**3GPP TSG RAN WG1 Meeting #108-e R1-2202835**

**e-Meeting, February 21st – March 3rd, 2022**

**Source: Moderator (Apple)**

**Title: Summary for [108-e-NR-CRs-06] Issue #8: Discussion on HARQ-ACK multiplexing on PUSCH**

**Agenda item: 7.1**

**Document for:** **Discussion and Decision**

# Introduction

This document provides the summary for the following email discussion in RAN1#108-e:

108-e-NR-CRs-06] Issue#8 Discussion on HARQ-ACK multiplexing on PUSCH with contributions [1], [2], [3], [4], ,[5] and [6](see the Appendix in Section 5 for a list of the proposals).

In RAN1 #106-e, there was a discussion on the topic with a summary of the status of the discussion for Rel-15 UE behavior as follows [10][11]:

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| Conclusion  * *For Rel-15, in the case of multiple overlapping PUSCHs with no overlapping PUCCH and if any  UL-TDAI n.e. 4 (for Type 2 codebook) or UL-TDAI e.q. 1 (for Type 1 codebook) the UE behavior is left to UE implementation.*  Agreement  * *For Rel-15 with more than one non-overlapping PUSCH and no overlapping PUCCH within a span on one slot (both single carrier and UL CA) and if*the UL-TDAI for the PUSCH*UL-TDAI not equal to 4 (for Type 2 codebook) or UL-TDAI equal to 1 (for Type 1 codebook), the UE behavior is up to the UE implementation* * *For Rel-15 with one PUSCH and no overlapping PUCCH within a span of one slot and if*the UL-TDAI for the PUSCH*UL-TDAI not equal to 4 (for Type 2 codebook) or UL-TDAI equal to 1 (for Type 1 codebook), there is no consensus for any conclusion on one aligned UE behavior.* |

In RAN1 #107-e, there was a discussion on the topic with a summary of the status of the discussion for Rel-16 UE behavior as follows [12][13]:

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| **Agreement**  For Rel-16 with multiple overlapping PUSCHs with no overlapping PUCCH with HARQ-ACK within a span of one PUCCH slot, if the UL-TDAI n.e. 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook) there is no consensus in RAN1 on Rel-16 UE behaviour    **Agreement**  For Rel-16 with one PUSCH and no overlapping PUCCH with HARQ-ACK within a span of one PUCCH slot (both single carrier and UL CA), if the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), the UE multiplexes HARQ-ACK following the UL-TDAI into the PUSCH. |

It was also agreed to continue discussion in the following:

* Continue discussion on UE behavior with respect to multiplexing HARQ-ACK in PUSCH for the following case in Rel-16.
  + More than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if for at least one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook)

# 1st Round

### Issue 1: Pending Decision

A majority of the contributions in this meeting divide the pending decision into two scenarios:

Scenario 1: More than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if only one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook)

Scenario 2: More than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook)

Some companies also discuss the use of the Rel-15 prioritization mechanism as discussed in the Appendix (Section 4).

A summary of the proposals are shown in the Table below with details in the Appendix in Section 5:

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|  | Scenario 1 | Scenario 2 |
| ZTE | Multiplex on the PUSCH using TDAI.  Only the DAI for the PUSCH overlapping with PUCCH is set to the other values, i.e., the total DAI in the last DL DCI | Multiplex using TDAI, *select the PUSCH for HARQ-ACK multiplexing from these PUSCHs according to the current PUSCH prioritization rule*  Only the DAI for the PUSCH overlapping with PUCCH is set to the other values, i.e., the total DAI in the last DL DCI |
| CATT | UE implementation | UE implementation |
| Apple | Multiplex on the PUSCH using TDAI. | UE implementation |
| Qualcomm | Multiplex on the PUSCH using TDAI. | UE implementation |
| Ericsson | The UE selects one PUSCH following the same PUSCH prioritization rules described in Clause 9 of TS 38.213. UE multiplexes on selected PUSCH if TDAI value indicates need for multiplexing. NOTE: this is equivalent to multiplexing for scenario 1. | |
| Huawei/HiSilicon | Multiplex on the PUSCH using TDAI. | Multiplex HARQ-ACK in PUSCH according to UL DAI according to the Rel-15 mechanism. The DAI field value of multiple PUSCH(s) should be the same |

For Scenario 1, we have the following company positions:

* Alt 1: Multiplex on the PUSCH using TDAI.
  + ZTE, Apple, Qualcomm, Ericsson, Huawei/HiSilicon (5)
* Alt 2: UE implementation
  + CATT (1)

For Scenario 2, we have the following company positions

* Multiplex using TDAI, *select the PUSCH for HARQ-ACK multiplexing from these PUSCHs according to the current PUSCH prioritization rule*
  + *ZTE, Ericsson, Huawei*
    - The DAI field value of multiple PUSCH(s) should be the same (ZTE, Huawei/HiSilicon)
    - Select the PUSCH for multiplexing and then decide to multiplex if TDAI indicates this (Ericsson)
* UE implementation
  + CATT, Apple, Qualcomm

### Proposal 1-1 (Scenario 1)

**Proposal 1:** For scenario 1, in which more than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if only one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook) the UE shall multiplex HARQ-ACK in PUSCH according to UL DAI

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| **Company** | **Comments** |
| Ericsson | **First general comment**: We request to understand first that in case of multiple PUSCHs in the PUCCH slot, why should we have different solutions for non-overlapping PUSCHs and overlapping PUSCHs?  Until last meeting there was no consensus for the case of overlapping PUSCHs. We request to have a discussion to understand the issues and aim to find a practical/unified solution that works for all cases including overlapping PUSCHs. Case of overlapping PUSCHs is very important for operators with at least FR1 UL CA planned.  Proposal 1 as such it is fine (please see our next comment), but we think we can find a unified solution rather than this fragmented approach where we understand the issues better. |
| AT&T | Generally, we are ok with Proposal 1, but also agree with the Ericsson comment that we should strive to avoid a fragmented dissimilar approach for each of the scenarios, i.e., UE behaviour/solutions for non-overlapping and overlapping PUSCH. Additionally, we do not support leaving solutions for these scenarios to UE implementation. |
| NTT DOCOMO | Agree with Ericsson. Why UE behaviors for overlapping case and non-overlapping case are different is quite unclear for us. The issue here is which PUSCH the UE should multiplexed HARQ-ACK on is unclear. The issue is common between the two cases. If we try to define UE behavior, the behavior should be applied to both cases.  As the behavior, we are fine with the proposal. |
| Verizon | Agree with the three companies above. |
| vivo | We agree with Ericsson and AT&T that unified solution is preferred for overlapping and non-overlapping case. I am wondering why gNB schedules more than one of the PUSCHs with the UL-TDAI not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook) in a PUCCH slot? There is only one HARQ-ACK PUCCH in the slot (for a certain priority. Here, I assume we are discussing the case that PUCCH and PUSCH have the same priority), and it would multiplex on only one PUSCH if DL DCI(s) is not missed, and gNB know which PUSCH would be used for multiplexing HARQ-ACK, gNB should indicate correct UL-DAI for the PUSCH for multiplexing, for the other PUSCHs, gNB should indicate 4 (for Type 2 codebook) or 0 (for Type 1 codebook).  In addition, I find one agreement made in Rel-15 in RAN1#94 meeting. Maybe it is a little too late to align the understanding on the current specification for HARQ-ACK multiplexing with no overlapping PUCCH. This agreement is for slot-level PUSCH repetition case. According to this agreement, it is clear that HARQ-ACK multiplexing only happen in the slot with overlapping PUCCH. If there is no overlapping PUCCH, there is no multiplexing. That is why I thought the current specified behavior is that UE only multiplexes HARQ-ACK on PUSCH when there is overlapping PUCCH in previous meeting:  Agreements**: (**in RAN1#94**)**   * The UE multiplexes HARQ-ACK in any slot of a multi-slot PUSCH transmission where the UE would otherwise transmit HARQ-ACK in a single slot PUCCH transmission, based on the HARQ timeline * DAI is applicable in any slot where the UE would transmit HARQ-ACK |
| CATT | In general, we agree with the comments from Ericsson and others that a unified solution is desired. We do not see the case different from the case of overlapping PUSCHs in CA where we agreed to be up to UE implementation as follows. That is also one of the reasons of our proposal to leave this case to UE implementation as well.   |  | | --- | | **Agreement**  For Rel-16 with one PUSCH and no overlapping PUCCH with HARQ-ACK within a span of one PUCCH slot (both single carrier and UL CA), if the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), the UE multiplexes HARQ-ACK following the UL-TDAI into the PUSCH. |   In addition, we would like to clarify the following case. According to the PUSCH selection rule, HARQ-ACK is multiplexed in CG PUSCH if PUCCH carrying HARQ-ACK overlaps with CG PUSCH and HARQ-ACK is multiplexed in DG PUSCH if PUCCH carrying HARQ-ACK does overlap with CG PUSCH.    According to the proposal, HARQ-ACK would be multiplexed in DG PUSCH following the UL-TDAI in UL grant, which implies that gNB would set the UL-TDAI depending on whether HARQ-ACK is expected to be multiplexed in DG PUSCH. For example, if PUCCH overlaps with both CG and DG PUSCHs, UL-TDAI would be set to 4 (for Type 2 codebook) or  equal to 0 (for Type 1 codebook) since HARQ-ACK is expected to be multiplexed in CG PUSCH. Is it the common understanding and the assumption we can follow for discussion for other cases? |
| QC | We support this proposal |
| Intel | We are fine with the Proposal 1. |
| MTK | We are fine with the Proposal 1. |
| ZTE | We support this proposal since this is similar as the scenario of only one PUSCH in a slot. |
| Samsung | Support the proposal. Also, if any stable conclusion/agreement would be achieved regarding unified solution, we are willing to support. |
| Huawei, HiSilicon | We support this proposal. |
| Nokia, NSB | Proposal #1 is OK. Agree with the Ericsson view. |
| Ericsson2 | We would like companies to consider the issue with this approach to solve the problem piece by piece.  **Now, even if we agree with this proposal, what about have more than one PUSCHs with UL-TDAI not equal to 4?**  As mentioned by other companies, the fundamental issue in whole exercise and all the cases, is that “which PUSCHs should we consider?”  Then I don’t think when that is clear, any company suggests to use different approach to select a PUSCH and follow the corresponding UL-TDAI.  Therefore, we urge the group for continuation of the discussion to focus to find a solution for the main question. |
| Apple | We support this proposal |

### Question 1-2 (Scenario 2)

In [5], Ericsson raises the following issue:

The value of UL-TDAI itself should only be taken into account at the last stage. In other words, it is important to consider first the PUSCHs with UL-TDAI, and not a PUSCH with a given UL-TDAI. Among those PUSCHs, we should apply the same procedures for *PUSCH prioritization* for UCI multiplexing similarly to the case when a PUCCH with KARQ-ACK is present. When a PUSCH is selected, then we can determine whether/how to multiplex HARQ-ACK on.

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| **Company** | **Comments** |
|  | **First general comment**: We request to understand first that in case of multiple PUSCHs in the PUCCH slot, why should we have different solutions for non-overlapping PUSCHs and overlapping PUSCHs?  Until last meeting there was no consensus for the case of overlapping PUSCHs. We request to have a discussion to understand the issues and aim to find a practical/unified solution that works for all cases including overlapping PUSCHs. Case of overlapping PUSCHs is very important for operators with at least FR1 UL CA planned.  **Second with respect to multiple PUSCHs:**  As we explained in our contributions, it is very important to find a solution how to handle these cases. We do not prefer, and also don’t see the need to differentiate the case for multiple PUSCHs.  We assume all companies are in favor of reusing the already existing procedures. The issue when PUCCH is not present, is that which PUSCHs are candidates for HARQ-ACK multiplexing. A very simple approach is to assume all of them. Or to assume all PUSCHs without UL-TDAI=4 or n.e 1 (for Type 2, Type 1). Then apply the PUSCH periodization rule to select a PUSCH and then follow UL-TDAI to perform multiplexing.  We tried to formulate the proposal below, and at the same time, show the similarities to the case when the PUCCH is present.   * When there is a PUCCH and there are multiple PUSCHs within the PUCCH slot (already consensus)   + - * the UE selects one PUSCH out of all the PUSCHs within the PUCCH slot that overlap with the PUCCH according to the rules specified, and then follows the T-DAI for the selected PUSCH to do HARQ-ACK multiplexing.     - **Proposal E///:** * When there is no PUCCH and there are multiple PUSCHs within the PUCCH slot (no consensus yet) * Option 1: the UE selects one PUSCH out of the PUSCHs within the PUCCH slot ~~that overlap with the PUCCH~~, according to the rules specified, and then follows the T-DAI for the selected PUSCH to do HARQ-ACK multiplexing. * Option 2: the UE selects one PUSCH out of the PUSCHs within the PUCCH slot ~~that overlap with the PUCCH~~ PUSCHs without UL-TDAI=4 in case Type 2, without UL-TDAI different than 1 in case of Type 1 CB, if any, according to the rules specified, and then follows the T-DAI for the selected PUSCH to do HARQ-ACK multiplexing.   Due to the importance of these cases, we are hoping the group help to find a solution and not settle on “no consensus” option. Therefore, we would like to understand the issues and appreciate answer to these questions:   * **Question 1: In Proposal E///, Is there issue to assume all PUSCHs and then follow the same procedure as when PUCCH is present (Option 1) ?** * **Question 2: In Proposal E///, Is there issue to assume all PUSCHs without Ul-TDAI=4 for Type 2 or not equal to 1 for Type 1 and then follow the same procedure as when PUCCH is present (Option 2)?** * **Question 3: Is there issue to handle more than 2 PUSCHs (overlapping or not) without Ul-TDAI=4 for Type 2 or not equal to 1 for Type 1?** * **Question 4: Is there concern with multiplexing timeline?**   As you see, we would like to have a solution for practical cases. If we understand what the issue is, we can find a solution together. Your feedbacks is appreciated. We ourselves tried to adjust our position as compared to previous meetings by reflecting more on the concerns raised.  As you know, the current situation is quite frustrating for NW vendors to get very limited use of UL DAI which in turn affects the performance that operators would experience in their networks. We are positive and hopeful that we can find a solution. |
| QC | If I understand correctly, with multiple PUSCHs in a slot, and multiple PUSCH has UL-TDAI not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), the difficulty/ambiguity is that how to determine the set of overlapping PUSCHs that the Rel-15/16 rule is applied to determine the destination/target PUSCH to multiplex A/N on, given there is no PUCCH to determine the overlapping PUSCHs. My understanding is that different UE vendors may already implemented different rules to determine the set hence it is hard to define a BC rule for those Rel-15/16 UEs already deployed. For Rel-17 spec, it might be OK to define a rule to fix this issue. |
| MTK | We have similar concern with QC about changing Rel-15/16 UEs behavior. If putting release number aside and focusing on developing a solution, we think some additional points should be clarified:   * only PUSCH that overlap with PUCCH is considered (network only sets UL TDAI for those PUSCH that did overlap with the missing PUCCH) * network provides the same UL TDAI for the overlapped PUSCH * by **“**the same procedures for PUSCH prioritization for UCI multiplexing**”**, it should be clarified that the rules are the same as given in Rel-15 38.213 Chapter 9 in the starting section |
| ZTE | The UE behavior should be the same regardless of the awareness of the PUCCH resource for the HARQ-ACK. When the PUCCH resource for HARQ-ACK is known to the UE, the UE select PUSCH for HARQ-ACK multiplexing among the PUSCHs overlapping with the PUCCH. It means the PUSCH not overlapping with PUCCH resource should be excluded first. Therefore, when the PUCCH resource is not known to the UE, the UL-TDAI should be used for excluding the PUSCH that does not overlap with PUCCH. So we think the UL-TDAI should be taken into account at first. |
| Huawei, HiSilicon | We think the UL-DAT should be taken into account when there is no PUCCH. It should be used to select to PUSCH that are overlapping with the intended PUCCH. |
| Nokia, NSB | The fact that different UE implementations may be out there, or in the pipeline cannot be a justification for 3GPP to leave it there and say “up to the UE implementation, let’s fix in some later release in some later day”. Rel-15 UL TDAI was already obsoleted with that forcing networks to abandon its usage. There is no point in debating what is BC rule that accompanies all the different UE implementations, as if different UE implementations are allowed, there is no standard and there is no deployable feature to begin with. For the multiple PUSCH case this obviously cannot be an acceptable way forward for companies interested in supporting UL CA. We are interested in deploying UL CA, and we are interested in UEs that indicate support for UL CA to be able to support UCI feedback THE SAME WAY when they are configured in UL CA mode in the practical cases. |
| Ericsson2 | We totally agree with views expressed by Nokia.  We respectfully disagree with the views on regarding Rel-15/16 implementation.  Please consider that there are two elements to provide HARQ-ACK feedback:   * 1) If DL assignment is detected (then a PUCCH would be present) * 2) If UL-TDAI is present (that is a control mechanism to send feedback that DL is missed).   The purpose of the second one is to provide robustness in the presence of absence of the first one.  It is not clear to us why such fundamental feature is completely missed in some Rel-15 implementations. We are hopeful that we can together fix this issue for Rel-16.  Also, for all involved parties, we all aware that the case of FR1 UL CA is of importance. Therefore, we are hoping that the group is committed to find solution.  We are hoping in the next phase of the discussion, we can focus on the fundamental question and that is :  **What is the set of candidate PUSCHs for HARQ-ACK multiplexing when PUCCH is absent?**  **F**inding a solution for that at least, leads us to a unified solution. |
| Apple | For the case with overlapping PUCCH, we do not differentiate TDAI = 4 and other values, because the only T-DAI value that matters is the PUSCH that is eventually selected. As long as the gNB and the UE have a common understanding which PUSCH to multiplex UCI (e.g. in a normal case without any missing DCI), we basically do not care what T-DAI other PUSCHs have.  But the handling of T-DAI values may matter when there is missing DCI (e.g. when there is no overlapping PUCCH), as it may affect the PUSCHs selected and the corresponding robustness of the scheme.  As an example,  if the PUCCH overlaps with PUSCH2/3 (both have T-DAI=2). If DCI for PUCCH is missed, the method in the quesiton does not consider T-DAI and it chooses PUSCH1 for multiplexing. But because the corresponding T-DAI = 4, no multiplexing actually occurs. But the real situation is the UE should choose between PUSCH2 and PUSCH3 for UCI multiplexing.    With this said, we think it makes sense to consider T-DAI value if the group decides to go in this direction, i.e., Option 2 is preferred compared to Option 1.  For Q3 and Q4, they can be discussed in more detail in section 2.1.3. Option 1/2 requires new multiplexing timeline limitations. |

### Question 1-3 (Scenario 2)

For Scenario 2 in which more than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook)

* Alt-1: Multiplex using TDAI, select the PUSCH for HARQ-ACK multiplexing from these PUSCHs according to the current PUSCH prioritization rule
  + Alt-1-1: TDAI values for the selected PUSCHs are the same
  + Alt-1-2: The TDAI value does not impact the selected PUSCH. The PUSCH selected determines the TDAI value used.
* Alt-2: Leave to UE implementation

NOTE: please discuss the effect of the multiplexing timeline on the alternative chosen.

