**3GPP TSG RAN WG1 Meeting #109-e R1-2205627**

**e-Meeting, May 9 – 20, 2022**

**Source: Moderator (Apple)**

**Title: Summary for [109-e-NR-CRs-01] HARQ-ACK multiplexing on PUSCH without PUCCH**

**Agenda item: 7.1**

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

# Introduction

This document provides the summary for the following email discussion in RAN1#109-e:

109-e-NR-CRs-01] Issue#1 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. |

In summary, we have the following status:

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| **Scenario** | **Agreements/Conclusions/Status** |
| Case 0: multiple overlapping PUSCHs with no overlapping PUCCH | 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** |
| Case 1, Case 2, Case 3 : more than one non-overlapping PUSCH and no overlapping PUCCH within a span on one slot (both single carrier and UL CA) | 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** |
| Case 4 : one PUSCH and no overlapping PUCCH within a span of one slot | 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 [6], the following conclusions and agreements were made for Rel-16 UEs:

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| **Scenario** | **Agreements/Conclusions/Status** |
| Case 0: multiple overlapping PUSCHs with no overlapping PUCCH | 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 behavior** |
| Case 1, Case 2, Case 3 : more than one non-overlapping PUSCH and no overlapping PUCCH within a span on one slot (both single carrier and UL CA) | 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) |
| Case 4 : one PUSCH and no overlapping PUCCH within a span of one slot | 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 RAN1 108-e [14], there **was consensus on the need for a unified solution for Rel-16 based on the concept of a “virtual PUCCH” spanning the PUCCH slot**. The outstanding issues focused on (a) how the UE selects the candidate PUSCHs and (b) how the gNB sets the TDAI values for the candidate PUSCHs.

# 1st Round

### Issue 1: Rel-16 Unified Solution

There is consensus to use the following a unified framework solution for Rel-16 and the future. From past discussions, items 2 and 3 below (in green) are stable

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**.**

This framework agrees to the following:

1. Use a “virtual PUCCH”
2. Consensus on using the Rel-15 prioritization framework
3. Consensus on having suitable limitations for multiplexing

To facilitate the discussion, we will discuss UE behavior and network behavior separately.

### Issue 1.1 UE behavior: Candidate PUSCH selection and Rel-16 capability

**Selection of the candidate PUSCH for multiplexing:**

* **Alt 1:** All the PUSCHs within the PUCCH slot are candidates
* **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

Company Positions:

* Alt 1: Ericsson, Nokia/NSN, Apple, LG, QC
* Alt 1 Advantage: (Ericsson/Nokia) specify behavior for the case that PUCCH is absent should not diverge from the specified behavior when a PUCCH would be present
* Alt 1 issue: (CATT) additional scheduling restriction requirement is needed for Option 1, e.g. whether UCI multiplexing timeline needs to be satisfied even for the DCI(s) associated with PUSCH(s) in a PUCCH slot which do not overlap with the PUCCH.
* Alt 2: ZTE, Huawei/Hi-Silicon, CATT, Intel, Apple
* Alt 2 Advantage: reduces potential for mis-alignment by gNB and UE
* Alt 2 issue:
  + (Ericsson) Changes operation from “PUSCH candidate selection then TDAI operation” to “TDAI operation then PUSCH candidate selection”
  + (LGE) Does this account for account for CG-based and PUSCHs scheduled by fallback DCI
    - 38.213, Section 9: *If a UE transmits multiple PUSCHs in a slot on respective serving cells that include first PUSCHs that are scheduled by DCI format(s) 0\_0 or DCI format(s) 0\_1 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 Subclause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in a PUSCH from the first PUSCHs*
    - *Answer: Yes. Current language does not exclude CG and fallback DCI.*

### Question 1: Alt-1 vs Alt-2

* **Alt 1:** All the PUSCHs within the PUCCH slot are candidates
* **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

