussed in [7], do you think further clarification is needed? If yes, would the clarification from [7] are acceptable? Please share your comments.**

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| **Company** | **Comment** |
| NTT DOCOMO | We think the proposal in [7] is not the issue on UL skip and hence no need to discuss it here.  On the other hand, Case 1-6 with SP-CSI instead of CG might be possible situation we need to consider. That is, when DG PUSCH and SP-CSI on PUSCH are overlapping on a serving cell and SP-CSI on PUSCH is overlapping with PUCCH, and DG PUSCH is non-overlapping with the PUCCH. In this case, even when DG PUSCH skip is configured, SP-CSI on PUSCH should be dropped before multiplexing, as CG case. |
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1. **For the issue 5-2 on UCI multiplexing for SR discussed in [7], do you think further clarification is needed? If yes, would the clarification from [7] are acceptable? Please share your comments.**

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| **Company** | **Comment** |
| NTT DOCOMO | We do not see motivation to update current spec and relationship with UL skip function. |
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1. **PUSCH skipping with different PHY priorities when LCH based prioritization is not configured**

In [1][3], the UE behaviour for PUSCH skipping with two PHY priorities when LCH based prioritization is not configured is discussed.

Since PUSCH skipping with two PHY priorities with or without LCH based prioritization is under discussion in URLLC session, so this issue can be discussed in the URLLC session.

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

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| **Company** | **Comment** |
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# List of contributions

1. R1-2102366 Discussion on PUSCH skipping with UCI overlapping OPPO
2. R1-2102440 Discussion on UL skipping for CG PUSCH Spreadtrum Communications
3. R1-2102480 Discussion on UL skipping for PUSCH ZTE
4. R1-2102582 Discussion on PUSCH skipping CATT
5. R1-2102816 Remaining issues with PUSCH skipping (without LCH and PHY prioritization) (Rel-16) Nokia, Nokia Shanghai Bell
6. R1-2102934 Discussion on PUSCH skipping with overlapping UCI on PUCCH in Rel-16 vivo
7. R1-2103078 Discussions on PUSCH skipping in Rel-16 Apple
8. R1-2103199 Discussion on PUSCH with ULSkipping and repetition Ericsson
9. R1-2103386 Discussion on UL skipping Huawei, HiSilicon
10. R1-2103553 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.

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| 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