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| **Company** | **Comments** |
| Ericsson | Definitely Alt 1. Please see our previous comments that is very general and applicable to this case too. |
| AT&T | To avoid fragmentation, we support defining a solution rather than leaving this for UE implementation. We support Alt-1, at a minimum a standardized approach. |
| NTT DOCOMO | Alt 1.  Basically NW cannot predict whether there is future scheduling of UL grant. In this sense, this scenario is a typical situation. For example, NW schedules from slot n PUSCH TX#1 at slot m, with UL DAI value for HARQ-ACK multiplexing. After that, NW schedules from slot n+2 PUSCH TX#2 at slot m, with UL DAI value for HARQ-ACK mux. At slot n, NW does not know the existence of additional scheduling from slot n+2, thereby both UL grants have UL DAI value for HARQ-ACK mux.  If scenario 1 should be solved, then also scenario 2 should be solved, not by UE implementation. |
| Verizon | Also prefer to have a standard based solution rather than leaving it to UE implementation. UE implementation should be the last resort. |
| Vivo | Current PUSCH prioritization rule is only among the PUSCHs overlapping with PUCCH, but there is no PUCCH with HARQ-ACK here, how to determine the PUSCHs for prioritization is not clear. Alt-1 is not workable. |
| CATT | We are open to Alt. 1 but would like to know whether there is any timeline impact. |
| QC | Firstly, as we commented for previous question, for Rel-15/16, there are already UEs deployed in the field, the change would be NBC to those UEs. If any spec change is needed to fix this issue, the change should target Rel-17.  Secondly, one PUSCH with UL-DAI not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook) is the typical case. More than one PUSCH with UL-DAI not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook) might be atypical case – why gNB would issue two of such UL-DAIs? Of course, we understand this can offer more scheduling flexibility to gNB, which could allow gNB to change mind on which PUSCH is used to multiplex A/N. But is that flexibility a must to operate the system? Once gNB decided using a PUSCH to mux A/N, why gNB can not stick with that decision?  As for Alt 1, we have a same comment as VIVO, Alt-1 need add more details to explore how to determine the set of overlapping PUSCHs, before it can work.  With the above, we support Alt-2 for Rel 15/16. Alt-1 with more details filled in can be considered for Rel-17. |
| Intel | We understand the intention that for Alt 1, i.e., it may have less blind detection. However, the selection of PUSCH for multiplexing HARQ-ACK may need careful consideration. In the existing rule for PUSCH determination, the PUCCH location is perfectly known at UE side and the procedure is deterministic and there is no ambiguity between gNB and UE side. In case when UE misses the DL grant, and correspondingly, does not know the exact PUCCH resource, the existing PUSCH selection rule does not apply. A new rule, e.g., 1st PUSCH in as a PUCCH slot…. Or, 1st PUSCH with UL DAI not equal to 4 or 0 in a PUCCH slot seems to not completely resolve the ambiguity issue. |
| MTK | Our preference is Alt-2 for Rel 15/16. For enhancement in Rel-17, we prefer Alt-1-1:   * only PUSCH that overlap with PUCCH is considered (network only sets UL TDAI for those PUSCH that did overlap with the missing PUCCH) * network provides the same UL TDAI for the overlapped PUSCH * by **“**the same procedures for PUSCH prioritization for UCI multiplexing**”**, it should be clarified that the rules are the same as given in Rel-15 38.213 Chapter 9 in the starting section |
| ZTE | We prefer Alt-1-1. As discussed above, the UL-TDAI should be taken into account at first to exclude the PUSCH not overlapping with the PUCCH. |
| Samsung | We fully understand concerns from UE and gNB side. As other companies commented, it is already discussed in previous RAN1 meeting that a UE doesn’t know which PUSCH resource group is used for multiplexing HARQ-ACK without knowing HARQ-ACK PUCCH based on current specification. Perhaps, we may need to discuss first whether this case is general case or not. |
| Huawei, HiSilicon | As indicated to question 1-2, We have a preference to Alt 1-1. |
| Nokia, NSB | Alt 1 is the only way to go.  Alt 2 = UL CA is not supported by the standard. This cannot be an acceptable resolution by a standards organization. What point is there to say that my implementation is according to a (non-existing “up to the UE implementation”) standard, if that implementation is useless? |
| Apple | We prefer Alt-2. For Alt-1, any PUSCH selection mechanism should (a) limit the multiplexing to a single PUSCH in the PUCCH slot and (b) respect the multiplexing timeline based on the first PUSCH in the PUSCH set. |

### Issue 2: Repetition

ZTE [1] and CATT [2] discuss the effect of repetition on the following agreement made in RAN1 #107-e [12]:    
**Agreement**

For Rel-16 with one PUSCH and no overlapping PUCCH with HARQ-ACK within a span of one PUCCH slot (both single carrier and UL CA), if the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), the UE multiplexes HARQ-ACK following the UL-TDAI into the PUSCH.

ZTE [1] has the following proposal:

*One of the PUSCH repetitions should be specified for HARQ-ACK multiplexing if the UE does not know the overlapping PUCCH slot due to missing detection of the DL DCI and the T-DAI in the UL grant is not equal to 4 for Type 2 codebook or is equal to 1 for Type 1 codebook.*

CATT [2] has the following proposal:

*The agreement in RAN1#107-e applies to PUSCH without repetition only. For Rel-16 with PUSCH repetition and no overlapping PUCCH with HARQ-ACK (both single carrier and UL CA), the UE does not multiplex HARQ-ACK into any PUSCH repetition.*

### Question 2-1:

Please indicate your position on the Agreement on the Rel-16 UE behavior with one PUSCH and no overlapping PUCCH with HARQ-ACK within a span of one PUCCH slot (both single carrier and UL CA), if the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook) :

***Alt 1:*** *One of the PUSCH repetitions should be specified for HARQ-ACK multiplexing if the UE does not know the overlapping PUCCH slot due to missing detection of the DL DCI and the T-DAI in the UL grant is not equal to 4 for Type 2 codebook or is equal to 1 for Type 1 codebook.*

***Alt 2:*** *The agreement in RAN1#107-e applies to PUSCH without repetition only. For Rel-16 with PUSCH repetition and no overlapping PUCCH with HARQ-ACK (both single carrier and UL CA), the UE does not multiplex HARQ-ACK into any PUSCH repetition.*

***Alt 3:*** *Any other option*

***Alt 4:*** *No change*

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| **Company** | **Comments** |
| Ericsson | We also aware of the case for PUSCH repetition that in principle the source of issue is the same.  Similarly, to case of PUSCH without repetition, there should be a solution.  Our first preference is Alt-1 when one can consider the first PUSCH in the repetition. |
| NTT DOCOMO | We are fine to define some rule, but we are not sure Alt 1 works well since even in Alt 1, NW needs to do blind decoding. Is this OK? |
| vivo | I copy one agreement as following made in NR R15 in RAN1#94 meeting.  Agreements**:**   * The UE multiplexes HARQ-ACK in any slot of a multi-slot PUSCH transmission where the UE would otherwise transmit HARQ-ACK in a single slot PUCCH transmission, based on the HARQ timeline * DAI is applicable in any slot where the UE would transmit HARQ-ACK   This agreement is for slot-level PUSCH repetition case. According to this agreement, it is clear that HARQ-ACK multiplexing only happen in the slot with overlapping PUCCH. If there is no overlapping PUCCH, there is no multiplexing. |
| CATT | We support Alt. 2.  Alt. 1 would require gNB blind detection in different repetitions. |
| QC | Same understanding as DCM that Alt 1 does not help gNB at all. On UE side, which PUSCH slot UE should pick to multiplex is unclear to us.  Also agree with VIVO that, based on RAN1#94, UE does not multiplex A/N on PUSCH in any slot within the multi-slot PUSCH.  With the above, we support Alt 2. |
| Intel | If we consider a unified solution and multiplex HARQ-ACK on the PUSCH with repetitions, our understanding is that if T-DAI in the UL grant is not equal to 4 for Type 2 codebook or is equal to 1 for Type 1 codebook, UE should multiplex HARQ-ACK on all the PUSCHs in the PUCCH slot. This is similar to what was defined in Rel-15/16. |
| MTK | For Rel-16, our preference is Alt. 2, considering that which PUSCH slot UE should pick to multiplex is unclear to us. |
| ZTE | We support Alt 1.  First, Alt 1 follows the principle of the previous agreement, where the UE performs the HARQ-ACK multiplexing. If a PUSCH repetition is specified, the network can schedule the PUCCH overlapping with this specified PUSCH repetition only. In this case, blind detection is not needed.  In Alt 2, the UE does not multiplex HARQ-ACK into any PUSCH repetition. It leads to the network cannot decode both PUCCH and PUSCH when DL-DCI is missing as the network cannot know this. Considering the overlapping between PUCCH and PUSCH is normal case when PUSCH repetition is enabled, Alt 2 is not best.  It also should be noted that the issue also exists for TBoMS transmission. It would be great if this issue could be addressed here, then reused for TBoMS transmission. |
| Samsung | We share similar view some drawbacks of alt. 1 e.g., blind detection, how to define PUSCH slot for multiplexing. It seems Alt. 2 is okay to us. Also, we are fine with other simple solution if any. |
| Huawei, HiSilicon | Alt.1 will lead to additional blind detection at the gNB. Alt.2 is acceptable to us. |
| Nokia, NSB | Alt 1.  Alt 2 = this scenario is not supported by the standard. If we adopt Alt 2 (due to inability to agree to a standard) we need to be clear that the standard does not support UL CA and PUSCH repetition. |
| Apple | We prefer Alt 2.  We would like to emphasize that both Alt 1 and Alt2 specify deterministic UE behaviors. So Alt 2 does not mean it is not supported by the standard. When comparing the two alternatives, the real question is how many blind detections the gNB would need to do. From this perspective, we do not clear advantage of one over another.  For Alt 1, it is unclear which PUSCH should be chosen, e.g. whether it is the first repetition. Assuming that the UE knows that there is no overlapping PUCCH for any repetition before the first repetition (which needs to be satisfied for Alt 1), there seems to be no technical reason to choose one repetition over another. |

### Issue 3: PUSCH Multiplexing Clarification

In [5], Ericsson raises the issue that there needs to be an understanding of the UE expected behavior with PUCCH overlap amongst all the companies and this can be used as a baseline to understand how the cases without overlap should be handled. To do this, they identify Cases A through F and ask for a survey on the expected UE behavior. These cases can be found in the draft folder in [Survey](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_108-e/Inbox/drafts/7.1/%5B108-e-NR-CRs-06%5D/Survery%20-%20AN%20mux%20in%20PUSCH%20w%20UL-TDAI%20without%20DL%20assignment%20after%20UL%20grant.pptx):

### Question 3-1: A, A-0, A-3, A-5

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Company | A  A-0  A-3  A-5 |
| Ericsson | We would like to thank Moderator to consider the survey.  We would like to explain that we are hoping that for the case when PUCCH is present, we all, provide the same answer (calibration 😊)  Then, we are hoping how to understand what solution would be the simplest for other cases that are important as we repeated multiple times.  As you may have noticed from our contribution, Case A, B, C are similar to D, E,F where different UL-TDAI is considered for the latter.  Thank you all for the efforts. |
| Ericsson  Both Option 1 and Option 2 OK for us for case of no PUCCH. Please see our comment for question 1-2.  Option 1: All PUSCHs with UL-TDAI candidates for AN mux.  Option 2: All PUSCHs without UL-TDAI=4 candidates for AN mux. | Option 1/Option 2   |  |  |  | | --- | --- | --- | | Case | Selected PUSCH | CB to mux. in selected PUSCH | | A | PUSCH A1 | (HARQ-ACK1, HARQ-ACK2) | | A-0 | PUSCH A1 | (NACK, NACK) | | A-3 | PUSCH A1 | (HARQ-ACK1, NACK) | | A-5 | PUSCH A1 | (NACK, HARQ-ACK2) | |
| NTT DOCOMO | For A/A-3/A-5, same understanding with Ericsson.  For A-0, our preference is the same as Ericsson’s comment while still under discussion as in the previous section. |
| MTK | We have concern about changing Rel-15/16 UEs behavior. If putting release number aside and only discussing the potential optimum solution, our understanding is the same as Ericsson. |
| ZTE | We think UE should select the PUSCH for HARQ-ACK multiplexing from the PUSCH with T-DAI not equal to 4 according to the current PUSCH prioritization rule.  We share the same view with Ericsson on the UE behaviors for these cases. |
| Nokia, NSB | We agree with the Ericsson interpretation. What is most important to us though, is that there is a single interpretation across the industry – something we actually think a standard is supposed to achieve. If different implementations exist today, then that will unfortunatley mean that someone will face the situation that their implementation is not aligned with the standard. This is nevertheless a smaller penalty than just saying that there cannot be a standard and no one can use the functionality because different implementations already exist. |
| Apple | For the scenario with PUCCH (A, A-3, A-5), we have the same view as Ericsson.  Scenario A-0 needs more discussion. |

### Question 3-2: B, B-0, B-1, B-2

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Company | B  B-0  B-1  B-2 |
| Ericsson  Both Option 1 and Option 2 OK for us for case of no PUCCH. Please see our comment for question 1-2.  Option 1: All PUSCHs with UL-TDAI candidates for AN mux.  Option 2: All PUSCHs without UL-TDAI=4 candidates for AN mux. | Option 1/Option 2   |  |  |  | | --- | --- | --- | | Case | Selected PUSCH | CB to mux. in selected PUSCH | | B | PUSCH A1 | (HARQ-ACK1, HARQ-ACK2) | | B-0 | PUSCH A1 | (NACK, NACK) | | B-1 | PUSCH A1 | (HARQ-ACK1, NACK) | | B-2 | PUSCH A1 | (NACK, HARQ-ACK2) | |
| NTT DOCOMO | For B/B-1/B-2, same understanding with Ericsson.  For B-0, our preference is PUSCH determined by the existing PUSCH determination rule (if PUSCH A1 is at smaller serving cell index, PUSCH A1) while still under discussion as in the previous section. |
| MTK | We have concern about changing Rel-15/16 UEs behavior. If putting release number aside and only discussing the potential optimum solution, our understanding is the same as Ericsson. |
| ZTE | We think UE should select the PUSCH for HARQ-ACK multiplexing from the PUSCH with T-DAI not equal to 4 according to the current PUSCH prioritization rule.  We share the same view with Ericsson on the UE behaviors for these cases. |
| Nokia, NSB | We share the same view as Ericsson on the UE behaviour. |
| Apple | For the scenario with PUCCH (B, B-1, B-2), we have the same view as Ericsson.  Scenario B-0 needs more discussion. |

### Question 3-3: C, C-0, C-1, C-2

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Company | C  C-0  C-1  C-2 |
| Ericsson  Both Option 1 and Option 2 OK for us for case of no PUCCH. Please see our comment for question 1-2.  Option 1: All PUSCHs with UL-TDAI candidates for AN mux.  Option 2: All PUSCHs without UL-TDAI=4 candidates for AN mux. | Option 1/Option 2   |  |  |  | | --- | --- | --- | | Case | Selected PUSCH | CB to mux. in selected PUSCH | | C | PUSCH A1 | (HARQ-ACK1, HARQ-ACK2) | | C-0 | PUSCH A1 | (NACK, NACK) | | C-1 | PUSCH A1 | (NACK, NACK) | | C-2 | PUSCH A1 | (NACK, NACK) | |
| NTT DOCOMO | For C, same understanding with Ericsson.  For C-0/C-1/C-2, our preference is PUSCH determined by the existing PUSCH determination rule (if PUSCH A1/B1 are at smaller serving cell index, PUSCH A1) while still under discussion as in the previous section. |
| MTK | We have concern about changing Rel-15/16 UEs behavior. If putting release number aside and only discussing the potential optimum solution, our understanding is the same as Ericsson. |
| ZTE | We think UE should select the PUSCH for HARQ-ACK multiplexing from the PUSCH with T-DAI not equal to 4 according to the current PUSCH prioritization rule.  We share the same view with Ericsson on the UE behaviors for these cases. |
| Nokia, NSB | We share the same view as Ericsson |
| Apple | For the scenario with PUCCH (C), we have the same view as Ericsson.  Scenarios C-0/C-1/C-2 need more discussion. |

### Question 3-4: D, D-0, D-3, D-5

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Company | D  D-0  D-3  D-5 |
| Ericsson  Both Option 1 and Option 2 OK for us for case of no PUCCH. Please see our comment for question 1-2.  Option 1: All PUSCHs with UL-TDAI candidates for AN mux.  Option 2: All PUSCHs without UL-TDAI=4 candidates for AN mux. | Option 1/Option 2   |  |  |  | | --- | --- | --- | | Case | Selected PUSCH | CB to mux. in selected PUSCH | | D | PUSCH A1 | (HARQ-ACK1, HARQ-ACK2) | | D-0 | PUSCH A1 | (NACK, NACK) | | D-3 | PUSCH A1 | (HARQ-ACK1, NACK) | | D-5 | PUSCH A1 | (NACK, HARQ-ACK2) | |
| NTT DOCOMO | For D/D-3/D-5, same understanding with Ericsson.  For D-0, our preference is the same as Ericsson’s comment while still under discussion as in the previous section. |
| MTK | We have concern about changing Rel-15/16 UEs behavior. If putting release number aside and only discussing the potential optimum solution, our understanding is the same as Ericsson. |
| ZTE | We think the UL-DAI should be the same if PUSCH A1 and PUSCH B1 both overlaps with PUCCH. |
| Nokia, NSB | We share the same view with Ericsson |
| Apple | For the scenario with PUCCH (D, D-3, D-5), we have the same view as Ericsson.  Scenario D-0 needs more discussion. |

### Question 3-5: E, E-0, E-1, E-2

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Company | E  E-0  E-1  E-2 |
| Ericsson  Both Option 1 and Option 2 OK for us for case of no PUCCH. Please see our comment for question 1-2.  Option 1: All PUSCHs with UL-TDAI candidates for AN mux.  Option 2: All PUSCHs without UL-TDAI=4 candidates for AN mux. | Option 1/Option 2   |  |  |  | | --- | --- | --- | | Case | Selected PUSCH | CB to mux. in selected PUSCH | | E | PUSCH A1 | (HARQ-ACK1, HARQ-ACK2) | | E-0 | PUSCH A1 | (NACK, NACK) | | E-1 | PUSCH A1 | (HARQ-ACK1, NACK) | | E-2 | PUSCH A1 | (NACK, HARQ-ACK2) | |
| NTT DOCOMO | For E/E-1/E-2, same understanding with Ericsson.  For E-0, our preference is the same as Ericsson’s comment while still under discussion as in the previous section. |
| MTK | We have concern about changing Rel-15/16 UEs behavior. If putting release number aside and only discussing the potential optimum solution, our understanding is the same as Ericsson. |
| ZTE | We think the UL-DAI should be the same if PUSCH A1 and PUSCH A2 both overlaps with PUCCH. |
| Apple | For the scenario with PUCCH (E, E-1, E-2), we have the same view as Ericsson.  Scenario E-0 needs more discussion. |

### Question 3-6: F, F-0, F-1, F-2

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Company | F  F-0  F-1  F-2 |
| Ericsson  Both Option 1 and Option 2 OK for us for case of no PUCCH. Please see our comment for question 1-2.  Option 1: All PUSCHs with UL-TDAI candidates for AN mux.  Option 2: All PUSCHs without UL-TDAI=4 candidates for AN mux. | Option 1/Option 2   |  |  |  | | --- | --- | --- | | Case | Selected PUSCH | CB to mux. in selected PUSCH | | F | PUSCH A1 | (HARQ-ACK1, HARQ-ACK2) | | F-0 | PUSCH A1 | (NACK, NACK) | | F-1 | PUSCH A1 | (NACK, NACK) | | F-2 | PUSCH A1 | (NACK, NACK) | |
| NTT DOCOMO | For F, same understanding with Ericsson.  For F-0/F-1/F-2, our preference is PUSCH determined by the existing PUSCH determination rule (if PUSCH A1 is at smaller serving cell index, PUSCH A1) while still under discussion as in the previous section. |
| MTK | We have concern about changing Rel-15/16 UEs behavior. If putting release number aside and only discussing the potential optimum solution, our understanding is the same as Ericsson. |
| ZTE | We think the UL-DAI should be the same if PUSCH A1, PUSCH B1 PUSCH A2, PUSCH A3 are all overlapping with PUCCH. |
| Nokia, NSB | We share the same view with Ericsson. |
| Apple | For the scenario with PUCCH (F), we have the same view as Ericsson.  Scenarios F-0/F-1/F-2 need more discussion. |

# Summary of 1st Round

### Proposal 1-1 (Scenario 1)

#### Proposal 1-1:

The positions of the companies are as follows:

* Accept proposal:
  + Ericsson, AT&T, NTT Docomo, Verizon, Vivo, Qualcomm, Intel, MTK, ZTE, Samsung, Huawei/HiSilicon, Nokia/NSB, Apple (13)
* Up to UE implementation:
  + CATT (1)

**Conclusion/Recommendation: Accept Proposal 1**

#### Additional Issue Raised: Need for Unified Solution for overlapping and non-overlapping case

The following companies identify a need for a unified solution:

* Ericsson, AT&T, NTT Docomo, Verizon, Vivo, CATT, Nokia/NSB (7)

**First general comment (Ericsson)**: We request to understand first that in case of multiple PUSCHs in the PUCCH slot, why should we have different solutions for non-overlapping PUSCHs and overlapping PUSCHs?