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| **Company** | **Comments** |
| NTT DOCOMO | Our preference is Alt 2 since NW can avoid different understanding of which PUSCH HARQ-ACK is multiplexed on, between UE and gNB. In Alt 1, this avoidance is impossible.  However, we can be flexible if majority support Alt 1. |
| LG | We prefer Alt 1 (and add “LG” as proponent of Alt 1 in above) to keep consistent UE behavior with the case when the HARQ-ACK PUCCH is present. |
| MTK | We tend to agree with DOCOMO and slightly prefer Alt 2.  However, in theory Alt 1 can still work that UE just ignores TDAI value and choose one PUSCH to do the multiplexing, and forgot the confusing T-DAI combinations. Hence, we can also be flexible to take Alt. 1 if NW vendors have strong concerns on Alt 2. |
| CATT | Our preference is Alt 2.  We would like to clarify the timeline requirement for Alt 1. Is it correct understanding that all the DCIs associated with the PUSCHs within the PUCCH slot should meet the multiplexing timeline with respect to the earliest PUSCH, i.e. multiplexing timeline needs to be satisfied for the DCIs associated with PUSCHs which do not overlap with the PUCCH?  For example, is the following case an error case since DCI 2 does not meet the multiplexing timeline with respect to PUSCH1. |
| Samsung | We realized that the following specification sentence could not be valid if selected PUSCH has DAI = 4 in case of alt. 1. Since current UE behavior would not multiplex HARQ-ACK information in the selected PUSCH if the UE hasn’t receive any PDCCH indicating HARQ-ACK information. Thus, UE always selects one PUSCH every PUCCH slot regardless of whether UE actually misses DL DCI or not.    <38.213>  If a UE is not provided *PDSCH-CodeBlockGroupTransmission* and the UE is scheduled for a PUSCH transmission by DCI format that includes a DAI field with value 𝑉T-DAIUL=4 and the UE has not received any PDCCH within the monitoring occasions for PDCCH with DCI format scheduling PDSCH receptions or having associated HARQ-ACK information without scheduling PDSCH receptions on any serving cell 𝑐 and the UE does not have HARQ-ACK information in response to a SPS PDSCH reception to multiplex in the PUSCH, as described in clause 9.1.3.1, the UE does not multiplex HARQ-ACK information in the PUSCH transmission.  Regarding the point raised by CATT, we think that this issue is also happened in Alt. 2 if PUSCH 1’s DAI is assumed to 3. Thus, we think that timeline issue should be handled by gNB implementation such that the timeline between last one of DCIs scheduling candidate PUSCHs group and the selected PUSCH for multiplexing HARQ-ACK should be larger than what current specification has defined. Otherwise, UE shall assume this is error case. |
| ZTE | The UE behavior should be consistent regardless of the UE detects the DL DCI so that the gNB blind detection is avoided. If the UE detects the DL DCI and the know the PUCCH resource, the UE selects the PUSCH overlapping with the PUCCH resource. Therefore, we prefer Alt 2 since the UL-DAI can implicitly indicate the which PUSCH overlaps with PUCCH resource.  On the other hand, we also agree that Alt 1 can work. The gNB can schedule all the PUSCH to overlap with the PUCCH resource to avoid the bind detection. So we can also accept Alt 1 if it is the majority view. |
| Huawei, HiSilicon | We support Alt 2. The fundamental issue with Alt. 1 is that the PUSCHs within the PUCCH slot are not necessarily overlapped with the PUCCH. In this case, the specific UL DAI values will be set by the gNB to avoid HARQ-ACK multiplexing on the PUSCH. For Type 2 CB, the gNB will set the UL DAI values to 4. From the UE perspective, the probability of missing 4 consecutive PDCCH can be assumed to be sufficiently low. For Type 1 CB, the gNB will set the UL DAI value to 0, it is not clear why this PUSCH should be included for the HARQ-ACK multiplexing. |
| vivo | Our preference is Alt 2. since NW can avoid different understanding of which PUSCH HARQ-ACK is multiplexed on, between UE and gNB by set one UL-DAI n.e. 4. |
| Intel | We prefer Alt. 2. This can help avoid the misunderstanding between gNB and UE side. |
| Nokia, NSB | As noted above, our preference is Alt.1 |
| QC | We support Alt. 1  Maybe I missed something. But I’d like to understand how Alt 2 works in Type 2 codebook. TDAI = 4 does not necessarily mean 0 bit A/N, it can mean 4 bits A/N as well. Since UE missed all DL grant in this case, UE cannot distinguish these two cases. We don’t see why TDAI=4 should be used as a criteria to filter candidate PUSCHs. |
| Apple | We are fine with either Alt 1 or Alt 2.  On the timeline question raised by CATT, we share the understanding that the multiplexing timeline condition needs to be satisfied for both DCI1 and DCI2. |
| Ericsson | We support Alt 1.  @HW, DCM, ZTE, Intel, … (supportive of Alt-2): It seems to me that there is a misunderstanding here. First, as QC mentioned, TDAI = 4 does not necessarily mean 0 bit A/N.  Second, the baseline is the normal operation (when PUCCH is present). In this case, to select a PUSCH for UCI multiplexing as in clause 9, the value of UL-TDAI does not play any role. When a PUSCH is selected for UCI mux, base don the procedures in other clauses, the value of DAI determines whether to multiplex or not.  To keep the same order of operations is very important. It is strange to change the order, and define a new behavior in specification, to do some optimization.  Alt-2 changes the order. It first uses the UL-TDAI to down-select the PUSCHs. Then it selects one PUSCH. Then follows UL-DAI for mux.  Therefore, in our view it seems the intention to support Alt-2 is to do some optimization at the cost of defining new behavior. This effort for the scenario that is abnormal, is not understandable.  @Samsung: I fail to understand your comment. Please check our proposed TP for Alt-1. It is exactly as the existing behavior. The UE selects a PUSCH based on procedure in clause 9. Then the procedure in the clause that you sited applies as the existing behavior. If UL-TDAI=4 (and here the UE doesn’t receive any PDCCH), the UE doesnt multiplex NACK. |
| Samsung2 | @Ericsson: Thank you for the follow-up. Regarding TP for Alt-1, the following part is newly suggested.  If the UE does not determine any PUCCH carrying HARQ-ACK information in the slot and the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling at least one the multiple PUSCHs, the UE multiplexes the UCI in the PUSCH if the UE indicates the corresponding capability [the name of the capability].  My question is which clause a UE should follow if proposed TP for Alt-1 is included in the specification. Again, the clause that I sited is saying that **the UE doesn’t multiplex** HARQ-ACK if UL-TDAI=4. While, the proposed TP is saying that **the UE multiplexes** HARQ-ACK regardless of UL-TDAI values. Is it correct understanding that the UE follows NO multiplexing behavior if the UE doesn’t report the new UE capability, otherwise the UE follows multiplexing behavior?  If above my question is clear, we are fine with Alt-1. Of course, alt-2 is also fine to us. |