In RAN1 #107-e, there was a strong preference for a unified design from the companies (See first round discussion, Q2 in Section 3 of R1-2112859). However, on a detailed discussion of the different solution alternatives, there was no way forward to enable a unified design hence the agreements we have today. In detail, there was no consensus on the solutions for the overlapping cases and rather than have a unified design with no consensus for the non-overlapping cases, companies compromised by enabling multiplexing in some specific non-overlapping cases.

**Conclusion: There is a strong preference for a unified design**

**Observation: Agreeing on a solution for the non-overlapping cases and then having a unifying design for the overlapping cases will be very difficult given the last year of discussions on the subject.**

**Recommendation: Strive for a solution to the current cases and then discuss if they can be extended to the overlapping case.**

### Question 1-2 (Scenario 2)

The following are the company positions:

* Option 1: Ericsson, Nokia (?) (2)
* Option 2: MTK, ZTE, Huawei, Apple (4)

Note that an additional issue was raised on whether the fix should be for Rel-16 or the future:

* Rel-17 Fix: Qualcomm, MTK (2)
* Rel-16 Fix: Ericsson, Nokia (2)

**Summary: Further details needed on Option 1 and Option 2 and further discussion on when the fix should be applied**

### Question 1-3 (Scenario 2)

* Alt 1:
  + Ericsson, AT&T, NTT Dococmo, Verizon, CATT (timeline impact), Qualcomm (Rel-17), MTK (Rel-17, Atl1-1), ZTE (Alt-1-1), Huawei (Alt 1-1), Nokia (Alt-1)
* Alt 2:
  + Vivo, Qualcomm, Intel, MTK (Rel-15/Rel-16), Apple

**Recommendation: Discuss possible solutions based on Alt-1. If a solution can be decided upon, then decide on if applicable to Rel-16 or Rel-17.**

### Question 2-1:

The following are the company positions:

* Alt 1: Ericsson (1st PUSCH), Intel (all PUSCHs), ZTE, Nokia/NSB (4)
* Alt 2: Vivo, Qualcomm, MTK (Rel-16), Samsung, Huawei, Apple (6)
* Other : NTT Docomo (1)

Proponents of Alt-1 suggest that the 1st PUSCH and all PUSCHs to be multiplexed on. Proponents of no multiplexing argue for a solution based on the following agreement:

RAN1#94 meeting.

Agreements**:**

* The UE multiplexes HARQ-ACK in any slot of a multi-slot PUSCH transmission where the UE would otherwise transmit HARQ-ACK in a single slot PUCCH transmission, based on the HARQ timeline
* DAI is applicable in any slot where the UE would transmit HARQ-ACK

**Conclusion: Continue discussions based on current rules suggested.**

### Issue 3: PUSCH Multiplexing Clarification

* **Consensus among all companies in cases where the PUCCH is present.**
* Some differences in cases where PUCCH is not present
  + Ericsson and Nokia are aligned.
  + NTT Docomo is aligned on some cases and for others, needs further discussion.
  + MTK has concerns about changing Rel-15/16 behavior. Aligned with Ericsson if optimum solution.
  + ZTE thinks UE should select the PUSCH for HARQ-ACK multiplexing from the PUSCH with T-DAI not equal to 4 according to the current PUSCH prioritization rule. Algined with Ericsson on these options.
  + Apple: scenarios without PUCCH need further discussion based on timeline and number of HARQ ACK multiplexes.

# 2nd Round

For scenario 2, (i.e., if more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook)) and ignoring what release this solution will be implemented in:

### Proposal 2-1 (Scenario 2):

The following generic steps should be taken for Scenario 2 (more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook):

1. Selection of the candidate PUSCH for multiplexing
2. Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs
3. Prioritization rules to select PUSCH for multiplexing: identical to 38.213
4. Limitations for multiplexing
   1. UE expects to multiplex on only 1 PUSCH in PUCCH slot.
   2. The gNB will/will not schedule additional PUSCHs in the PUCCH slot in addition to the candidate PUSCHs.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | OK with these generic steps. |
| Ericsson | We support the generic steps proposed by Moderator. We strongly support a unified solution and this approach is the baseline. |
| QC | We have sympathy for the situation on the function UL-TDAI. But we don’t think the consequence of “leaving it to UE implementation for multiple PUSCHs case” would make UL CA not working. No, it is not that devastating. The following are my rationales.  Rationale 1:   1. With multiple PUSCHs scheduled in a slot, it is sufficient for gNB to schedule only one PUSCH with UL-TDAI not equal to 4 (for type 2 codebook) or equal to 1 (for type 1 codebook). And in this case, majority are fine to support multiplexing A/N on the PUSCH following the UL-TDAI. So UL CA works in this typical use case, which is illustrated by the following figure (where the A/N in the dashed box in the “ghost A/N” which is assumed by gNB but not seeing by the UE).      1. There is no motivation for gNB to schedule later PUSCHs with UL-TDAI not equal to 4 (for type 2 codebook) or equal to 1 (for type 1 codebook). So the scenario looks a corner case to me. The following is why I think gNB has no motivation to do so.   In the above example, let’s assume PUSCH 1 is scheduled first, followed by PUSCH2, then PUSCH 3. The only reason gNB want to indicate a new UL-TDAI on later PUSCH 2 or PUSCH 3 is that after gNB schedule PUSCH 1, there are some DL traffic arrive and gNB scheduled PDSCH. Therefore, gNB need to increase # A/N feedback from 2 bits to more, say 3 bits. So gNB has to indicate a new UL-TDAI=3 and move the A/N mux to PUSCH 2 (because it cannot override the UL-TDAI on already scheduled PUSCH 1). So, gNB wish to achieve this goal (UE mux 3 bits on PUSCH 2) via the scheduling/indication of UL-TDAI as illustrate in the following figure.    Now, let’s analyze if the goal can be achieved.  First assuming if UE did not miss DL grant, UE knows where the PUCCH is. Then UE will mux 2 bits on PUSCH 1, this is not what gNB want. Hence there is no motivation for gNB to do the above scheduling/indication of the UL-TDAI for PUSCH 2.  Now assuming if UE missed DL grants, UE follow the solution we are discussing, UE still multiplex 2 bits A/N on PUSCH 1. There is again no motivation for gNB to do the above scheduling/indication of the UL-TDAI for PUSCH 2.  Rationale 2: the solution could lead to UE behavior that is not expected by gNB, which could fail gNB decoding.  In the following example. Following the solution, all PUSCH (1/2/3) in the slot are included to execute A/N mux. Then UE follow 213 to mux on the smallest CC which is PUSCH 1. So UE mux 2 bits A/N on PUSCH 1. But gNB does not know UE missed DL grant, gNB would expect UE mux 3 bits on PUSCH 2. So the solution can not work. What gNB has to do is blind detection anyway with or without a solution. Furthermore, considering UE can also miss UL grant, it seems blind detection on gNB is the only way out. The significance of seeking a solution is not as important as assumed.    In summary, we don’t think leaving it up to UE implementation is unreasonable, because   1. The typical use case with only one UL-DAI nq 4 (for type 2 codebook) or eq 1 (for type 1 codebook) is already supported with a solution. More than one UL-DAI nq 4 (for type 2 codebook) or eq 1 (for type 1 codebook) is atypical case which can leave to UE implementation. 2. Blind detection anyway is needed for the atypical case with or without a defined solution in RAN1. |
| Samsung | We also hope to find unified solution to resolve the issue. However, we need to discuss first whether existing multiple DAIs is possible in reality with following specification.  A UE does not expect to detect a DCI format scheduling a PDSCH reception or a SPS PDSCH release 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.  Let’s assume that gNB schedules DL grant 1 🡪 UL grant 1 (DAI=1) 🡪 DL grant 2 🡪 UL grant 2 (DAI=2). At the time when a UE receives UL grant 2, the UE expects to multiple HARQ-ACK on the PUSCH scheduled by UL grant 1. So, scheduling DL grant 2 is unexpected UE behavior, and this should be avoided by gNB scheduling. In that sense, multiple PUSCHs having different DAI values in a slot seems not reasonable scenario, and we are wondering whether Qualcomm’s 2nd/3rd examples are valid or not.  Maybe, following case is possible: gNB schedules DL grant 1 🡪 UL grant 1 (DAI=1) 🡪 UL grant (DAI=1). Although current specification has defined a rule on how to select PUSCH to be multiplexed with HARQ-ACK, it is a little bit unclear why gNB is scheduling two UL grants having the same DAI value before discussing details. |
| ZTE | We understand the last bullet means the gNB will/will not schedule additional PUSCHs in the PUCCH slot in addition to the candidate PUSCHs. We are fine with the generic steps. We also hope we can get an unified solution. |
| MTK | We are generally fine with the generic steps proposed by Moderator, while the concerns from QC and Samsung may have to be addressed along the way. |
| Ericsson2 | We would like to thank companies for sharing views/rationales on this topic.  Special thanks for elaborating these cases.   * First, it seems to us that there is an underlying assumption in QC analysis that scheduling PDSCH after UL grant is allowed and hence update the decision for PUSCH to carry HARQ-ACK. **We share the same view as Samsung that behavior is not allowed by specifications**. In fact, the text cited by Samsung that we also discussed in our contributions, has put severe scheduling restrictions. This has forced us to seek some enhancements under TEI Rel-17, such as facing limited number of K1 or problems with scheduling DL in case of PUSCH repetitions. In all those discussions, when we referred to this scheduling restriction, no company commented that there not such a restriction. Therefore, is any of the solutions proposed by QC to be considered, we have to relax the scheduling restriction cited by Samsung (also in our contribution). * Second, it is important to consider that when we schedule, how to handle miss-detection, and whether to do blind detection or RLC retransmission, etc., are all up to gNB implementation since there are many factors in place. As we mentioned repeatedly, with standards, we understand what would be the expected behavior for each case, and then make the decision. **The issue with UL-TDAI is that its main purpose is to help in cases when DL assignment is missed (some or all), and the standard should be clear with expected behavior.** The purpose of this exercise is not to provide implementation solution to gNB how to handle these cases, although, it is very much appreciated. * I think it is very important to clarify this aspect , since Samsung also raised the question “it is a little bit unclear why gNB is scheduling two UL grants having the same DAI value”.   Consider Case G below that PUSCH A1 is on PCell and A2 on Scell.    Due to DL miss-detection, the gNB has to consider any of the following outcomes that can happen (G to G-4). You see clearly that in case of G-1, having same UL-TDAI value, ensures HARQ-ACK would be sent on SCell. However, this doesn’t mean if that happens what gNB does. Maybe gNB does blind detection on SCell, maybe ignores, … That is not the discussion for specifications. **The point is the UE behaviour should be clear due to the presence of the UL-TDAI since UE is expected to send feedback. In that exercise, we believe a unified solution, complying with the current standards should be in place.** |
| Nokia, NSB | We support the generic steps. Thanks to Ericsson for elaborating the need for specification rather than innovating how the system could operate if there is no specification. |
| Apple | We have some sympathy on QC’s and Samsung’s comment that the most typical case is a single PUSCH with T-DAI n.e. 4.  It would be very helpful if the network vendors can share their views on the typical cases having T-DAI values (n.e. 4) for multiple PUSCHs in UL CA, and a focused discussion to develop a solution based on the typical cases could be more effective.  For the scheduling constraint, we also share the understanding that DL grant is not expected after UL grant to change the HARQ-ACK codebook size. It would be good to align the understanding so that we better understand the cases we are dealing with.  We think one potential case for multiple PUSCHs with TDAI n.e. 4 is when the gNB would like to schedule another PUSCH, and this additional PUSCH becomes the one to be selected for UCI multiplexing based on the defined rules. In this case, the new PUSCH needs to have TDAI n.e. 4 also. But again, it would be helpful if the network vendors can share their views on the most typical cases that we should cover.  We totally agree that in the end it is up to the gNB in terms of how to handle the error cases. However, when we compare different solutions on the table, whether/how much it can potentially save gNB complexity is one of the biggest factors to be considered. If gNB complexity is not considered and gNB is willing to do blind decoding for all PUSCHs, we don’t have an issue even if UE behavior is undefined.  The generic steps listed are a good starting point for developing the solution in our view. |
| Intel | We are fine with the generic steps and prefer a unified solution.  For 4a in Limitations for multiplexing, it would be good to clarify that only HARQ-ACK is multiplexed on PUSCH or additional PUCCH carrying CSI cannot be configured/multiplexed on the PUSCH.  For 4b, we share similar view as ZTE that this should be within a PUCCH slot. |
| CATT | We also think it would be beneficial to discuss whether it is typical to have multiple T-DAIs for PUSCHs indicating multiplexing HARQ-ACK in a same PUCCH slot.  For QC’s example, we share the same understanding with Samsung and Ericsson that it is precluded according to current specification.  For the example case G provided by Ericsson, we understand the intention is to multiplex HARQ-ACK in A2 in case DCI A1 is missed. The benefit is that HARQ-ACK is not dropped but the cost is the increase of gNB complexity. |
| vivo | We share the same view QC that the solution can’t work. I just copy the example given by QC below.    We tend that it is reasonable for gNB to schedule only one PUSCH with UL-TDAI not equal to 4 (for type 2 codebook) or equal to 1 (for type 1 codebook). we also share the understanding that DL grant is not expected after UL grant to change the HARQ-ACK codebook size. |
| QC2 | Still, we are not convinced why gNB will issue multiple UL-TDAIs nq 4 (for type 2 CB) or eq 1(for type 1CB)? Thank for point out the additional gNB scheduling restriction that is missed in my previous example. However, even in my previous example that I removed the restriction, there is no motivation for gNB to issue multiple UL-TDAIs nq 4 (for type 2 CB) or eq 1(for type 1CB). Can Infra vendors please explain what is the use case for multiple UL-TDAIs nq 4 (for type 2 CB) or eq 1(for type 1CB)? For example, in the following figure, why NW set UL-TDAI =1 in both DCI A1 and A2?  Even if we assume the following case is a meaningful use case, for <=2 bits A/N feedback, there is no problem at gNB. Because <=2 bits A/N puncture PUSCH, regardless UE put 1/2 bits A/N on PUSCH A1 or A2, it will not impact gNB receiver. gNB just assume UE does not miss any DCI, go to PUSCH A1 to decode A/N and it should detect NACK/DTX anyway, which matches what happened at UE (missed DL grant). For PUSCH decoding, since gNB assume 1/2 bits puncture PUSCH so there is no problem neither. The problem occurs with >2 bits A/N. But UE need to miss >1 DL DCIs for that to occur, which is a small probability.  Chart  Description automatically generated  In summary, due to following two reasons, we think the case we are studying is a corner case. It cannot destroy UL CA functionality, unless I missed something.   * No motivation for gNB to issue >1 UL-TDAI nq 4 (for type 2 CB) or eq 1(for type 1CB) * The issue only exist with missing more than 1 DL DCIs, which is a rare event. |

### Proposal 2-2 (Alternative Options)

If amenable to Proposal 2-1, please select a preferred alternative based on the options in Round 1:

**Alt 1:**

1. Selection of the candidate PUSCH for multiplexing
   1. All the PUSCHs within the PUCCH slot are candidates
2. Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs
   1. No restrictions on the TDAI values
3. Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213
4. Limitations for multiplexing
   1. UE expects to multiplex on only 1 PUSCH in PUCCH slot.
   2. PUSCHs to be selected obey multiplexing timeline for the first PUSCH in the PUSCH candidate set.
      1. gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline.

**Alt 2:**

1. Selection of the candidate PUSCH for multiplexing
   1. PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates
2. Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs
   1. N/W sets all TDAI values that overlap with PUCCH to the same value with TDAI n.e. 4
3. Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213
4. Limitations for multiplexing
   1. UE expects to multiplex on only 1 PUSCH in the PUCCH slot.
   2. PUSCHs to be selected obey multiplexing timeline for the first PUSCH in the PUSCH candidate set.
      1. gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline OR if gNB schedules any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline, the gNB should indicate 4 (for Type 2 codebook) or 0 (for Type 1 codebook)

**Alt 3:** Other solutions

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | Alt 2. If we understand Alt 1 correctly, Alt 1 needs blind decoding at gNB side since which PUSCH is selected is unknown at gNB side. |
| Ericsson | Both Alt-1 and Alt-2 are acceptable to us, with Alt-1 being our 1st preference.  @DCM: For both Alt-1 and Alt-2, it is clear for the gNB that in case UE misses all the DL-assignment which PUSCH is selected for HARQ-ACK (in this case only NACK) multiplexing. There is no ambiguity in that. |
| QC | If we want to seek a solution, we don’t think Alt-1 nor Alt 2 are good solution. Our solution is **Alt-3: multiplex on the last scheduled PUSCH in the slot, following the UL-TDAI in the lastly received UL grant.**  The rationale is the last UL grant give gNB the opportunity to mux more A/N bits, which is the motivation to issue new UL-TDAI; otherwise the previous (a single) nq 4 UL-TDAI would be sufficient.  Furthermore, Alt-1 and Alt-2 requires blind detection at gNB, as illustrated below (basically repeat the comments in previous section 4.1.1)  Following Alt-1/2, UE mux 2 bits A/N on PUSCH 1. But gNB does not know UE missed DL grant, gNB would expect UE mux 3 bits on PUSCH 2. So Alt-1/2 cannot work. What gNB has to do is blind detection anyway with or without a solution.  I have to admit my proposed Alt-3 would still need gNB to do blind detection due to missing UL grant (which is the caveat for all alternatives), but it at least remove the blind detection due to missing DL grants. |
| Samsung | If only one PUSCH (UL-TDAI not equal to 4 in case of Type 2, or UL-TDAI equal to 1 in case of Type 1 CB) is available in a slot, solution can be simple. |
| ZTE | Our preference is Alt. 2 |
| MTK | As an amendment to Proposal 2-1, our preference is Alt. 2. |
| Ericsson2 | On Alt-3 proposed by QC:  First, please see our related comments in the previous section. It seems to us there is an underlying assumption of being able to schedule after 1st UL grant that in our view violates the spec. For Alt 3 to work, we need to remove that restriction (which is definitely fine with us, but we don’t think that would be feasible based on our experience in TEI Rel-17 discussions).  Additionally, in case of UL CA, when PCell is 15 kHz and SCell 30 kHz, usually the latest UL grant is for SCell. Assuming the last DCI rule (Alt-3) , the result would be that PUSCH on SCell would be selected, while with Alt-1 and Allt-2, following the unified solution as if PUCCH was present, PUSCH on PCell would be selected.  Therefore, Alt-3 not only raises the concern on relying on an underlying assumption that in our understanding doesn’t comply with spec (though we would be very happy to get rid of that 😊 ), it also results in unexpected outcome and adds unnecessary complications, which would make it effectively not useful. |
| Nokia, NSB | We’d be able to accept either of the two alternatives. Our preference is Alt1. Agree with Ericsson that Qualcomm’s Alt3 is not something that takes us forward. |
| Apple | As commented in the first round, we think Alt-2 works better in the cases when only DL grant(s) are missing. With Alt-1, the UE may choose a PUSCH with TDAI=4 and not multiplex at all in the end. In this sense, we see Alt-2 has some advantage over Alt-1.  But we are open to consider either Alt-1 or Alt-2. |
| Intel | We slightly prefer Alt2 as it is reasonable to select subset of PUSCHs as candidate for the following step. All PUSCHs in a PUCCH slot may imply additional blind decoding at gNB side. |
| CATT | Our understanding is that we are trying to achieve a unified solution here. But on the other hand, companies expect us agree Proposal 1-1 where it is Alt 2 not Alt 1, isn’t it? So we are a little bit confused here.  In addition, it is our understanding that Alt 1 would require additional timeline requirement, i.e. DCI for PUSCH that does not overlap with the PUCCH needs to meet multiplexing timeline with respect to the first PUSCH in the same PUCCH slot. Is it the correct understanding?  For Alt 2, we would like to understand the intention of point 2. Can anyone clarify? |
| vivo | Same view as Samsung. |
| QC2 | Again, the example I provide before is just to show Alt-1 and Alt-2 will multiplex A/N on wrong PUSCH. The scheduling restriction in spec is not the main point. But fine, if we want to find examples compliant to spec. Let’s consider case D in Ericsson provided, with a slight modification that shorten the PUCCH to be in the second half of the slot. In this example, when both DL DCIs are missed which creates the scenario we are discussing, following Alt-1 or Alt 2, UE will mux 2 bits A/N on PUSCH A1, while NW expecting UE mux 4 bits A/N on PUSCH B1. Following Alt 3, UE mux 4 bits A/N on PUSCH B1. Is not Alt-3 better than Alt 1 or 2?    @Ericsson, regarding this comment: “Additionally, in case of UL CA, when PCell is 15 kHz and SCell 30 kHz, usually the latest UL grant is for SCell. Assuming the last DCI rule (Alt-3) , the result would be that PUSCH on SCell would be selected, while with Alt-1 and Allt-2, following the unified solution as if PUCCH was present, PUSCH on PCell would be selected.”, can you illustrate why last UL grant is for Scell? If so, what is the problem to mux A/N on PUSCH on Scell? |