**Rel-16 implementations:**

In RAN1 #108-e, concerns were raised by companies on the adoption of the unified solution for Rel-16 UE implementations. Option 3 of [14] and the following observation from Ericsson/Nokia [5] were proposed to resolve this issue:

1. *Introduction of capability for the solution can ease the UE implementations concern. While the behavior is specified and implemented by UEs, the presence of a capability improves the system performance due to less Ues with unknown ehavior in the NW.*

### Recommendation 1: CR capability

Accept capability indicating that a Rel-16 UE can implement this CR

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| **Company** | **Comments** |
| NTT DOCOMO | Our preference is not to introduce UE capability for this topic, but we can accept it. |
| LG | We are open to consider the UE capability for this issue. |
| MTK | We support to introduce a new R16 UE capability for this CR. |
| CATT | We are open to consider a new UE capability. |
| Samsung | Although we should avoid to introduce new Rel-16 UE capability in this very late stage, we can accept if majority of companies are fine with that because it has been very controversial issue. |
| ZTE | We are open to consider a new UE capability. |
| Huawei, HiSilicon | We are fine to introduce a new Rel-16 UE capability. |
| vivo | We are open to consider a new UE capability. |
| Intel | We are fine to consider this for Rel-16. |
| Nokia, NSB | As noted in the contribution, this was understood to be the way to find a compromise and be able to agree to a unified solution that would not have to wait for Rel-17 products. Hence the proposal, even though this was not our preference we’d be willing to take it to have a chance for an agreement. |
| QC | We support introduce a new Rel 16 UE capability for this CR, to avoid impact to Rel-16 UEs already deployed in the field. |
| Apple | We are fine to introduce a R16 UE capability. |
| Ericsson | Same view as Nokia. I hope it is understood that having capability is a compromise from our side to have a unified solution (Alt 1). |

### Issue 1.2 : Network Behavior: NW set TDAI value.

**Selection of the candidate PUSCH for multiplexing:**

* **Alt 2-1:** The N/W can set all TDAI values that overlap with PUCCH to different values with TDAI n.e. 4 i.e. no specification impact.
* **Alt 2-2:** The N/W should set all TDAI values that overlap with PUCCH to the same value with TDAI n.e. 4 i.e. will need to be specified.