### Question 4-3: This solution should be applicable to Rel-16 or Rel-17

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | Prefer Rel-16, but OK with Rel-17 as well. |
| Ericsson | Rel-17 is not acceptable to us. W should fix the problem for Rel-16.  We are hoping that alternatives listed (specially Alt-2) has accommodated the concerns. |
| QC | Unfortunately, adopt a solution for Rel-16 is not acceptable to us, as Rel-16 UE is already implemented/commercialized/deployed. Take a solution for Rel-17 is fine for us, although again we don’t see it helps much to remove/reduce the necessity of gNB blind detection. |
| Samsung | Prefer to fix Rel-16 if possible. |
| ZTE | We should try to apply this solution for Rel-16 as possible. |
| MTK | Our preference in Rel-17, but we can be open to discuss the possibility of Rel-16, if there is serious issue identified in the field. |
| Ericsson2 | As we explained before, the point is the UE behavior should be clear due to the presence of the UL-TDAI since UE is expected to send feedback. We had the same view for Rel-15. Then, the arguments of devices already deployed left us not to even fix the simple case of single PUSCH for Rel-15.  There was awareness of this issue even for Rel-15. Therefore, planned implementation for Rel-16 should/(should have) consider(ed) the need for correction. |
| Nokia, NSB | Rel-17 is too late, this is a Rel-15 bug that we are fixing. We can accept that no Rel-15 UEs will be considered as UL CA capable, although don’t quite understand what is the benefit of NOT fixing a Rel-15 specification issue in Rel-15. There is no reason to not allow the support of UL CA with Rel-16 devices. 🡺 Fix should be from Rel-16 onwards. |
| Apple | We are open to consider a solution for R16. |
| Intel | We prefer to fix this in Rel-16. |
| CATT | Fine with Rel-16. |
| vivo | We prefer to fix this for Rel-16. We are also fine with R17 only considering some companies have the concern that Rel-16 UE is already implemented/commercialized/deployed. |

### Proposal 2-3 (Repetition)

The PUSCH for multiplexing is selected by:

***Alt 1-1:*** *One of the PUSCH repetitions should be specified for HARQ-ACK multiplexing if the UE does not know the overlapping PUCCH slot due to missing detection of the DL DCI and the T-DAI in the UL grant is not equal to 4 for Type 2 codebook or is equal to 1 for Type 1 codebook.*

* *First PUSCH*

***Alt 1-2:*** *All PUSCH repetitions should be specified for HARQ-ACK multiplexing if the UE does not know the overlapping PUCCH slot due to missing detection of the DL DCI and the T-DAI in the UL grant is not equal to 4 for Type 2 codebook or is equal to 1 for Type 1 codebook.*

* *All PUSCHs*

***Alt 2:*** *The agreement in RAN1#107-e applies to PUSCH without repetition only. For Rel-16 with PUSCH repetition and no overlapping PUCCH with HARQ-ACK (both single carrier and UL CA), the UE does not multiplex HARQ-ACK into any PUSCH repetition.*

|  |  |  |
| --- | --- | --- |
| **Company** | **Comments** | |
| NTT DOCOMO | **Alt 1-1 Pros** |  |
| **Alt 1-1 Cons** | gNB blind decoding of two cases: 1) HARQ-ACK on the first PUSCH, 2) HARQ-ACK on the PUSCH with PUCCH overlap as intended by gNB |
| **Alt 1-2 Pros** |  |
| **Alt 1-2 Cons** | gNB blind decoding of two cases: 1) HARQ-ACK on all PUSCHs, 2) HARQ-ACK only on the PUSCH with PUCCH overlap as intended by gNB |
| **Alt 2 Pros** |  |
| **Alt 2 Cons** | gNB blind decoding of two cases: 1) All PUSCHs without HARQ-ACK, 2) HARQ-ACK on the PUSCH with PUCCH overlap as intended by gNB |
| Ericsson | **General comments:**  First, ignoring multiplexing HARQ-ACK, brings us to the same original issue as discussed for PUSCH without repetition to allow a behavior that defeats the purpose of Ul-TDAI. Therefore, we are objecting to Alt-2.  Second, With regard to Alt-1, we share same view as Nokia that the same principle is still applied that the solution should be unified to address non-CA and CA cases. So, when we look at one PUCCH slot, the same unified solution is applied and then, Alt-1, puts addition condition (as in Proposal 2-2) whether to consider 1st PUSCH or all PUSCH (Alt 1-1, or Alt 1-2, respectively).  Third, between Alt-1-1 and Alt-1-2, we experience that the usually we can only multiplex in the first few repetitions, especially in case of TDD. The reason is that we don’t have enough k1 values to be able to schedule PDSCHs such that their corresponding HARQ-ACK would be multiplexed in last repetitions. We can usually “reach” the first PUSCH repetitions by the 8 k1 values that we have. Therefore, it is more realistic that we would end up usually to multiplex in earlier repetitions, e.g. in the first two repetitions, and consequently, it would be an overkill to multiplex in all the PUSCHs.  Hence, as DCM mentioned both Alt require blind detections, but it seems to us Alt-1-1 is the closest to what would be the case in practice. | |
| **Alt 1-1 Pros** | Less number of blind detections and better match with the realistic scenario |
| **Alt 1-1 Cons** |  |
| **Alt 1-2 Pros** |  |
| **Alt 1-2 Cons** | Overkill in number of blind detections. |
| **Alt 2 Pros** |  |
| **Alt 2 Cons** | The same issue as in PUSCH without repetition. Defeats the purpose of UL-TDAI. |
| QC | **Alt 1-1 Pros** |  |
| **Alt 1-1 Cons** | Need blind detection. |
| **Alt 1-2 Pros** |  |
| **Alt 1-2 Cons** | It is overkilling. If A/N<=2 bits, A/N puncture all PUSCH repetitions, which unnecessarily degrade PUSCH performance. |
| **Alt 2 Pros** | At least for A/N<=2 bits, Alt 2 does not require gNB to do blind detection. For A/N decoding, gNB just goes the slot where it expects A/N feedback to decode A/N. Of course, gNB picked a few junk LLRs (they are actually PUSCH LLRs) and very likely NACK/DTX will be decoded, which actually match UE behavior. For PUSCH decoding, since gNB assuming A/N puncture PUSCH, no blind detection is needed neither.  Also, Alt 2 is aligned with current specification text. |
| **Alt 2 Cons** |  |
| Samsung | We think that Alt. 2 seems to require the smallest gNB blind detection number since gNB only blindly detects x-th PUSCH repetition which is originally intended to multiplex HARQ-ACK. While, Alt. 1-1 requires at least two blind detections: first PUSCH and x-th PUSCH and Alt. 1-2 requires N-1 blind detections except x-th PUSCH if there are N PUSCH repetitions assuming that x-th PUSCH will be multiplexed with HARQ-ACK. | |
| ZTE | For Alt 1-1, if the PUCCH is on the first slot, there is no blind detection issue. Alt 1-1 provides a high flexiblity for the network. If the network can accept blind detection, it can schedule the PUCCH on any slot. If the network don’t like blind detection, it always schedules the PUCCH on the first slot at the cost of scheduling restriction. It is up to the network to choose which way.  For Alt 1-2 and Alt 2, the network has no choice and bind detection is always needed.  Therefore, Alt 1-1 is the best solution. | |
| **Alt 1-1 Pros** | * The UE behavior is clear and can be predicted. * No blind detection issue. * High flexibility for the network |
| **Alt 1-1 Cons** | May be Scheduling restriction. The PUCCH can not be scheduled on the PUSCH slot other than the first PUSCH if the network don’t want blind detection. |
| **Alt 1-2 Pros** |  |
| **Alt 1-2 Cons** | The UE behavior depends on the awareness of the PUCCH resource.   * If it knows the PUCCH resource, the HARQ-ACK is multiplexed in the PUSCH overlapping with PUCCH. * If it does not know the PUCCH resource, HARQ-ACK is multiplexed in all the PUSCHs.   The blind detection at network is needed. |
| **Alt 2 Pros** |  |
| **Alt 2 Cons** | Same as Alt 1-2, blind detection at network is needed. |
| MTK | **Alt 2 > Alt 1-1 > Alt 1-2** | The pros and cons are clearly addressed by companies above, so we just list our preference in the left. We can be open to discuss taking one of Alt 1-1/1-2 if we are the only company objecting. |
| Ericsson2 | We appreciate companies considering number of blind detection for preferred alternative. However, we request companies that the baseline **should be that the feedback should be provided because of UL-TDAI.** This fact does not change if the case is repetition, or no repetition, or single PUSCH, or multiple, overlapping or non-overlapping.  Then, we can discuss which alternative is more feasible.  Also, we disagree with the statement that Alt-2 is according to the spec, for the same reason as for PUSCH without repetition.  It is important to keep in mind that because of UL-TDAI, the NW vendors are even more restriction to schedule DL in case of repetition (please see HW contribution that we supported as well for TEI Rel-17 in previous meetings). We cannot schedule after the UL grant and this impact becomes more sever in case of repetition. **ALL BECAUSE OF UL-TDAI!**  **Therefore, we expect UE provides the expected feedback. Otherwise, let’s remove this scheduling restriction.** | |
| Nokia, NSB | Support Alt 1-1 | |
| Apple | We agree with the analysis by Samsung, and think Alt 2 requires smaller number of blind decoding at the gNB. | |
| Intel | We are fine with either Alt 1-1 or Alt 1-2. Alt 2 is not preferred. A unified solution is preferred for all different cases: single PUSCH, multiple PUSCHs, PUSCH with repetitions, etc.  For bind decoding complexity, our understanding is that it depends on how many PUSCHs overlap with intended PUCCH resource carrying A/N. For Alt 1-1, there is tradeoff between scheduling restriction and blind decoding complexity. For Alt1-2, our view is that this follows similar behavior in the current spec, i.e., when PUCCH overlaps with more than one PUSCH with repetitions. | |
| CATT | Same view as QC, Samsung, Apple. | |
| vivo | Alt 2.  Alt 2 is aligned with the previous agreement and current specification text. We agree with the analysis by Samsung that Alt 2 requires smaller number of blind decoding at the gNB. | |

# Summary of 2nd Round

### Proposal 2-1 (Scenario 2) (updated based on ZTE’s correction):

The following generic steps should be taken for Scenario 2 (more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook):

1. Selection of the candidate PUSCH for multiplexing
2. Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs
3. Prioritization rules to select PUSCH for multiplexing: identical to 38.213
4. Limitations for multiplexing
   1. UE expects to multiplex on only 1 PUSCH in PUCCH slot with only HARQ-ACK multiplexed on PUSCH
   2. The gNB will/will not schedule additional PUSCHs in the PUCCH slot in addition to the candidate PUSCHs.

The company positions are as follows:

* Support
  + NTT Docomo, Ericsson, ZTE, MTK (conditional), Nokia, Apple, Intel (8)
* Not support
  + Qualcomm, Vivo (2)

**Conclusion: A majority of companies support the generic method**

Issue: gNB vendors discuss if it is typical to have multiple T-DAIs n.e. 4 (for Type 2 CB) or equal to 1 (for Type 1 CB) or is this a corner case

* + Qualcomm, Samsung, Apple, CATT
* QC
  + No motivation for gNB to issue >1 UL-TDAI nq 4 (for type 2 CB) or eq 1(for type 1CB)
  + The issue only exist with missing more than 1 DL DCIs, which is a rare event.
  + NOTE: example 2 and 3 not allowed based on specification
* Samsung: This scenario is possible: gNB schedules DL grant 1 🡪 UL grant 1 (DAI=1) 🡪 UL grant (DAI=1). However, it is a little bit unclear why gNB is scheduling two UL grants having the same DAI value before discussing details
  + Ericsson: Consider Case G below that PUSCH A1 is on PCell and A2 on Scell.

A screenshot of a computer

Description automatically generated with medium confidence

**Due to DL miss-detection, the gNB has to consider any of the following outcomes that can happen (G to G-4). You see clearly that in case of G-1, having same UL-TDAI value, ensures HARQ-ACK would be sent on SCell**.

Timeline

Description automatically generated with medium confidence

* Apple: We think one potential case for multiple PUSCHs with TDAI n.e. 4 is when the gNB would like to schedule another PUSCH, and this additional PUSCH becomes the one to be selected for UCI multiplexing based on the defined rules. In this case, the new PUSCH needs to have TDAI n.e. 4 also. But again, it would be helpful if the network vendors can share their views on the most typical cases that we should cover.

**Conclusion: Continue discussion on if typical to have multiple T-DAIs n.e. 4 (for Type 2 CB) or equal to 1 (for Type 1 CB)**

### Proposal 2-2 (Alternative Options)

The following are the company positions:

* Alt 1: Ericsson (1st preference), Nokia, Apple (2nd preference), Intel (2nd preference) (4)
* Alt 2: NTT DOCOMO, Ericsson (2nd preference), ZTE, MTK, Nokia, Apple (1st preference), Intel (1st preference) (7)
* Alt 3: multiplex on the last scheduled PUSCH in the slot, following the UL-TDAI in the lastly received UL grant: Qualcomm (1)
* Alt 4: We do not expect more than 1 PUSCH with UL TDAI n.e. 4 (Type 2 CB) or UL TDAI equal to 1 (Type 1 CB): Samsung, Vivo (2)

**Conclusion: We can eliminate Alt 1 from the discussion and focus on Alt 2, Alt 3 and Alt 4 as everyone in Alt.1 is in Alt.2.**

### Question 4-3: This solution should be applicable to Rel-16 or Rel-17

The company positions are as follows:

* Rel 16 : NTT DOCOMO, Samsung, ZTE, MTK, Apple, Intel, CATT, Vivo (8)
  + Object: Qualcomm,
* Rel 17 : Qualcomm, NTT DOCOMO, MTK, Apple, Vivo (5)
  + Object: Ericsson, Nokia

**Conclusion: Majority prefer Rel-16 but objections on both sides. Focus on finding solution. Continue discussion on the topic once solution finalized.**

### Proposal 2-3 (Repetition)

The pros and cons are as follows:

|  |  |
| --- | --- |
| **Comments** | |
| **Alt 1-1 Pros** | [Ericsson] Less number of blind detections and better match with the realistic scenario  [ZTE] The UE behavior is clear and can be predicted, No blind detection issue, High flexibility for the network |
| **Alt 1-1 Cons** | [NTT DOCOMO] gNB blind decoding of two cases: 1) HARQ-ACK on the first PUSCH, 2) HARQ-ACK on the PUSCH with PUCCH overlap as intended by gNB  [ZTE] May be Scheduling restriction. The PUCCH can not be scheduled on the PUSCH slot other than the first PUSCH if the network don’t want blind detection. |
| **Alt 1-2 Pros** |  |
| **Alt 1-2 Cons** | [NTT DOCOMO] [ZTE]gNB blind decoding of two cases: 1) HARQ-ACK on all PUSCHs, 2) HARQ-ACK only on the PUSCH with PUCCH overlap as intended by gNB  [Ericsson][QC] Overkill in number of blind detections. |
| **Alt-2 Pros** | [QC] At least for A/N<=2 bits, Alt 2 does not require gNB to do blind detection. For A/N decoding, gNB just goes the slot where it expects A/N feedback to decode A/N. Of course, gNB picked a few junk LLRs (they are actually PUSCH LLRs) and very likely NACK/DTX will be decoded, which actually match UE behavior. For PUSCH decoding, since gNB assuming A/N puncture PUSCH, no blind detection is needed neither.  Also, Alt 2 is aligned with current specification text.  [Samsung] We think that Alt. 2 seems to require the smallest gNB blind detection number since gNB only blindly detects x-th PUSCH repetition which is originally intended to multiplex HARQ-ACK. While, Alt. 1-1 requires at least two blind detections: first PUSCH and x-th PUSCH and Alt. 1-2 requires N-1 blind detections except x-th PUSCH if there are N PUSCH repetitions assuming that x-th PUSCH will be multiplexed with HARQ-ACK. |
| **Alt-2 Cons** | [NTT DOCOMO] [ZTE] gNB blind decoding of two cases: 1) All PUSCHs without HARQ-ACK, 2) HARQ-ACK on the PUSCH with PUCCH overlap as intended by gNB  [Ericsson] defeats the purpose of Ul-TDAI  Q: for the mulit-slot case, if we have a scenario where the gNB expects the HARQ-ACK in the 1st PUSCH and does not receive it, can it not set up a new PUCCH on another slot and receive it there ? The chances of both PUCCHs being missed is low. |

Company Positions:

Alt 1-1: Ericsson, ZTE, Nokia, Intel

Alt 1-2: Intel

Alt 2: Qualcomm, MTK (flexible), Apple (preferred), Vivo

* Not preferred: Intel, Ericsson, Nokia

Conclusion: we can remove Alt 1-2 based on the survey. Clear objections to Alt-2. Can we accept Alt 1-1 ?

# 3rd Round

### Question 3-1: Discussion Specific Questions.

Although directed at specific companies, everyone is free to answer.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Moderator | @Vivo: if you “share the understanding that DL grant is not expected after UL grant to change the HARQ-ACK codebook size” then does example 3 from Qualcomm serve as a justification for the solutions not working ?  @ Samsung, @ Vivo: if the gNB vendors are able to show that they may need to schedule more than 1 PUSCH with UL TDAI n.e. 4 (Type 2 CB) or UL TDAI equal to 1 (Type 1 CB) will you be willing to go with the majority Alt-2 if the solution converges?  @ CATT, in answer to your questions:   * both Alt-1 and Alt-2 have the same steps as the Proposal 1-1. They achieve them in slightly different ways based on the details in the sub-bullets. The main bullets are identical to Proposal 1-1 (as an example Alt 1.1 is identical to Alt 2.1), but the sub-bullets are different (Alt 1.1.a is different from Alt 2.1.a). * For Alt 1, your timeline question is correct. The timeline limitations are captured in Alt 1 4.b.i * For Alt 2.2, there were multiple companies that had this restriction in their proposals (e.g. Huawei, ZTE) hence the use of the word “potential”. We will clarify this as we discuss further.   @ Qualcomm: On Alt-3, (a) we would need to define similar timeline limitations for multiplexing as we have in Alt-2 (b) in previous discussions in the overlapping case, we have acknowledged that there is no perfect solution. As an example, if in comment QC2, the PUCCH were to be in the 1st half of the slot, then Alt 3 would also provide the wrong answer and Alt-2 would be fine. (c) In RAN1 #106-e, we identified multiple solutions including a “virtual PUCCH” and the “last overlapping PUSCH” both of which Qualcomm initially supported. Would it be possible to accept this “virtual PUCCH-like” solution (dropped in RAN1 #106-e) as a candidate vs. Alt-4 ? |
| Samsung | Thanks for the question. Regarding the question by FL, we are open to discuss Alt. 2 as a baseline. Although we understand that Alt. 2 is high level framework, it should be clarified on how a UE determine multiplexing timeline in case where the UE doesn’t know exact PUCCH resource. |
| Ericsson | On the first question to Vivo, we would like to share our understanding that the examples shown by QC are based on the assumption that is not supported by spec. Hence, it means that they are not applicable.  On comment related to multiple PUSCH with UL-TDAI we have provided examples in previous round. We explain more with the next question. |
| QC | First of all, it is very important to make sure make sure the landscape of the discussion clear to everyone. Just to make sure everyone is on the same page, we have a question to FL and to the group: **Are we revisiting scenario that already concluded in RAN1 107e with the following agreement**? **Or the discussion is only limited to the scenario of multiple nonoverlapping PUSCHs that was not concluded in last meeting?**  **Agreement**  For Rel-16 with multiple overlapping PUSCHs with no overlapping PUCCH with HARQ-ACK within a span of one PUCCH slot, if the UL-TDAI n.e. 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook) there is no consensus in RAN1 on Rel-16 UE behaviour |
| Moderator | Thank you QC. From my understanding, we have not broken the agreement for Rel-16. To do that we need an explicit question with agreement from everyone given that this is a consensus-based group and given the trend of the discussions so far, it is best to do this in a phased manner. At this point, we are looking for a solution for the scenario not agreed in the last meeting. On getting this solution, we will have to explicitly ask the question whether this solution applicable to the case for multiple overlapping PUSCHs. |
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### Question 3-2: Multiple TDAIs.