Company Positions from contributions:

* Alt 2-1: Ericsson, Nokia/NSN, Apple, CATT, LGE
* Alt 2-2: ZTE, Huawei/Hi-Silicon, Intel, Apple

In the last meeting, it was shown by some network vendors that they currently utilize the flexibility afforded by the fact that this network behavior is not currently mandated by the specification. As such, it may be better to leave it to network implementation as is currently the case. Note that this does not impact the UE implementation as it only excludes TDAI = 4

**Recommendation:** Leave to gNB implementation. No specification impact.

### Recommendation 2: Network behavior

Leave to gNB implementation i.e. no specification impact.

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| **Company** | **Comments** |
| NTT DOCOMO | We support Alt 2-2. If we go with Alt 2-1, ‘no specification impact’ should be ensured. |
| LG | We support Alt 2-1 since there is no critical reason to have impact to the current spec. |
| MTK | We slightly prefer Alt 2-2.  If different T-DAI values exist in the same PUCCH slot, UE would be confused about how many DL DCIs are missed. For example, there are 3 overlapping PUSCHs in the same PUCCH slot, and their T-DAI values are 1, 2, 3 respectively, it is confusing how can we have different number of missing DCIs in the same slot.  Having said that, if NW vendors have strong concerns on Alt 2-2, then we can be flexible to take Alt 2-1, since it seems to still work if UE just follows the prioritization rule to choose one PUSCH. |
| CATT | We support the proposal.  As provided in our contribution, there are cases that gNB cannot set same T-DAI for all the PUSCHs overlapping with a same PUCCH. |
| Samsung | Fine with the moderator’s recommendation. |
| ZTE | We slightly prefer Alt 2-2 because we think the UL DCI should be later than the DL DCI and there is no need to update the UL T-DAI. We are also fine with Alt 2-1 because It can also work. Therefore, we support this proposal. |
| Huawei, HiSilicon | We support Alt 2-2. In addition, we are not sure whether this can be left to gNB implementation without specification impact since it will have an impact on the candidate PUSCHs selection for HARQ-ACK multiplexing.  On Alt 2-1, we would like to understand how likely this would happen that a UE will has no issue with receiving UL DCI but keeps missing DL DCIs? Even this does happen, a new PUCCH resource (PUCCH2 in the following figure) may be selected by the gNB and the PUSCHs overlapping with the new PUCCH for HARQ-ACK multiplexing may also be changed (PUSCH2 and PUSCH3). But following Alt 2-1, the UE will still choose all PUSCHs with different DAIs for HARQ-ACK multiplexing (PUSCH1, PUSCH2 and PUSCH3). This could cause a misunderstanding between the gNB and the UE. In summary, we don’t think Alt 2-1 is the right way to go.    On the example provided by CATT, we think it is precluded in the current speciation (TS38.213, section 9)  A UE does not expect to multiplex in a PUSCH transmission in one slot with SCS configuration UCI of same type that the UE would transmit in PUCCHs in different slots with SCS configuration if . |
| Vivo | We support Alt 2-1 since from gNB’s perspective, gNB knows the PUSCH to be selected for multiplexing and no reason to set ultiple UL-DAI n.e. 4. |
| Intel | We prefer Alt 2-2. However, if majority consider Alt 2-1 and no specification impact is needed, we can live with that. |
| Nokia, NSB | We support Alt 2-1. Notably this proposal adds nothing to the spec, whereas Alt2-2 would require specifying the restriction. |
| QC | We support Alt 2-1. We don’t see the need to restrict NW behavior in this case. |
| Apple | We support the proposal. |
| Ericsson | We support Alt 2-1.  Considering the comments from proponents of Alt 2-2, it seems to us that an important aspect is forgotten.   1. We should not forget that the baseline is the normal behavior (when PCCH is detected..). Where in the current specification is stated that Ul-TDAI should be same? Nowhere. 2. Then, please remember that when gNB schedules and have data to send in PDSCH, set the UL-DAI accordingly. That means the gNB doesn’t set the UL-TDAI for the case when PDSCHs are not received. 3. So, how is it going to work?   In other words, for Alt 2-2, what is the corresponding behavior for Normal case? Wouldn’t be the same UL-TDAI?  Then it means for Alt 2-2, we also have to define a new behaviour in spec for the normal case when the gNB schedules PDSCHs.  I assume that is not the intention of proponents of Alt 2-2, but that is hat we have to do. I understand the focus is on the abnormal case (no PUCCH), but we should not forget the setting DAI is for the normal case. |

### Issue 2: Text Proposals for Agreements

We will work on the TPs in parallel with the general agreement.

### Issue 2.1: TP for agreement in RAN1 #107-e

This proposal is based on an update from the version in R1-2204554 [5]. In RAN1#107-e, the following agreement was made:

**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.

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| UE procedure for reporting control information  <unchanged text omitted>  A UE does not expect to detect a DCI format scheduling a PDSCH reception or a SPS PDSCH release,a DCI format 1\_1 indicating Scell dormancy, or a DCI format including a One-shot HARQ-ACK request field with value 1, and indicating a resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot if the UE previously detects a DCI format scheduling a PUSCH transmission in the slot and if the UE multiplexes HARQ-ACK information in the PUSCH transmission.  If a UE transmits one PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions and the UE does not determine any PUCCH carrying HARQ-ACK information in the slot, the UE multiplexes HARQ-ACK information in the PUSCH transmission. |

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| 9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel  <unchanged text omitted>  A UE determines  HARQ-ACK information bits, for a total number of  HARQ-ACK information bits, of a HARQ-ACK codebook for transmission in a PUCCH or a PUSCH according to the following pseudo-code. In the following pseudo-code, if the UE does not receive a transport block or a CBG, due to the UE not detecting a corresponding DCI format 1\_0 or DCI format 1\_1, the UE generates a NACK value for the transport block or the CBG. The cardinality of the set  defines a total number  of occasions for PDSCH reception or SPS PDSCH release for serving cell  corresponding to the HARQ-ACK information bits.  <unchanged text omitted> |

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| 9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel  <unchanged text omitted>  If the UE transmits HARQ-ACK information in a PUSCH or a PUCCH in slot  with reference to slots for PUCCH transmission  and for any PUCCH format, the UE determines the , for a total number of  HARQ-ACK information bits, according to the following pseudo-code:  <unchanged text omitted> |

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| **Company** | **Comments** |
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### Issue 2.2: CR cover page

This proposal is based on an update from the version in R1-2204554 [5]. Please review for correctness whether or not you support this or not.

**Consequences if not approved:**

* This CR completes an incompletely specified Rel-15 functionality for multiplexing HARQ-ACK in a PUSCH in a PUCCH slot when the UE misses any HARQ-ACK to transmit in any PUCCH but receives UL grant(s) with UL-TDAI field to transmit a single PUSCH or multiple PUSCHs in the PUCCH slot.A UE implemented based on an earlier version of the specification, and for case of multiple PUSCHs not able to indicate the new UE capability, may still be compliant with this CR, while a UE not compliant with the CR has unknown behavior. See isolated impact analysis.

**Isolated impact analysis**

* If a gNB is implemented according to the CR, but the UE is not, the UE behavior is unclear when HARQ-ACK is to be multiplexed in a PUSCH on a PUCCH slot where the UE transmits one or more PUSCHs scheduled by UL grant(s) with UL-TDAI in the PUCCH slot on one or more than 1 carrier, potentially leading to loss of UCI as well as loss of PUSCH.
* If the UE is implemented according to the CR, but the gNB is not, the gNB assumption on where it expects to find the UCI is unclear when HARQ-ACK is to be multilplexed in a PUSCH on a PUCCH slot where the UE transmits ne or more PUSCHs scheduled by UL grant(s) with UL-TDAI in the PUCCH slot on one or more than 1 carrier, potentially leading to loss of UCI as well as loss of PUSCH.

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| **Company** | **Comments** |
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### Issue 2.3: TP for Alt 1 proposal

This proposal is based on an update from the version in R1-2204554 [5]. We will work on the TPs in parallel with the general agreement. Please review for correctness whether or not you support this or not.