* Q 3-2-1: Which is the most typical case:
  + Alt 1: It is typical to have multiple T-DAIs n.e. 4 (for Type 2 CB) or equal to 1 (for Type 1 CB).
  + Alt 2: It is NOT typical to have multiple T-DAIs n.e. 4 (for Type 2 CB) or equal to 1 (for Type 1 CB).
* Q 3-2-2: What are the most typical cases we should cover ?
* Q 3-2-3: In the case of Type 2 CB, can the gNB set multiple TDAI n.e 4 to different values ? This will affect the proposal item 2 as pointed out by CATT in their comment.

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| **Company** | **Comments** |
| Samsung | At least, we don’t see any scenario where gNB schedules multiple PUSCHs having different DAI values.  Regarding the case that Ericsson explained the motivation of multiple DAI values, we understood to improve HARQ-ACK reliability due to UL grant missing event with the cost of blind detection although we think that it seems not typical case since DCI missing event is very rare. But, we respect gNB implementation if this is essential/typical operation. |
| Ericsson | First, we find it very strange that companies claiming is it strange to have multiple PUSCHs with UL-TDAT (n. eq 4). The real deployment scenarios are complicated, but it is allowed to have multiple UL-TDAI and here, we explain how it can be benefited showing one example. Hopefully that helps the common understanding.  We repeat the example below (we also had many scenarios in our contribution together with discussion) and rephrase out points:   * Does any company assume that when we are discussing DL miss-detection, that only applicable to DL assignment and never happens to UL grant?   + I am sure all agree that is not the case. * Hence, the scenario I presented below is very typical scenario for UL CA (Case G):     Any of these three DCIs may be missed. Hence, UE would see any of the following cases:    Why Case G and Case G-2 are strange?   * Even considered the procedures when PUCCH is present is the same for G and G-0, where in both there are two PUSCHs with UL-TDAI (ne. 4). * UE may receive G-1 due to UL grant mis-detection. Is there anything strange there? No. * UE may receive G-4? Is there any issue? No.   Additional comment: If such a figure (Case G) is illustrated, it doesn’t mean that typical scenario is that one PDSCH is scheduled. The point of illustration is to show more clearly that there are multiple DCIs and any of the DCIs can be missed. One can draw another figure with multiple PDSCHs scheduled on PCEll and Scell, the same point is still valid. I hope the discussion is not about whether gNB schedules 1-2 PDSCHs or more, and need to do puncturing or rate matching.  So, we find the discussion that we have to justify using UL-TDAI (ne. 4) is strange. We feel the discussion is going to the directions that is not standard related.  To emphasize:   * F**rom spec point of view, there is no issue to have multiple PUSCH with UL-TDAU (n.eq 4). It is up to a NW vendor whether/how to use it.** * **And we are insisting to focus on completing specification of the behavior based on UL-TDAI.** |
| Nokia, NSB | Q 3-2-1 and Q 3-2-2 typical vs. atypical is not relevant, what matters is if these should be supported by the specification (they were supposed to be from day 1, but a piece of thread was missing and seems different companies just filled in the blanks) and do we have enough justification to fix the, (yes we do). As Ericsson points out, these cases have a valid use case, and they were intended to be supported as well, now we are somehow debating whether an omission in the spec that leads to different UE behaviours is worth fixing when what we need to focus on is how to fix the spec.  Q 3-2-3, there is nothing in the specification that would say these are not possible and valid scenarios. |
| QC | Based on some companies’ proposal, this is a Rel-16 CR. Given we are in Rel-17 phase, this could be NBC CR, we think the discussion around question 3-2 is very relevant. The group need to be convinced that this is a typical use case which is critical enough to justify the Rel-16 NBC CR.  In the last round of discussion, thanks Ericsson to clarify. Now we see NW like to issue more than 1 UL DAIs to solve the UL DCI missing issue, at the cost of gNB blind detection. On this, we’d like to understand how much a solution can help reducing # BDs.  Assume the following example from Ericsson, with missing UL DCI, NW need to do 2 BDs. If leave it up to UE implementation, NW also need to do 2 BDs. Even we generate to N PUSCHs, it seems to me the number of BDs is the same, which is N. So, if the motivation for >1 UL DAIs comes with the assumption that gNB need to do BD, then we don’t see much difference between a fix and up to UE implementation.  Chart  Description automatically generated  Furthermore, it seems to me it is a fact that, with <=2 bits A/N, there is no issue even for the multiple PUSCH scenario. The issue only exists with >2 bits A/N, which would occur with small probability of missing >1 DCIs.  We understand the preference of NW vendors to fix this issue. Even with the above, we are still willing to work together with NW vendors to fix this issue. But, please also consider UE implementation/commercialization. We clearly stated that we already implemented/commercialized Rel-16 UEs, can companies insist to fix this in Rel-16 please provide solution to avoid NBC impact to deployed Rel-16 UEs?  With the above, we cannot accept fixing this in Rel-16 unless someone can provide BC solution. We can accept fixing this in Rel-17. |
| LG | We have similar view with Nokia.  Regarding Q 3-2-1 and Q 3-2-2, rather than identifying which case is (more) typical, it seems how to draw common understanding/conclusion on the case is more important based on current spec once the case is not precluded explicitly in the spec.  And regarding Q 3-2-3, there doesn’t seem to be specific restriction to preclude the case in the spec. |
| Apple | The intention for us to ask about the typical use cases with multiple PUSCHs with TDAI n.e. 4 is **not trying to argue whether to support it or not**. Instead, we want to understand the more typical cases so that we can handle the missing DCI cases better. We have a few options on the table which clearly defines the UE behavior. But when we compare these few options and try to select one out of them, the typical use cases would matter.  Q 3-2-2: we provided one potential use case we see, but it seems that none of the network vendors acknowledge such a use case. The only case we see so far is the one provided by Ericsson where the network is willing to do more blind decoding for PUSCHs to handle missing UL grant.  Q3-2-3: we don’t think any restriction is needed because it does not matter from UE perspective whether all the TDAI values are the same or not. It can be left to gNB implementation. |
| Intel | We agree the spec does not explicit restrict how TDAI is set, but we think the whole design should be based on reasonable scenarios.  For Q 3-2-1 and Q 3-2-2, we understand the scenario that gNB set multiple TDAI n.e 4 would be useful as explained by Ericsson. But for scenario in Q 3-2-3, we fail to understand the scenario. Considering all DL DCI for A/N comes before any UL grant for overlapped PUSCHs, we can’t see any reason that gNB sets different TDAI for different UL grant for the same HARQ-ACK codebook. |
| NTT DOCOMO | We think that we need to consider a case where gNB transmits UL grant at slot n and another UL grant at slot n+2. In this case, gNB at slot n would not know whether the additional UL grant is sent at slot n+2. Thus, at slot n, gNB assumes that HARQ-ACK should be multiplexed on the PUSCH scheduled by the UL grant at slot n; after that gNB updates their assumption as HARQ-ACK should be multiplexed on the PUSCH scheduled by the UL grant at slot n+2.  For this situation (seems typical), multiple UL grants having value for HARQ-ACK mux should be allowed. |

### Question 3-3: Solution Alt-2 Details

Please review the updated Alt-2 details

For Scenario 2 (more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook):

1. Selection of the candidate PUSCH for multiplexing
   1. PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates
2. Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs for Type 2 Codebook
   1. **Option 1-1:** N/W sets all TDAI values that overlap with PUCCH to the same value with TDAI n.e. 4
   2. **Option 1-2:** N/W sets all TDAI values that overlap with PUCCH to different values with TDAI n.e. 4
3. Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213
4. Limitations for multiplexing
   1. UE expects to multiplex on only 1 PUSCH in the PUCCH slot with only HARQ-ACK multiplexed on PUSCH.
   2. PUSCHs to be selected obey multiplexing timeline for the first PUSCH in the PUCCH slot in the PUSCH candidate set.
      1. **Option 2-1:** gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline
      2. **Option 2-2:** if gNB schedules any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline, the gNB should indicate 4 (for Type 2 codebook) or 0 (for Type 1 codebook)

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| **Company** | **Comments** |
| Moderator | Please comment on added text in item 4.a: UE expects to multiplex on only 1 PUSCH in the PUCCH slot with only HARQ-ACK multiplexed on PUSCH  Please down-select from Option 1-1 and Option 1-2 on item 2  Please down-select from Option 2-1 and Option 2-2 on item 4.b |
| Samsung | Option 1-1 for 2nd step.  Before down-selecting between option 2-1 and option 2-2, it should clarify what multiplexing timeline means from UE side since the UE doesn’t know HARQ-ACK PUCCH resource and doesn’t implement multiplexing procedure actually if the UE misses DL grant. So, it is not clear to us “PUSCHs to be selected obey multiplexing timeline” since “DL grant” and “PUCCH resource scheduled by DL grant” is not visible to UE side.  For option 2-2, we don’t need to consider PUSCH(s) having DAI = 4 (for type 2) and DAI = 0 (for type 1) since those PUSCH(s) are already excluded from step 1. (selection of the candidate PUSCH for multiplexing). For option 2-1, it is already precluded by current specification. What additional impact we should consider for option 2-1 and option 2-2 on top of UE behaviors that current specification is providing? |
| Moderator | The understanding is based on the following text in the specification:  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 𝑆0 of the earliest PUCCH or PUSCH, among a group overlapping PUCCHs and PUSCHs in the slot, satisfies the following timeline conditions - if there is no aperiodic CSI report multiplexed in a PUSCH in the group of overlapping PUCCHs and PUSCHs, S0 is not before a symbol with CP starting after T\_proc2\_,ux after the last symbol of   - any PDCCH with the DCI scheduling and overlapping PUSCH  Based on the above text, all the DCIs for the all the candidate PUSCHs should come before the first PUSCH. In the figure below,    With option 2-1, PUSCH 4 will not happen.  With Option 2-2, PUSCH 4 can happen but TDAI = 4 |
| Ericsson | On question about multiplexing timeline, it will be Tproc,2 from the earliest PUSCH.  On Option 1-1 vs Option 1-2:   * First of all, as you know, in our view, the value of DAI should not be a parameter. We were OK to compromise because for some reasons , some UE vendors have problem with. But technically, it should not be a parameter for design. * Option 1-2 is not acceptable. The motivation for that is not clear. If it is based on examples shown by QC in previous round, as we explained, they are not according to the spec. * Option 1-1 based on the scheduling restriction in spec, is more acceptable. Although we don’t see any technical reason for any of these.   On Option 2-1 and Option 2-2:   * We support Option 2-1. * Although we understand the Option 2-2, but it is very strange. It appears that gNB sets UL DAI planning for miss-detection, rather than “using the UL-DAI” to handle errors in case miss-detection happens. |
| Nokia, NSB | On option 1-1 and 1-2, when being forced to select from this space, as explained by Ericsson, we need to pick 1-1.  On option 2-1 vs. 2.2, we support option 2-1. Again as explained by Ericsson, 2-2 seems to ignore the motivation for UL-DAI, and the possible loss of DCIs, and only worries of how the UE processes the DCIs it detected. |
| QC | For option 1-1 vs 1-2: if we see the motivation for gNB to schedule >1 TDAIs n.q. 4 , then it seems no need to add any restriction. Whether use same or different TDAI value can be up to gNB, again if the group are convinced with >1 TDAI n.q. 4  For option 2-1 vs 2-2: option 2-1 is more aligned with the principle for Rel-15 UCI multiplexing timeline. We support option 2-1 |
| LG | We have similar view with QC.  For Option 1-1 and 1-2, since there is no restriction to preclude either option explicitly in the spec, it implies that it can be up to gNB whether to set same or different T-DAI value.  For Option 2-1 vs. 2-2, for keeping the principle of Rel-15 multiplexing timeline, Option 2-1 is preferable. |
| MTK | For option 1-1 vs 1-2: We prefer Option 1-1  For option 2-1 vs 2-2: We prefer Option 2-1 |
| Moderator | As at now, we have the following breakdown:  Option 1-1: Samsung, Ericsson, Nokia/NSB, MTK (4)  Option 1-2: QC (if > 1 TDAI n.e. 4), LG (if > 1 TDAI n.e. 4) (2)   * Objected :Ericsson   **Comment: Continue discussion from other companies that have not commented ?**  Option 2-1: Ericsson, Nokia/NSB, Qualcomm, LG, MTK (5)  Option 2-2: none  **Conclusion: Go with option 2-1 ?** |
| Apple | For Option 1-1 vs Option 1-2, we wonder if Option 1-2 should be the following instead:  **Option 1-2:** N/W can set~~s~~ ~~all~~ the TDAI values that overlap with PUCCH to different values with TDAI n.e. 4  Even though it makes sense for the N/W to set TDAI values the same, it seems unnecessary to specify such constraint in the specs, because it does not affect UE behaviors at all. But we would be fine with Option 1-1 also if that is the majority.  For Option 2-1 vs 2-2, we are fine with either option. |
| Intel | For option 1-1 vs 1-2, we prefer Option 1-1.  For option 2-1 vs 2-2, we’d like to understand, option 2-1 is only for PUSCH with UL DAI n.q. 4 (for type-2 codebook) and n.q.1 for (type-1 codebook)? If yes, we support option 2-1, otherwise, we prefer option 2-2 because it is unclear to us why gNB should be restricted to schedule a PUSCH not intended for A/N multiplexing with UCI multiplexing timeline.  Regarding “UE expects to multiplex on only 1 PUSCH in the PUCCH slot with only HARQ-ACK multiplexed on PUSCH”, we’d like to further clarify whether CSI can be multiplexed on other PUSCHs overlapping with the CSI PUCCH resource. In our understanding, gNB expects a PUCCH with the assumption of multiplexing of HARQ-ACK and CSI, if AN PUCCH overlaps with CSI PUCCH.  For Alt-2, we’d like to clarify, whether “1 PUSCH in the PUCCH slot” is the PUSCH with starting symbol in the PUCCH slot, or the PUSCH with ending symbol in the PUCCH slot? For example, due to different SCS for PUCCH and PUSCH, or sub-slot for PUCCH, it is possible that a PUSCH crosses two PUCCH slot. |
| NTT DOCOMO | It seems that 1-1/2-1 are valid direction. |

### Question 3-3: Solution Alt-3 Details

1. Selection of the candidate PUSCH for multiplexing
   1. 1 candidate PUSCH: last scheduled PUSCH in the slot, following the UL-TDAI in the lastly received UL grant
2. Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs for Type 2 Codebook
   1. **N/A**
3. Prioritization rules to select PUSCH for multiplexing: N/A
4. Limitations for multiplexing (need to be defined)

Please define any multiplexing limitations for this method

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| **Company** | **Comments** |
| Samsung | If only one DAI value (DAI n.e. 4 for type 2 and DAI e.q 1 for type 1) is available in the slot, this solution can be feasible. Otherwise, not sure this solution can address the motivation that Ericsson explained regarding multiple PUSCH(s) having DAI value n.e. 4/e.q. 1. |
| Ericsson | As we explained, Alt 3 is based on an assumption that is not supported by spec. Also, it defines a solution that is not unified.  We do not support this solution. |
| Nokia, NSB | We do not support this alternative |
| ZTE | We don’t support this alternative. It may lead to two behaviors on the PUSCH selection for HARQ-ACK multiplexing. One is to select the last PUSCH. The other one is the PUSCH prioritization as agreed. It should be noted the earliest PUSCH should be selected in this case. It seems the two PUSCH selection rule is a bit contradictory to each other. |
| QC | We are not sure why Ericsson still think Alt 3 is based on the assumption not supported by spec. We can ignore the example I gave before, just apply Alt 3 to examples provide by Ericsson. For example, Let’s consider case D provided by Ericsson, with a slight modification that shorten the PUCCH to be in the second half of the slot. In this example, when both DL DCIs are missed which creates the scenario we are discussing, following Alt-1 or Alt 2, UE will mux 2 bits A/N on PUSCH A1, while NW expecting UE mux 4 bits A/N on PUSCH B1. Following Alt 3, UE mux 4 bits A/N on PUSCH B1. Isn’t Alt-3 better than Alt 1 or 2?    @Moderator, to your comment “Alt 3 does not work if the PUCCH is moved to the first half of the slot” – No, in the above example scenario, a reasonable gNB should not schedule PUCCH in the first half of the slot. Because if gNB does that, in nominal case without DCI missing, UE will multiplex 6 bits (assuming DAI=2 interpret as 6 here) A/N on PUSCH A1 following UL-DAI =2, where gNB only expect 4 bits A/N.  @Ericsson, actually, can you please explain why case D is a useful scenario? gNB knows it scheduled 2 PDSCH and expect 4 bits A/N feedback. That is why gNB set the DAI=4 in DCI B1, right? But then why it will schedule to transmit this long PUCCH which results to multiplex 6 bits A/N? There are two bits dummy NACK overhead that can be avoided. Or maybe another way to rephase my question is that why gNB set DAI=2 in DCI A1? Why not set it to DAI=4? |
| LG | We share the same view with other companies.  We don’t support Solution Alt 3 since it seems to violate basic principle that for UCI multiplexing on a PUSCH, the T-DAI in UL DCI scheduling the same PUSCH is used.  This is also the reason why any UL T-DAI value is not used for UCI multiplexing on CG PUSCH. |
| Moderator | @ QC: I see your point based on my comment.  Support: QC Do not support: Samsung, Ericsson, Nokia/NSB, ZTE, LG (5)  **Comment: de-prioritize Alt 3 ?** |
| Apple | We prefer not to introduce a solution that is completely outside of the current framework, and it is not clear Alt 3 has any obvious advantage over Alt 2. As the moderator suggested, timeline constraint also needs to be introduced for all the PUSCHs within a slot. In addition, rules need to be defined on the “last” DCI if multiple DCIs overlap in time. |
| Intel | We shar same view with other companies, and we don’t support Alt 3. |
| NTT DOCOMO | We shar same view with other companies, and we don’t support Alt 3. |

### Question 3-4: Down-selection

Please indicate your solution preference/objections to a specific solution

* Alt 2: Derived from Generic solution
* Alt 3: multiplex on the last scheduled PUSCH in the slot, following the UL-TDAI in the lastly received UL grant
* Alt 4: We do not expect more than 1 PUSCH with UL TDAI n.e. 4 with its existing solution

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| **Company** | **Comments** |
| Samsung | We think that Alt. 4 is the simplest/clean solution. But we are not objective of other alternatives if motivation/feasibility is clearly understood. |
| Ericsson | From these three, we only support Alt 2 (although our preference is Alt 1).  Alt 3: As we explained in previous round, it is based on an assumption that violates the spec. If Alt 3 is chosen, the scheduling restriction from spec should be removed. Then, we can consider it. But we don’t accept Alt 3 when the scheduling restriction still remains.  Alt 4: As we explained, this is not a correct assumption, and we disagree to have a solution based on this assumption. |
| Nokia, NSB | If forced to pick from this set, we can only accept alt 2. |
| ZTE | We support Alt. 2. |
| QC | For Rel-17, we are flexible to go with any of the above alternatives.  For Rel-16, We can accept Alt 4, because it is BC. We don’t accept Alt 1, 2,3 because it is NBC to already implemented/commercialized/deployed Rel-16 UEs. |
| LG | Alt 2 seems to be preferable. |
| Moderator | Alt 2: Ericsson, Nokia, ZTE, LG, QC (Rel-17)  Alt 3: none  Alt 4: Samsung, Qualcomm (Rel-16)  Comment: continue discussions with comments from other companies |
| Apple | We support Alt 2. |
| Intel | We support Alt.2. |
| NTT DOCOMO | We support Alt.2. |
| QC2 | To proponents of alternative 2, I think we missed one important aspect. Alt 2 does PUSCH pruning by excluding PUSCH with UL-TDAI = 4. However, UL-TDAI = 4 not necessary mean 0 bit A/N, during to wrap around. gNB can set UL\_TDAI=4 in a later UL grant to indicate multiplex 4 bits HARQ-ACK, if a previous UL grant indicate UL-DAI=3.  So, we think in Rel-17, Ericsson’s original proposal Alternative 1, which does not exclude PUSCH with UL-TDAI=4 makes more sense, and it is more aligned with Rel-15 spec as well.  For Alterative 4, the intention is to allow only a single UL-TDAI indicate a value n.q. 4. With this intention, it is OK to interpret UL-TDAI = 4 as mux 0 bit A/N. But with Alternative 2, it does not make sense to interpret UL-TDAI = 4 as mux 0 bit A/N.  With the above, we suggest to reconsider Alt 1 for Rel-17. If we want to fix this issue, I think we need seek for a more reasonable approach. |

### Proposal 3-1: Repetition

Based on the current discussion, we propose the following based on Alt 1-1:

The PUSCH for multiplexing is selected by:

*One of the PUSCH repetitions should be specified for HARQ-ACK multiplexing if the UE does not know the overlapping PUCCH slot due to missing detection of the DL DCI and the T-DAI in the UL grant is not equal to 4 for Type 2 codebook or is equal to 1 for Type 1 codebook.*

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| **Company** | **Comments** |
| Samsung | Although we understand unified solution for DAI regardless of repetition, it is not clear to us on what performance benefit selecting one of PUSCH repetitions is in terms of blind detection compared with alt. 3 (no multiplexing) based on our analysis provided in previous round. It is noted that the proposal still cannot solve the problem if there are two HARQ-ACK PUCCHs which are overlapping different PUSCH repetitions and DL grants scheduling the two PUCCHs are missing. |
| Ericsson | We support the proposal.  Our explanation to Samsung comment is that: For the chose between no multiplexing at all, and multiplexing on the first/second one, definitely it is preferred to multiplex on the first/second one because of UL-TDAI for the same reason as single PUSCH.  Now, the unknown (which PUSCH), is extended in time domain. Theoretically, one can say all of them are valid candidate.  But again, we explained because of scheduling and also limited k1 values, the last ones wouldn’t have overlapping PUCCHs.  Which means that we can reduce the range in time for unknown PUSCHs. Therefore, first PUSCHs would have PUCCHs.  Now, not diverging with the same principle that the UE should UE UL-TDAI for reporting error (as well the case for no repetition), we argue that it very much makes sense to use it for 1st PUSCHs. Still, based on the same principle, this is very much preferred that not using the UL-TDAI at all (i.e. Alt 3). |
| Nokia, NSB | We can accept this proposal |
| ZTE | We support this proposal.  We don’t agree that Alt 3 has the least number of blind detection. The network should always decode with two assumptions, i.e., HARQ-ACK is multiplexed and HARQ-ACK is not multiplexed. However, for the proposal, in most case (PUCCH is scheduled in the specified PUSCH repetition), blind detection is not needed. In another case, decoding with two assumptions is needed, which is equal to Alt 3 in terms of the number of bind detection.  In our understanding, the scenario that two HARQ-ACK PUCCH overlapping with different PUSCH repetition cannot happen due to at least the following reasons in addition to the comments from Ericsson.   1. There is only one UL-TDAI in the UL grant. It is impossible to indicate the HARQ-ACK for two PUCCH, especially when the two PUCCH have different numbers of HARQ-ACK bits. 2. Considering the timeline requirement that UL grant should be after the DL grant, the DL grant corresponding to the second PUCCH may not satisfy the requirement. It means the second PUCCH scheduling is not allowed. |
| QC | We don’t support this proposal, due to similar reasons as Samsung. Furthermore, this proposal deviate from current spec that clearly says UE does not multiplex PUSCH in a slot, if no A/N in PUCCH would transmit in the slot. |
| LG | We have similar view with QC and Samsung.  In case with no actual PUCCH, it might, anyhow, be unclear which slot is targeted/subject to the T-DAI from gNB/UE perspective. For this reason, the proposal doesn’t seem to be supportive. |
| Apple | We are generally fine with the proposal, but it may be good to be specific that we refer to the first repetition here. |
| Intel | We’re fine with this proposal to have a unified solution for DAI regardless of repetition.  Regarding Samsung’s comment for two PUCCHs overlapping with two PUSCH repetitions, in our understanding, these two PUCCHs are in different PUCCH slots. gNB anyway needs to do blind detection for the presence of AN for these two PUCCHs. Thus, we think the blind detection is not decreased by Alt 3. And also, we think it is less likely to have a dynamically scheduled PUCCH in later PUCCH slot overlapping with a later PUSCH repetition with limited K1, as commented by Ericsson. If the later PUCCH is SPS PUCCH, then, there is no issue for blind detection. |
| NTT DOCOMO | We can accept this proposal |
| CATT | We do not agree with the proposal for the same reason as Samsung. |

# 3rd Round Summary

### Question 3-2: Multiple TDAIs.

The following are the company positions:

* Typical Scenario is needed: Samsung, Qualcomm, Apple, Intel (4)
  + don’t see any scenario where gNB schedules multiple PUSCHs having different DAI values. **respect gNB implementation if this is essential/typical operation**
  + **consider UE implementation/commercialization given that Rel-16 UEs already implemented/commercialized**.
* Multiple UL grants having value for HARQ-ACK mux should be allowed: Ericsson, Nokia/NSB, LG, NTT DOCOMO (4)
  + From **spec point of view, there is no issue to have multiple PUSCH with UL-TDAI** (n.eq 4).
  + It is up to a **NW vendor whether/how to use** it.
  + Multiple possible scenarios given by Ericsson and NTT DOCOMO

**Conclusion: No consensus either way and we cannot use this information to assist in our decision.**

### Question 3-3: Solution Alt-2 Details

As at now, we have the following breakdown:

* Option 1-1: Samsung, Ericsson, Nokia/NSB, MTK, Apple, Intel, NTT DOCOMO (7)
* Option 1-2: QC (if > 1 TDAI n.e. 4), LG (if > 1 TDAI n.e. 4) (2)
  + Objected :Ericsson

**Conclusion: Clear majority on Option 1-1**

* Option 2-1: Ericsson, Nokia/NSB, Qualcomm, LG, MTK, Apple, NTT DOCOMO (7)
* Option 2-2: Intel

**Conclusion: Clear majority on Option 2-1.**

Given the clear majority, would it be possible to set Alt-2 to the clear majority i.e as follows:

For Scenario 2 (more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook):

1. Selection of the candidate PUSCH for multiplexing
   1. PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates
2. Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs for Type 2 Codebook
   1. **Option 1-1:** N/W sets all TDAI values that overlap with PUCCH to the same value with TDAI n.e. 4
   2. **~~Option 1-2:~~** ~~N/W sets all TDAI values that overlap with PUCCH to different values with TDAI n.e. 4~~
3. Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213
4. Limitations for multiplexing
   1. UE expects to multiplex on only 1 PUSCH in the PUCCH slot with only HARQ-ACK multiplexed on PUSCH.
   2. PUSCHs to be selected obey multiplexing timeline for the first PUSCH in the PUCCH slot in the PUSCH candidate set.
      1. **Option 2-1:** gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline
      2. **~~Option 2-2:~~** ~~if gNB schedules any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline, the gNB should indicate 4 (for Type 2 codebook) or 0 (for Type 1 codebook)~~

### Question 3-3: Solution Alt-3 Details

Summary of the company positions:

* Support: QC (1)
* Do not support: Samsung, Ericsson, Nokia/NSB, ZTE, LG, Apple, Intel, NTT DOCOMO (8)

**Conclusion: Do not support Alt 3**

### Question 3-4: Down-selection

Company Positions

* Alt 2: Derived from Generic solution
  + Ericsson, Nokia, ZTE, LG, QC (Rel-17), Apple, Intel, NTT DOCMOO (8)
* Alt 3: multiplex on the last scheduled PUSCH in the slot, following the UL-TDAI in the lastly received UL grant
  + None
* Alt 4: We do not expect more than 1 PUSCH with UL TDAI n.e. 4 with its existing solution
  + Samsung, Qualcomm (Rel-16) (2)

**Conclusion:**

* Clear majority favor Alt. 2 for Rel-17.
* Majority favor Alt. 2 for Rel-16
* Alt-3 can be removed from discussion
* NOTE 1: Alt-4 is a sub-set of Alt-2. Can we use this to get a compromise ?
* NOTE 2: Qualcomm raises issue that UL-TDAI = 4 not necessary mean 0 bit A/N, during to wrap around. gNB can set UL\_TDAI=4 in a later UL grant to indicate multiplex 4 bits HARQ-ACK, if a previous UL grant indicate UL-DAI=3. We may need to discuss this in the next round.

### Proposal 3-1: Repetition

Support: Ericsson, Nokia/NSB, ZTE, Apple (first repetition), Intel, NTT DOCOMO (6)

No Support: Samsung, QC, LG, CATT (4)

**Conclusion: No consensus on this topic. De-prioritize for next round**

# 4th Round

### Proposal 4-1: Rel-17 Unified Solution

**For Rel-17UEs, in both overlapping and non-overlapping scenarios (unified design), Alt-2 as detailed below should be specified:**

1. Selection of the candidate PUSCH for multiplexing
   1. PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates
2. Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs for Type 2 Codebook
   1. Option 1-1: N/W sets all TDAI values that overlap with PUCCH to the same value with TDAI n.e. 4
3. Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213
4. Limitations for multiplexing
   1. UE expects to multiplex on only 1 PUSCH in the PUCCH slot with only HARQ-ACK multiplexed on PUSCH.
   2. PUSCHs to be selected obey multiplexing timeline for the first PUSCH in the PUCCH slot in the PUSCH candidate set.
      1. **Option 2-1:** gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline

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| **Company** | **Comments** |
| QC | A few comments on 4. Limitations for multiplexing:  a. multiplexing A/N on only 1 PUSCH makes sense. However, we are not sure why only A/N is allowed multiplexing on PUSCH. In our understanding of spec, CSI can also be multiplexed on same/different PUSCH in the same slot.  b. It seems not clear what does it mean by “PUSCHs to be selected obey multiplexing timeline for the first PUSCH in the PUCCH slot in the PUSCH candidate set”? Does this mean only the PUSCH selected to multiplex A/N need to obey multiplexing timeline, while the rest PUSCH in the slot does not need to obey the multiplexing timeline? However, in Rel-15 nominal case (where PUCCH exist), all the PUSCHs in the candidate set obey multiplexing timeline. This seems not aligned with Rel-15 spec. Can someone please clarify? |
| ZTE | We can support this proposal.  Regarding the first comment from QC, our understanding is similar with QC that CSI can be multiplexed on the same/different PUSCH in the same slot, depending on the overlapping case. Here we are discussing the HARQ-ACK multiplexing without detected DL DCI. For CSI multiplexing, there is no such issue since it does not have DL DCI.  Regarding the second comment from QC, our understanding is that, in Rel-15, the PUSCH in the candidate set is the PUSCH overlapping with PUCCH, which is equal to the PUSCH to be selected for UCI multiplexing. |
| NTT DOCOMO | We are generally fine with the proposal.  Regarding QC’s comment, we noticed that QC’s first comment is valid. For example the selected PUSCH for HARQ-ACK mux may have A-CSI. It seems that the text is prohibiting this case, this would not aligned with the intention. That part should be removed. |
| Intel | We share similar view as QC that we also need to consider the case when CSI is multiplexed on PUSCH. In our understanding, gNB expects a PUCCH with the assumption of multiplexing of HARQ-ACK and CSI, if AN PUCCH overlaps with CSI PUCCH. But if UE miss-detects AN PUCCH, the resultant PUCCH would be different from what gNB expects, e.g., gNB expects a resultant PUCCH overlaps with PUSCH 1, while CSI PUCCH only overlaps with PUSCH2. We think UE behavior for such case should also be defined. Otherwise, we still have a hole in the spec. |
| MTK | We are generally fine with the proposal.  Regarding QC’s on 4.b, if 4.b is removed, does it mean all the PUSCHs in the candidate set obey multiplexing timeline? If this is common understanding then we are ok to remove 4.b. |
| Samsung | We are fine with the direction of the proposal. Regarding 4.b, we are similar question how to determine multiplex timeline for PUSCHs. Maybe, some clarification is necessary. Our understanding is that selected PUSCH should be the earliest PUSCH in the group of PUSCHs in the PUCCH slot and other PUSCHs than the selected PUSCH may not need to consider multiplexing timeline. Regarding option 1-1, after looking at other companies’ view, we tend to agree there is no need to mandate same DAI for multiple PUSCHs because current specification does not specify this rule. |
| Moderator | **@ Qualcomm/ @MTK/@Samsung : timeline**  All PUSCHs that will be used for prioritization (candidate set) have to satisfy the multiplexing timeline based on the first one to arrive.    In above figure, PUSCH 1 (DCI 1), PUSCH 2 (DCI 2), PUSCH 3 (DCI 3). Based on Alt 2, PUSCH 4 is not allowed AND DCI 1, DCI 2 and DCI 3) have to come before the multiplexing timeline of PUSCH 1.  To make sure everyone is on the same page, I think 4.b. should be kept.  **@QC/@ Intel/@NTT DOCOMO : only HARQ-ACK**  Added “with only HARQ-ACK” in round 2 based on Intel’s comment and asked for comments: “We are fine with the generic steps and prefer a unified solution. For 4a in Limitations for multiplexing, it would be good to clarify that only HARQ-ACK is multiplexed on PUSCH or additional PUCCH carrying CSI cannot be configured/multiplexed on the PUSCH.”  Given the current discussion (supported by QC, NTT DOCOMO,Intel), I am removing this limitation.  **@ Intel: miss AN PUCCH and get CSI PUCCH**  “But if UE miss-detects AN PUCCH, the resultant PUCCH would be different from what gNB expects, e.g., gNB expects a resultant PUCCH overlaps with PUSCH 1, while CSI PUCCH only overlaps with PUSCH2. We think UE behavior for such case should also be defined. Otherwise, we still have a hole in the spec”.  Most likely the UE would multiplex based on the current rules and the gNB may have to estimate. To fix this would require thinking about a second level of detailed scenario + solution identification. I would say that we table this scenario for now and maybe discuss it with the repetition scenario. |
| QC | @moderator, if it is common understanding that all the PUSCH in the candidate set for potential A/N multiplexing have to satisfy the timeline, then I suggest just capture 4b in that way. The current wording of 4b is not clear to me, because it is not defined which one is the first PUSCH. Does the first defined based on staring of the PUSCH transmission, or base on reception of UL grant, or anything else. I assume it is defined based on PUSCH transmission. Then, maybe we can clarify 4b as the following?   * **All the PUSCHs in the determined candidate set after step 1 have to satisfy Rel-15 UCI multiplexing timeline, defined with respect the starting symbol of the earliest PUSCH transmission in the candidate set.**   @all, we really don’t see the need for the second bullet, i.e, “2”, to restrict NW behavior. What kind of spec impact we are expecting with “2”? Also, how does keeping “2” or removing “2” would impact this solution. We don’t see any difference from UE perspective between with and without “2”. So, it just adds unnecessary restriction to NW. we still insist to remove “2”. |
| Ericsson | For Rel-17 Proposal 4-1, we have the following comments:   * Regarding 4b, we share the same view as QC and we prefer to use QC formulation of this bullet for timeline condition. * Regarding 2, we share the same view as QC. As we stated earlier, we believe the proper operation is Alt-1. However, during the discussion for Rel-16, we learned that there are implementation constraints by UE vendors insisting on having the same UL-TDAI. In order to have progress for Rel-16 and consideration for implementation, we are fine to compromise to that for the bigger objective to ensure support of UL CA. However, for Rel-17, we don’t see it is justified to carry on with this constraint. Please note that is different from the scheduling constraint. That still remains (unfortunately 😊) also for Rel-17. **However, Rel-15/Rel-16/Rel-17 specifications do not enforce any UL-TDA value**. This gives implementation flexibility to NW, while not affecting the principle for PUSCH prioritization for the problem at hand. |
| Apple | We support the proposal in principle, and we are open to consider any refinement of the proposal to make it clearer. |

### Proposal 4-2: Rel-16 Compromise Solution

**Please indicate all that you can support and those that you object to:**

For Rel-16, one of the following should be specified:

Non-agreed scenario: more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook):

* Option 1: For the non-agreed scenario, Alt 2
* Option 2: For the non-agreed scenario, Alt 4
* Option 3: For the non-agreed scenario, Alt-2 with a UE capability defined on if it can multiplex on more than 1 PUSCH with TDAI n.e. 4 (for   
  Type 2 CB) or TDAI e.q. 1 (for Type 1 CB).
* Option 4: For the non-agreed scenario, UE implementation between Alt 2 and Alt 4
* Option 5: Agree on Alt 2 (Alt 1) for Rel-17. Then in the Rel-17 CR cover page, add magic sentence “**The CR is for Rel-17. But the Rel-17 CR can be early implementable by a Rel-16 UE/gNB**”

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| **Company** | **Comments** |
| QC | We object Option 1, because it is NBC to Rel-16 already commercialized.  Option 2 is fine to us.  Option 3 introduce a Rel-16 capability at very late stage for Rel-16. It is not preferred.  We suggest another option 5, which might be a WF: Agree on Alt 2 or Alt 1 (we prefer Alt 1) for Rel-17. Then in the Rel-17 CR cover page, add this magic sentence “**The CR is for Rel-17. But the Rel-17 CR can be early implementable by a Rel-16 UE/gNB**” |
| ZTE | We support Option 1 and Option 3. We think Option 3 is a good compromise since the UE can report its capability.. |
| NTT DOCOMO | For clarification, what is “the non-agreed scenario”?  If we can agree a solution for Rel-17, we are fine with either for rel-16. Actually without any agreement, it means that Option 2 is the outcome. |
| Intel | We support Option 1. We can also live with Option 3. |
| MTK | We prefer Option 2 but do not object to other options. |
| Samsung | It is not clear to what non-agreed scenario exactly means. Is this non-overlapping multiple PUSCH? or overlapping multiplexing PUSCH? |
| Moderator | @ Qualcomm: Added Option 5 to list (added in red)  @ Samsung: Non-agreed scenario: more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook) (added in red) |
| Nokia, NSB (March 2nd) | Postponing the solution to Rel-17 is not really helpful if we can’t get even the basic UL CA for FR1-FDD + FR1-TDD specified for Rel-16. So what we could aim for is to have a Rel-16 solution that is a subset of the Rel-17 unified solution (magic sentence proposal 5 in 8.1.1 is not doing it as we would still not know what the Rel-16 UEs are supposed to do), that would hopefully be the minimum delta for what anyone is having in the pipeline. If there are some UE population that doesn’t 100% comply with all the combinations when a particular DCI is missed is the price we’d be willing to pay, but we don’t see that as a sufficient reason to not specify any functionality for Rel-16 for the question at hand.  **Trying to make a step-wise proposal below with 2 UL carriers for R16 and generic for R17:**   * Rel-16: Resolve the issue for the case with 2 cells with overlapping PUSCHs, where we can assume that one of the cells is PCell   + With this we probably still revisit the step2, and the need for NW scheduling restrictions, hence the square brackets. * Rel-17: Resolve the issue for >2 cells with overlapping PUSCHs and don’t have the PCell restriction.   Cyan edits are ours and I call this now option 6.  \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  **Option 6**  For Scenario 2 (more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook):   * Selection of the candidate PUSCH for multiplexing   1. PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates * [Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs for Type 2 Codebook]   1. [**Option 1-1:** N/W sets all TDAI values that overlap with PUCCH to the same value with TDAI n.e. 4] * Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213   1. For Rel-16: The prioritization to select PUSCH for multiplexing is only applicable for two cell UL CA case, where one cell is the PCell   2. For Rel-17: The above Rel-16 restriction is lifted. * Limitations for multiplexing   1. UE expects to multiplex on only 1 PUSCH in the PUCCH slot with only HARQ-ACK multiplexed on PUSCH.   2. PUSCHs to be selected obey multiplexing timeline for the first PUSCH in the PUCCH slot in the PUSCH candidate set.      1. **Option 2-1:** gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline |
| QC | @moderator, strictly speaking, I think the non-agreed scenario is only for: multiple non-overlapping PUSCHs in a PUCCH slot, because there was the following agreement for multiple overlapping PUSCHs. Of course, we are open to discuss whether back-propagate the Rel-16 compromised solution, if agreed, from non-agreed scenario to the agreed scenario. But I think that is what the discussion in next section is trying to do.  **Agreement**  For Rel-16 with multiple overlapping PUSCHs with no overlapping PUCCH with HARQ-ACK within a span of one PUCCH slot, if the UL-TDAI n.e. 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook) there is no consensus in RAN1 on Rel-16 UE behaviour |
| Ericsson | We only support Option 1, and as further compromise we can accept Nokia’s compromised proposal Option 6. We do not support other options.   * On Option 1, this is already a compromised solutions from our perspective to adopt Alt 2 from Alt 1. * On Option 2 (Alt 4): This option basically means that gNB schedules only one PUSCH. As we explained before, we find this Alt very strange. As we have explained the gNB does not scheduled to optimize for DL miss-detection. However, when DL mis-detection is in place, the Ul-TDAI mechanism helps to discover the event. We are also fine with compromised solution by Nokia Option 6 since the compromise is based on realistic scenarios. * On Option 3 (Alt 2 with capability): We disagree with this solution here. Introducing a new capability is redundant and also doesn’t solve the problem. Since the underlying case is multiple overlapping PUSCHs, this new capability to large extent is that the UE does not support UL CA. * Option 4: We can not understand this solution combo solution since it is equivalent to no solution and leave it to UE implementation as in Rel-16. It reads as the UE indicates the capability, but then it is UE to UE to behave based on its reported capability or not. * Option 5: We disagree and fully support the views expressed by Nokia. * Option 6: As the 2nd preference, we can accept this option. Since our intention is to address the UL CA operation, this option seems to simplify even further to prioritize 2 UL that is inline with the current situation. But we are OK with this constraint for Rel-16 when we can fix it in Rel17. It is difficult for us as NW vendor to be more accommodating and convinced with even more compromise that leads to break the functionality and effectively takes to Rel-15 (no solution). We do hope we can avoid that situation.   On QC comment: The agreement was no consensus (and not ruling out scenarios). As moderator explained earlier, companies have shown interest in unified solution.  We are hoping that QC perhaps can consider Option 6. (Please note we are supportive of the changes you suggested for timeline and point 2 on Ul-TDAI restriction). I hope that help us together to move forward. |
| Apple | We are generally open to consider any option that can address the concerns from companies for Rel-16. |
| QC | We cannot accept option 6. But we can accept a variation of option 6, which is listed as below.  **Option 6a**  For Scenario 2 (more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook):   * Selection of the candidate PUSCH for multiplexing   1. PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates * [Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs for Type 2 Codebook]   1. [**Option 1-1:** N/W sets all TDAI values that overlap with PUCCH to the same value with TDAI n.e. 4] * Prioritization rules to select PUSCH for multiplexing. ~~Prioritization rules are identical to 38.213~~   1. For Rel-16: Prioritization rules are as following ~~The prioritization to select PUSCH for multiplexing is only applicable for two cell UL CA case, where one cell is the PCell~~      + **If Pcell has PUSCH, multiplex HARQ-ACK on PUSCH on Pcell, following its UL-TDAI.**      + **Otherwise, multiplexing HARQ-ACK on a PUSCH on Scell, if any, following its UL-TAI.**        - **If the Pcell PUCCH slot overlaps with more than one Scell PUSCHs, multiplexing HARQ-ACK on the earliest PUSCH on Scell.**   2. For Rel-17: Prioritization rules are identical to 38.213~~The above Rel-16 restriction is lifted.~~ * Limitations for multiplexing   1. UE expects to multiplex HARQ-ACK on only 1 PUSCH in the PUCCH slot.   2. All the PUSCHs in the determined candidate set after step 1 have to satisfy Rel-15 UCI multiplexing timeline, defined with respect the starting symbol of the earliest PUSCH transmission in the candidate set**.**       1. gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline |

### Proposal 4-3: Rel 16 Unified Solution

**Alt 2 ~~may be~~ applied to the non-overlapping case, superseding the following agreement from RAN1 #107:**

**Agreement**

For Rel-16 with multiple overlapping PUSCHs with no overlapping PUCCH with HARQ-ACK within a span of one PUCCH slot, if the UL-TDAI n.e. 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook) there is no consensus in RAN1 on Rel-16 UE behaviour

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| **Company** | **Comments** |
| QC | Our answer to this question depends on what solution is adopted.  If option 2 is adopted, it is fine to extend it to the previously agreed case.  If option 5 is adopted, it is also fine to extend it the previous agreed case. |
| ZTE | We support this proposal. |
| NTT DOCOMO | OK |
| Intel | We are fine with the proposal. |
| MTK | We do not see this really necessary. It is always possible there is no consensus in one phase while RAN1 may achieve consensus in a later phase. |
| Samsung | We are okay with finding unified solution targeting for Rel-16. But, not clear to us on “Alt. 2 may”. What is intention of using “may”? |
| Moderator | @Samsung: removed may |
| Nokia, NSB (March 2nd) | Please see our compromise proposal (named option 6) in 8.1.2 |
| QC | Since Alt 2 is recommend for Rel-16, we object this proposal, as it creates NBC issue for already commercialized/deployed Rel-16 UEs.  Like we commented before, if Alt 4: “UE does not expect more than 1 PUSCH with UL TDAI n.e. 4 (Type 2 CB) or UL TDAI equal to 1 (Type 1 CB)” is adopted for Rel-16 as a solution, we are OK to extend it to previous agreed case. |
| Ericsson | We see this proposal confusing.  As we requested clarification, Moderator kindly has clarified Proposal 4-2 that Non-agreed scenario: more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook):  That includes both overlapping and non-overlapping PUSCHs. At least, we provided feedback for Proposal 4-2 assuming unified solutions.  Hence, all the comments for Proposal 4-2 are valid here.  Therefore, even for this case, we only support Option 1 and are also OK to further compromise to Option 6 proposed by Nokia.  The reasons are the same. |
| Apple | Fine with the proposal, assuming the intention is to extend Alt 2 to cover overlapping scenarios. |

### Question 4-1: UL-TDAI = 4

UL-TDAI = 4 does not necessary mean 0 bit A/N, during to wrap around. gNB can set UL\_TDAI=4 in a later UL grant to indicate multiplex 4 bits HARQ-ACK, if a previous UL grant indicate UL-DAI=3. How does this affect Alt-2 ?

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| **Company** | **Comments** |
| QC | Considering the UL-TDAI wrapping around issue, we think the original Alt 1 proposed by Ericsson is better than Alt 2. Alt 1 does not use UL-TDAI to exclude PUSCHs. There is no much justification to exclude PUSCHs with UL-TDAI = 4, as it does not necessarily mean 0 A/N bits. UL-TDAI = 4 could mean 4/8/12/… bits. |
| ZTE | The assumption is it is impossible for the UE to miss 4 consecutive DCIs. Otherwise, the DAI mechanism cannot work. Based on this assumption, if the UE does not detect any DCI, it will assume UL-TDAI=4 means 0 bit A/N. |
| NTT DOCOMO | Agree with ZTE. No need to consider such consecutive DCIs misdetection for DCI. |
| Intel | For both LTE and NR, it is a common understand that the case UE consecutively miss-detects up to 4 PDCCHs is a corner case, that’s why DAI is 2 bits. So, we don’t think we should consider such corner case. In other words, we share same understanding with ZTE that UE assumes UL TDAI=4 means 0, if UE does not detect any DCI. |
| MTK | Share similar view with ZTE. |
| Samsung | Similar view with ZTE. Missing consecutive 4 DCIs is very corner case. |
| Ericsson | We share the same view as QC as we discussed in earlier round.  The reason we were OK was due to the push by some vendors.  On ZTE, true that this assumption affects the likelihood of the scenario, but we have to admit that technically, it is strange and in the design, some PUSCHs are excluded arbitrary. It would be preferred to keep the design solid and not use such exclusions. |
| Apple | Based on the discussion so far, given the scheduling constraint, it is typical that the UL-TDAI values are the same for the PUSCHs that may have HARQ-ACK multiplexed on. This means that if actual TDAI is indeed 4, we would see UL-TDAI of 4 for all the PUSCHs. In this case, Alt 1 and Alt 2 have the same outcome, i.e., HARQ-ACK is not multiplexed on any of the PUSCHs. On the other hand, if the actual TDAI is not 4, the PUSCHs with UL-TDAI =4 should not expect HARQ-ACK to be multiplexed on. Therefore, Alt 2 is better in our view. |

### Question 4-2: Effect of CSI

Regarding “UE expects to multiplex on only 1 PUSCH in the PUCCH slot with only HARQ-ACK multiplexed on PUSCH”, we’d like to further clarify whether CSI can be multiplexed on other PUSCHs overlapping with the CSI PUCCH resource. In our understanding, gNB expects a PUCCH with the assumption of multiplexing of HARQ-ACK and CSI, if AN PUCCH overlaps with CSI PUCCH.

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| **Company** | **Comments** |
| QC | In our understanding, spec allows multiplex P-CSI and A/N on two different PUSCHs. For A-CSI, A/N and A-CSI are always multiplexed on a same PUSCH. |
| ZTE | In our understanding, CSI can be multiplexed in another PUSCH if CSI PUCCH does not overlapping with neither HARQ-ACK PUCCH nor PUSCH selected for HARQ-ACK multiplexing.  If AN PUCCH overlaps with CSI PUCCH, HARQ-ACK and CSI should be multiplexed in the same PUSCH. |
| NTT DOCOMO | For CSI PUCCH case, CSI can be multiplexed on a PUSCH with/without HARQ-ACK as commented by ZTE.  For A-CSI case (CSI triggered for PUSCH), HARQ-ACK is multiplexed on the PUSCH with A-CSI if overlapped. Otherwise, HARQ-ACK might be multiplexed with another PUSCH. |
| Intel | As mentioned above, this may have issues if A/N PUCCH resource overlaps with CSI PUCCH. if UE miss-detects AN PUCCH, the resultant PUCCH would be different from what gNB expects, e.g., gNB expects a resultant PUCCH overlaps with PUSCH 1, while P-CSI PUCCH only overlaps with PUSCH2. As shown in the figure below, we think UE behavior for such case should also be defined. Otherwise, we still have a hole in the spec. |
| MTK | Share similar view as DCM. |
| Samsung | We think that CSI PUCCH issue should be deprioritized since it is not still clear full operation of multiplexing PUSCH and HARQ-ACK PUCCH when a UE doesn’t know HARQ-ACK PUCCH. |
| Ericsson | We share same view as QC, ZTE, DCM.  To Intel: For the scenario that Intel presents, due the missing AN PUCCH, NACK would be multiplexed on PUSCH1 because of UL-TDAI, but PUSCH2 would be multiplexed with PUSCH2.  Please note that clarifying the behavior when AN PUCCH is absent, does not mean that the solution should ensure NACK to be end up in the PUSCH as if AN PUCCH was present. There are the cases that NW has to deal with (that’s why in our contribution we illustrated that what NW schedules, might be perceived very differently at UE). **However, the important aspect is to know what UE would do for each case.** Then NW takes this information into account to plan considering many other factor. |
| Apple | We think this case can be discussed further after we solve the case without PUCCH first. |

### Question 4-3: PUCCH Slot

For Alt-2, we’d like to clarify, whether “1 PUSCH in the PUCCH slot” is the PUSCH with starting symbol in the PUCCH slot, or the PUSCH with ending symbol in the PUCCH slot? For example, due to different SCS for PUCCH and PUSCH, or sub-slot for PUCCH, it is possible that a PUSCH crosses two PUCCH slot.

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| **Company** | **Comments** |
| QC | We think this is a secondary issue. In real deployment, normally Pcell SCS is smaller than Scell. Hence Pcell PUCCH slot duration is longer than Scell PUSCH slot. Both staring and ending symbol of a PUSCH should fall into a same PUCCH slot.  The case in this question can only occurs with Pcell SCS larger than Scell, which not typical use case. If that occurs, we don’t have strong opinion which way to go. |
| ZTE | We don’t have strong view on this.  BTW, for the proposal 3-1, we understand the discussions focus on Rel-16. We agree with moderator that it may be difficult to achieve a consensus in Rel-16. But we think we can continue the discussion for Rel-17 just like the proposal 4-1, since companies may have different views for Rel-16 and Rel-17. So maybe we can continue the discussion in the 4th round only for Rel-17? |
| NTT DOCOMO | It seems that one PUSCH per PUCCH slot is the intention. Two PUCCHs with HARQ-ACK cannot be overlapped with a PUSCH, then starting symbol/ending symbol would not matter. |
| Intel | Since it is for Rel-16 discussion, sub-slot configuration for a PUCCH would be a typical scenario, even for the same SCS or larger SCS for Pcell than Scell. In case of sub-slot, the PUCCH slot is actually a PUCCH sub-slot.  If all companies think longer duration of a slot for PUSCH than a PUCCH slot does not exist, we’re fine to drop the discussion. But if companies think it is a valid scenario, we’d like to clarify this issue. |
| MTK | We share similar view with QC that the case in this question can only occur with PCell (or PUCCH SCell) SCS larger than SCell (or with a small sub-slot duration as mentioned by Intel). With the consideration that normally PUCCH would not appear in a per slot basis, we also see “a PUSCH crosses two PUCCH slot” as a corner/rare case. However, it does not mean this cannot happen, so if companies want to also define the UE behavior for this case, we can be fine for it. |
| Ericsson | Also we agree that is a secondary issue but the answer to this question is clear from our point of view.  When PUCCH is absent, the PUCCH slot is consider. That means the procedures are equivalent as if the PUCCH was present and covering the full PUCCH slot/sub-slot. Then the first PUSCH can be determined the same way even in case of different SCS. |
| Apple | We can further discuss whether we want to handle such a case or not. If yes, our initial thinking is that we should consider all the PUSCHs overlapping with the PUCCH slot. But this may need more careful consideration. |

# 4th Round Summary

### Proposal 4-1: Rel-17 Unified Solution

The company positions are as follows: Support: ZTE, NTT DOCOMO, QC (?), Intel (?), MTK, Samsung

Based on the comments, we will update the proposal as follows:

* Remove A/N limitation as recommended by QC, Intel and NTT DOCOMO
* Clarify multiplexing timeline as recommended by QC
* Will de-prioritize AN and CSI PUCCH issue for this meeting. We can continue to discuss in the next meeting.
* For the 2nd bullet, there seems to be a difference in opinion on whether same or different value of the TDAI can be set. Note that this does not affect the UE behavior but given we have multiple companies that say differently, we place the options in brackets.
* Additional comments indicate that given this is Rel-17, we should not remove Alt-1 from the discussion.

I have the following recommendation:

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| **Recommendation 1:**  **For Rel-17 UEs, for a unified design, the following should be specified:**   1. Selection of the candidate PUSCH for multiplexing    1. **Alt-1:** All the PUSCHs within the PUCCH slot are candidates    2. **Alt-2:** PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates    3. N/W sets all TDAI values that overlap with PUCCH to the [same/different] value with TDAI n.e. 4 2. Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213 3. Limitations for multiplexing    1. UE expects to multiplex HARQ-ACK on only 1 PUSCH in the PUCCH slot ~~with only HARQ-ACK multiplexed on PUSCH~~.    2. ~~PUSCHs to be selected obey multiplexing timeline for the first PUSCH in the PUCCH slot in the PUSCH candidate set.~~    3. All the PUSCHs in the determined candidate set after step 1 have to satisfy Rel-15 UCI multiplexing timeline, defined with respect the starting symbol of the earliest PUSCH transmission in the candidate set**.**        1. gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline |

### Proposal 4-2: Rel-16 Compromise Solution

On this topic, I agree with QC on the non-agreed scenario i.e.

1. Continue discussion on UE behavior with respect to multiplexing HARQ-ACK in PUSCH for the following case in Rel-16.
   1. More than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if for at least one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook)

Based on our discussions so far, we have two scenarios with the following recommendations:

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| **Recommendation 2:**  In Rel-16, for scenario 1, in which more than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if only one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook) **the UE shall multiplex HARQ-ACK in PUSCH according to UL DAI** |

For Scenario 2 in which more than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook), the following are the company positions:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Option 1 | Option 2 | Option 3 | Option 4  No takers | Option 5 | Option 6 |
| QC | Object | Okay | Not preferred |  | Okay |  |
| ZTE | Okay |  | Okay |  |  |  |
| NTT DOCOMO | Okay | Okay |  |  |  |  |
| Intel | Okay |  | Okay |  |  |  |
| MTK |  | Okay |  |  |  |  |
| Nokia |  | Object ? |  |  | Object | Okay |
| Ericsson | Okay | Object | Object |  | Object | Okay |
| Apple | Okay | Okay | Okay |  |  |  |

There is currently no consensus on the Rel-16 UE behavior.

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| Recommendation 3  For Scenario 2 in which more than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook), Continue discussions in next meeting based on Option 1, Option 2, Option 3, Option 5 and Option 6. |

### Proposal 4-3: Rel 16 Unified Solution

Apologize to the companies for the confusion. 4-2 was to deal with the existing non-overlapping cases and 4-3 was to deal with the extension.

We may need to discuss this later with the correct questions.

### Question 4-1: UL-TDAI = 4

The following are the company positions:

* QC, Ericsson: Use Alt-1 vs Alt 2
* Corner case : ZTE, NTT DOCOMO, Intel, MTK, Samsung

**Conclusion: Majority feel it is a corner case. De-prioritize for this meeting.**

### Question 4-2: Effect of CSI

* **Spec allows multiplex P-CSI and A/N on two different PUSCHs. For A-CSI, A/N and A-CSI are always multiplexed on a same PUSCH.: QC, Ericsson**
* CSI can be multiplexed in another PUSCH if CSI PUCCH does not overlapping with neither HARQ-ACK PUCCH nor PUSCH selected for HARQ-ACK multiplexing: ZTE, NTTT DOCOMO, MTK, Ericsson
* AN PUCCH overlaps with CSI PUCCH, HARQ-ACK and CSI should be multiplexed in the same PUSCH: ZTE, NTT DOCOMO, MTK, Ericsson
* De-prioritized : Samsung, Apple

**Conclusion: Secondary issue and de-prioritized for this meeting**

### Question 4-3: PUCCH Slot

**Conclusion: Secondary issue and de-prioritized for this meeting**

# Recommendations

Based on the discussions so far in this meeting, the following recommendations will be made.

### Recommendation 1

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| **Recommendation 1:**  **Proposal 4-1:**  **For Rel-17 UEs, for a unified design, the following should be specified:**   1. Selection of the candidate PUSCH for multiplexing    1. **Candidate PUSCHs**       1. **Alt-1:** All the PUSCHs within the PUCCH slot are candidates       2. **Alt-2:** PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates    2. N/W sets all TDAI values that overlap with PUCCH to the [same/different] value with TDAI n.e. 4 2. Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213 3. Limitations for multiplexing    1. UE expects to multiplex HARQ-ACK on only 1 PUSCH selected based on step 2 in the PUCCH slot ~~with only HARQ-ACK multiplexed on PUSCH~~.    2. ~~PUSCHs to be selected obey multiplexing timeline for the first PUSCH in the PUCCH slot in the PUSCH candidate set.~~    3. All the PUSCHs in the determined candidate set after step 1 have to satisfy Rel-15 UCI multiplexing timeline, defined with respect the starting symbol of the earliest PUSCH transmission in the candidate set**.**        1. gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline |

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| **Company** | **Comments** |
| MTK | One clarification for Proposal 4-1:   * Bullets “a, b, c” are put in parallel, while it seems we have to choose only one of “a,b” and decide some details of “c”.   Since “a, b” are two alternatives to be chosen, we suggest to merge “a, b” as one bullet with two alternatives (Alt-1/Alt-2) to make the structure more clear. |
| QC | For Alt 1 and Alt 2 under “Selection of the candidate PUSCH for multiplexing”, I assume it should be down selection between Alt 1 and Alt 2? |
| LG | Same question with QC. Can we assume that we need down selection between Alt 1 and Alt 2, and between “same” and “different” in above?  Another question or comment is that, regarding the only 1 PUSCH in the sub-bullet “UE expects to multiplex HARQ-ACK on only 1 PUSCH in the PUCCH slot in above, does it mean one PUSCH selected based on prioritization rule in 38.213? |
| Intel | We have same question for QC and LG on the alternatives and [same/different]. Also for the recommendations, are these intended for email approval or for information only?  For limitation on multiplexing, for a), we suggest to add “FFS: when CSI PUCCH is present in the PUCCH slot” as in our view, we also need to resolve the CSI multiplexing issue together with A/N multiplexing on PUSCH in order complete the feature.   * UE expects to multiplex HARQ-ACK on only 1 PUSCH in the PUCCH slot.   + FFS: when CSI PUCCH is present in the PUCCH slot |
| CATT | [CATT] If it is for Rel-17, we think the discussion may be quite complicated considering intra-UE multiplexing across different priorities supported in Rel-17 URLLC. It is not clear yet to us whether/how the alternatives work. For example, assuming HP and LP PUCCH have different time units, how a PUCCH slot is defined. We think more discussion would be needed so we are not fine with the proposal for now. |
| Moderator | @ MTK: modified  @ Qualcomm: Yes  @ LG: Yes to same question as Qualcomm  Yes to question on PUSCH selected (based on step 2).. added to proposal  @ Intel  They were meant for email approval but unfortunately we are past the deadline. On the CSI issue, in recommendation 4, we added it as one of the issues to be discussed. Would prefer to deal with the CSI issue separately. |

### Recommendation 2

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| **Recommendation 2:**  **Proposal 4-2:**  In Rel -16, For scenario 1, in which more than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if only one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook) **the UE shall multiplex HARQ-ACK in that PUSCH according to its UL-TDAI** |

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| --- | --- |
| **Company** | **Comments** |
| MTK | Support |
| QC | Support.  Also suggesting editorial change: **the UE shall multiplex HARQ-ACK in that PUSCH according to its UL-TDAI** |
| LG | I guess the underline assumption why “only one of” is added in above, is that in fact, the PUCCH with HARQ-ACK originally scheduled by gNB would be overlapped with the “only one” PUSCH (but not overlapped with other PUSCHs).  Is this correct/common understanding? |
| Intel | We are fine with the proposal with QC’s update. |
| CATT | [CATT] Based on the discussions, it seems that majority companies support the proposal in principle so we can compromise here. But we think a unified solution is still preferred. At least it is not clear to us why it cannot be applied to the case where there are multiple overlapping PUSCHs and only one of them has an UL-DAI indicating HARQ-ACK multiplexing. If anyway we would discuss a unified solution according to Approach B in the next recommendation, we do not see the need to have special handling for this case in this meeting. |
| Samsung | [From email] Regarding CATT’s comment, we share similar view. It seems premature to conclude a specific case without common understanding on unified solution for all possible scenarios although most of companies are fine with the proposal. |
| Ericsson | [from email] We share the same view as CATT and Samsung. We spent the major time of the meeting to find a unified solution. In that exercise we explored different options (Option 1, .., 6, 6a).  Due to importance of this topic for helping industry with UL CA, we suggest to continue discussion next meeting and focus on the unified solution. That is more productive that agreeing piece-wise solution. This meeting helped us to understand better the problems that we have to address to achieve this goal.  We can take Recommendation 3 (Approach B) by Moderator as a guideline for the discussion. |
| Moderator | @ Qualcomm, @ Intel: updated  @ LG  Yes. It was also a way of divding the “@least one of” phrase from the last meeting into two manageable problems, one that could easily be solved and one that would have some more challenges in getting solved. |

### Recommendation 3

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| Recommendation 3  Proposal 4-3: Continue discussion of Approach A and Approach B in next meeting.  **Approach A:**  In Rel-16, for Scenario 2 in which more than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook), Continue discussions in next meeting based on Option 1, Option 2, Option 3, Option 5 and Option 6.  FFS: Discuss applicability to a Rel-16 Unified Solution  **Approach B:**  In Rel-16, for a unified solution, continue discussions in next meeting based on Option 1, Option 2, Option 3, Option 5 and Option 6. |

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| **Company** | **Comments** |
| MTK | Support |
| QC | Can FL please add the follow option 6a in both Approach A and B under the above recommendation 3? Basically, we cannot accept option 6. But we can accept a variation of option 6 (denote as 6a), which is listed as below. We’d like to make sure option 6a can also be discussed in next meeting.  **Option 6a**  For Scenario 2 (more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook):   * Selection of the candidate PUSCH for multiplexing   1. PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates * [Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs for Type 2 Codebook]   1. [**Option 1-1:** N/W sets all TDAI values that overlap with PUCCH to the same value with TDAI n.e. 4] * Prioritization rules to select PUSCH for multiplexing. ~~Prioritization rules are identical to 38.213~~   1. For Rel-16: Prioritization rules are as following ~~The prioritization to select PUSCH for multiplexing is only applicable for two cell UL CA case, where one cell is the PCell~~      + **If Pcell has PUSCH, multiplex HARQ-ACK on PUSCH on Pcell, following its UL-TDAI.**      + **Otherwise, multiplexing HARQ-ACK on a PUSCH on Scell, if any, following its UL-TAI.**        - **If the Pcell PUCCH slot overlaps with more than one Scell PUSCHs, multiplexing HARQ-ACK on the earliest PUSCH on Scell.**   2. For Rel-17: Prioritization rules are identical to 38.213~~The above Rel-16 restriction is lifted.~~ * Limitations for multiplexing   1. UE expects to multiplex HARQ-ACK on only 1 PUSCH in the PUCCH slot.   2. All the PUSCHs in the determined candidate set after step 1 have to satisfy Rel-15 UCI multiplexing timeline, defined with respect the starting symbol of the earliest PUSCH transmission in the candidate set**.**       1. gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline |

### Recommendation 4

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| **Recommendation 4**  These topics are de-prioritized for this meeting and may be discussed in the future:   * Repetition * Effect of CSI |

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| **Company** | **Comments** |
| MTK | Support |
| QC | We are fine with the proposal |

# Conclusions

* Recommendation from the Chair:
  + I see there is perhaps some converged view to resolve the issue for Rel-17 with a unified solution. However, this part of the puzzle does not seem urgent to me. Furthermore, Recommendation 1 is a summary of alternatives. We can do a proper decision on one of the alternatives this later.
  + What is more urgent at this point would be the Rel-15/16 portion of the discussions. However, the discussions are still quite diverging. Recommendation 3 and 4 does not have much in terms of making meaningful decision. Recommendation 2 does but there is strong concern from both Nokia and Ericsson.

**Plan for next meeting:**

Recommendation 3 (Approach B)

~~In Rel-16,~~ For  a unified solution for Rel-16, continue discussions in next meeting based on the following: Option 1, Option 2, Option 3, Option 5 and Option 6 and Option 6a.

* Option 1: Merged Alt1/Alt2 solution

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| 1. Selection of the candidate PUSCH for multiplexing    1. **Candidate PUSCHs**       1. **Alt-1:** All the PUSCHs within the PUCCH slot are candidates       2. **Alt-2:** PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates    2. N/W sets all TDAI values that overlap with PUCCH to the [same/different] value with TDAI n.e. 4 2. Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213 3. Limitations for multiplexing    1. UE expects to multiplex HARQ-ACK on only 1 PUSCH selected based on step 2 in the PUCCH slot.    2. All the PUSCHs in the determined candidate set after step 1 have to satisfy Rel-15 UCI multiplexing timeline, defined with respect the starting symbol of the earliest PUSCH transmission in the candidate set**.**        1. gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline |

* Option 2:

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| * A UE does not expect more than 1 PUSCH with UL TDAI n.e. 4. The UE shall multiplex HARQ-ACK in that PUSCH according to its UL-TDAI. |

* Option 3:

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| * UE capability indicating UE can implement Option 1 or Option 2 |

* Option 3:

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| * Agree on Option 1 for Rel-17. Then in the Rel-17 CR cover page, add magic sentence “**The CR is for Rel-17. But the Rel-17 CR can be early implementable by a Rel-16 UE/gNB**” |

* Option 6:

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| **Option 6**  For Scenario 2 (more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook):   * Selection of the candidate PUSCH for multiplexing   + PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates * [Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs for Type 2 Codebook]   + [**Option 1-1:** N/W sets all TDAI values that overlap with PUCCH to the same value with TDAI n.e. 4] * Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213   + For Rel-16: The prioritization to select PUSCH for multiplexing is only applicable for two cell UL CA case, where one cell is the PCell   + For Rel-17: The above Rel-16 restriction is lifted. * Limitations for multiplexing   + UE expects to multiplex on only 1 PUSCH in the PUCCH slot with only HARQ-ACK multiplexed on PUSCH.   + PUSCHs to be selected obey multiplexing timeline for the first PUSCH in the PUCCH slot in the PUSCH candidate set. * **Option 2-1:** gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline |

**Option 6a**

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| **Option 6a**  For Scenario 2 (more than one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook):   * Selection of the candidate PUSCH for multiplexing   1. PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB within the PUCCH slot are candidates * [Potential restrictions on how N/W sets TDAI values for the candidate PUSCHs for Type 2 Codebook]   1. [**Option 1-1:** N/W sets all TDAI values that overlap with PUCCH to the same value with TDAI n.e. 4] * Prioritization rules to select PUSCH for multiplexing. ~~Prioritization rules are identical to 38.213~~   1. For Rel-16: Prioritization rules are as following ~~The prioritization to select PUSCH for multiplexing is only applicable for two cell UL CA case, where one cell is the PCell~~      + **If Pcell has PUSCH, multiplex HARQ-ACK on PUSCH on Pcell, following its UL-TDAI.**      + **Otherwise, multiplexing HARQ-ACK on a PUSCH on Scell, if any, following its UL-TAI.**        - **If the Pcell PUCCH slot overlaps with more than one Scell PUSCHs, multiplexing HARQ-ACK on the earliest PUSCH on Scell.**   2. For Rel-17: Prioritization rules are identical to 38.213~~The above Rel-16 restriction is lifted.~~ * Limitations for multiplexing   1. UE expects to multiplex HARQ-ACK on only 1 PUSCH in the PUCCH slot.   2. All the PUSCHs in the determined candidate set after step 1 have to satisfy Rel-15 UCI multiplexing timeline, defined with respect the starting symbol of the earliest PUSCH transmission in the candidate set**.**   gNB will not schedule any additional PUSCH in the PUCCH slot that does not satisfy the multiplexing timeline |

# References

1. R1-2201146 Discussion on HARQ-ACK multiplexing on PUSCH ZTE, RAN1 #108-e
2. R1-2201324 Discussion on HARQ-ACK multiplexing in PUSCH without PUCCH CATT, RAN1 #108-e
3. R1-2201755 On Remaining Issues for PUSCH UCI Multiplexing without HARQ-ACK PUCCH Apple, RAN1 #108-e
4. R1-2202115 Remaining issues for HARQ-ACK multiplexing on PUSCH without PUCCH Qualcomm Incorporated, RAN1 #108-e
5. R1-2202374 Remaining issues for HARQ-ACK multiplexing on PUSCH without PUCCH Ericsson, RAN1 #108-e
6. R1-2202431 Discussion on HARQ-ACK multiplexing on PUSCH without PUCCH, Huawei/HiSilicon RAN1 #108-e
7. 3GPP TS 38.213, v15.13.0.
8. R1-1907441, Multiplexing of overlapping PUCCH and PUSCH with different numerologies, Nokia, RAN1 #97
9. R1-2106327, Summary for [105-e-NR-7.1CRs-02] Discussions on PUSCH UCI Multiplexing without HARQ-ACK PUCCH, Moderator (Apple), RAN1 #105-e
10. Chairman’s Notes, RAN1 #106-e
11. R1-2108647, Summary for [106-e-NR-7.1CRs-07] Discussion on HARQ-ACK multiplexing on PUSCH without PUCCH, Apple (Moderator), RAN1 #106-e
12. Chairman’s Notes, RAN1 #107-e
13. R1-2108647 Summary for [106-e-NR-7.1CRs-07] Discussion on HARQ-ACK multiplexing on PUSCH without PUCCH, Moderator (Apple), RAN1 #107-e

# Appendix: Background

### PUCCH Prioritization Rules for Rel-15:

In the case of overlapping PUCCH resources and PUSCHs, determination of whether or not the UE multiplexes information in a PUSCH transmission was discussed in the following conclusion in RAN1 #97[9][10]:

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| **conclusion**  For the issue raised in the draft CR [R1-1906302](https://www.3gpp.org/Users/komeoteri/Documents/3GPP/Meetings/2021%20April%20RAN1%20%20104bis-e%20Meeting/Docs/R1-1906302.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). 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 serving cell with smaller ~~CC~~ serving cell index > PUSCHs on serving cell with larger 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. |

The UCI multiplexing on PUCCH is specified in Section 9.2.5 of [7] and the PUSCH prioritization rule for UCI multiplexing on PUSCH is specified in Section 9 of [7]:

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| **PUSCH prioritization rule for HARQ-ACK multiplexing (Clause 9 of TS 38.213)**  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.  If a UE transmits multiple PUSCHs in a slot on respective serving cells and the UE would multiplex UCI in one of the multiple PUSCHs and the UE does not multiplex aperiodic CSI in any of the multiple PUSCHs, the UE multiplexes the UCI in a PUSCH of the serving cell with the smallest *ServCellIndex* subject to the conditions in clause 9.2.5 for UCI multiplexing being fulfilled. If the UE transmits more than one PUSCHs in the slot on the serving cell with the smallest *ServCellIndex* that fulfil the conditions in clause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in the earliest PUSCH that the UE transmits in the slot.  If a UE transmits a PUSCH over multiple slots and the UE would transmit a PUCCH with HARQ-ACK and/or CSI information over a single slot that overlaps with the PUSCH transmission in one or more slots of the multiple slots, and the PUSCH transmission in the one or more slots fulfills the conditions in clause 9.2.5 for multiplexing the HARQ-ACK and/or CSI information, the UE multiplexes the HARQ-ACK and/or CSI information in the PUSCH transmission in the one or more slots. The UE does not multiplex HARQ-ACK and/or CSI information in the PUSCH transmission in a slot from the multiple slots if the UE would not transmit a single-slot PUCCH with HARQ-ACK and/or CSI information in the slot in case the PUSCH transmission was absent. |

# Appendix: Contribution Proposals

The following proposals have been made in the contributions:

### ZTE: R1-2201146 [1]

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| ***Proposal 1:*** *One of the PUSCH repetitions should be specified for HARQ-ACK multiplexing if the UE does not know the overlapping PUCCH slot due to missing detection of the DL DCI and the T-DAI in the UL grant is not equal to 4 for Type 2 codebook or is equal to 1 for Type 1 codebook.*  ***Proposal 2:*** *For multiple non-overlapping PUSCH in a slot, the UE should perform HARQ-ACK multiplexing in the PUSCH with DAI equal to 1 for Type 1 codebook or not equal 4 for Type 2 codebook. If there are more than one such PUSCHs, the UE should select the PUSCH for HARQ-ACK multiplexing from these PUSCHs according to the current PUSCH prioritization rule.* |

### CATT R1-2201324 [2]

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| ***Proposal 1:*** *The following agreement in RAN1#107-e applies to PUSCH without repetition only.*  *Agreement*  *For Rel-16 with one PUSCH and no overlapping PUCCH with HARQ-ACK within a span of one PUCCH slot (both single carrier and UL CA), if the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), the UE multiplexes HARQ-ACK following the UL-TDAI into the PUSCH.*  ***Proposal 2:***  *For Rel-16 with PUSCH repetition and no overlapping PUCCH with HARQ-ACK (both single carrier and UL CA), the UE does not multiplex HARQ-ACK into any PUSCH repetition.*  *Proposal 3: For the following case in Rel-16, the UE behavior is left to UE implementation.*   * *More than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if for at least one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook)* |

### Apple : R1-2201755 [3]

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| ***Proposal 1:***   * *Scenario 1: For Rel-16 UEs with more than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if for at MOST one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook)*   + *In this case, the UE can multiplex on the PUSCH with UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook)* * *Scenario 2: For Rel-16 UEs with more than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if MORE THAN one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or  equal to 1 (for Type 1 codebook) :*    + *In this case, the UE behavior is similar to case 0.* * *We assume that the decisions are made at time t1 = time before PUSCH preparation timeline* |

### Qualcomm R1-2202115 [4]

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| *Proposal 1: for the case of more than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if at least one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook)*   * *if there is more than one PUSCH in the more than one non-overlapping PUSCH have UL-TDAI not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), it is up to UE implementation to handle this case.* * *if there is only one PUSCH (denote as PUSCH A) in the more than one non-overlapping PUSCH has UL-TDAI not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), a UE multiplex HARQ-ACK following the UL-TDAI into that PUSCH A.* |

### Ericsson R1-2202374 [5]

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| ***Observation 1*** *The UL DAI field in the DCI is intended to provide a control mechanism to ensure that the UE multiplexes a determined number of HARQ-ACK bits obtained from the indicated UL-DAI in a PUSCH even if the UE misses one or all the corresponding DL assignments.*  ***Observation 2*** *Ignoring HARQ-ACK multiplexing in a PUSCH when indicated by UL-DAI in case of missing all the DL assignments, not only defeats the purpose of UL-DAI, but negates any motivation for the corresponding imposed scheduling restrictions due to UL-DAI.*  *Based on the discussion in the previous sections we propose the following:*  ***Proposal 1*** *When a UE determines that there is at least one PUSCH with corresponding UL-TDAIs within a span of a PUCCH slot (both single carrier and UL CA), if the UE determines that there is no PUCCH with HARQ-ACK in the PUCCH slot:*  *• The UE expects that multiplexing timeline is fulfilled for all the PUSCHs with corresponding UL-TDAI within the PUCCH slot.*  *• The UE selects one PUSCH following the same PUSCH prioritization rules described in Clause 9 of TS 38.213.*  *• If the UL-TDAI corresponding to the selected PUSCH is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), the UE multiplexes HARQ-ACK following the UL-TDAI into the selected PUSCH. Otherwise, the UE does not multiplex any HARQ-ACK in the selected PUSCH.* |

### Huawei/HiSilicon R1-2202431 [6]

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| ***Proposal 1:*** *In case of more than one non-overlapping PUSCH and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), if for at least one of the PUSCHs the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), and if sub-slot feedback is not supported,*   * *The UE shall multiplex HARQ-ACK in PUSCH according to UL DAI if there is only one PUSCH with UL DAI not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook)* * *The UE shall multiplex HARQ-ACK in PUSCH according to UL DAI if there are more than one PUSCH with UL DAI not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook) according to Rel-15 mechanism* * *The DAI field value of multiple PUSCH(s) should be the same* |