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| UE procedure for reporting control information  <unchanged text omitted>  If a UE multiplexes aperiodic CSI in a PUSCH and the UE would multiplex UCI that includes HARQ-ACK information in a PUCCH that overlaps with the PUSCH and the timing conditions for overlapping PUCCHs and PUSCHs in clause 9.2.5 are fulfilled, the UE multiplexes only the HARQ-ACK information in the PUSCH and does not transmit the PUCCH.  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the multiple PUSCHs overlap in the slot with a PUCCH carrying HARQ-ACK information or at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE determines the PUSCH for UCI multiplexing by applying the following procedure:   * If the ~~a UE transmits~~ multiple PUSCHs ~~in a slot on respective serving cells that include~~ 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 ~~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 the UE does not determine any PUCCH carrying HARQ-ACK information in the slot and the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling at least one the multiple PUSCHs, the UE multiplexes the UCI in the PUSCH if the UE indicates the corresponding capability [the name of the capability].   <unchanged text omitted> |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | We think the following part is new UE behavior and thus not aligned with section 2.1.5/2.1.6. We do not support this TP.  ‘If ... and the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling at least one the multiple PUSCHs, the UE multiplexes the UCI in the PUSCH ...’  In our understanding, current spec does not define UE behavior when UL grant corresponding to the selected PUSCH to multiplex HARQ-ACK indicates not to multiplex HARQ-ACK. Thus we think the following text is aligned with section 2.1.5/2.1.6.  ‘If ... and the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling the PUSCH, the UE multiplexes the UCI in the PUSCH ...’ |
| Nokia, NSB | Re: DOCOMO, I think you are correct, the DAI field has to be on the DCI that scheduled exactly that PUSCH. |
| Ericsson | DCM: Thanks for the comment. That definitely was not the intention as Nokia mentioned. Another alternative to Nokia’s suggestion can be below:   * If the UE does not determine any PUCCH carrying HARQ-ACK information in the slot and ~~the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling~~ at least one the multiple PUSCHs is scheduled by a DCI format with a DAI field, the UE multiplexes the UCI in the PUSCH if the UE indicates the corresponding capability [the name of the capability]. |

### Issue 2.4: TP for Alt 2 proposal

This proposal is based on an update from the FL based on a version in R1-2204554 [5]. We will work on the TPs in parallel with the general agreement. Please review for correctness whether or not you support this or not.

|  |
| --- |
| UE procedure for reporting control information  <unchanged text omitted>  If a UE multiplexes aperiodic CSI in a PUSCH and the UE would multiplex UCI that includes HARQ-ACK information in a PUCCH that overlaps with the PUSCH and the timing conditions for overlapping PUCCHs and PUSCHs in clause 9.2.5 are fulfilled, the UE multiplexes only the HARQ-ACK information in the PUSCH and does not transmit the PUCCH.  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the multiple PUSCHs overlap in the slot with a PUCCH carrying HARQ-ACK information or at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE determines the PUSCH for UCI multiplexing by applying the following procedure:   * If the ~~a UE transmits~~ multiple PUSCHs ~~in a slot on respective serving cells that include~~ 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 ~~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 the UE does not determine any PUCCH carrying HARQ-ACK information in the slot and the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling at least one the multiple PUSCHs PUSCHs without UL-TDAI=4 in case Type 2 CB, and without UL-TDAI n.e. 1 in case of Type 1 CB, the UE multiplexes the UCI in the PUSCH if the UE indicates the corresponding capability [the name of the capability].   <unchanged text omitted> |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | The proposed TP doesn’t reflect Alt-2.  Please note that the last bullet is only the condition for capability.  The selection of PUSCH is done in first two sub-bullets.  Hence, for Alt-2, one should change to select from multile PUSCHs, those without UL-DAI =4. Also, has to distinguish this case from normal case. So, the TP would require additional changes in first two bullets. |

### Issue 3: Repetition

A few companies continued the discussion on HARQ-ACK multiplexing without PUCCH with repetition:

|  |  |
| --- | --- |
| ZTE [2] | *Proposal 2: 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.* |
| Ericsson/Nokia [5] | *When a PUSCH scheduled by DCI is repeated and the corresponding UL grant indicates UL-TDAI but a PUCCH with HARQ-ACK is absent throughout the PUSCH repetition, the first PUSCH of the repetition is considered as a candidate PUSCH for HARQ-ACK multiplexing following the unified solution.* |
| Intel [6] | *Proposal 3: For PUSCH repetition case, 1st PUSCH repetition within a PUCCH slot is selected for HARQ-ACK multiplexing.* |
| CATT [3] | *Otherwise if the selected PUSCH is with repetition, UE does not multiplex HARQ-ACK in the selected PUSCH repetition.* |
| Nokia from [14] | *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.* |

In summary, we have the following positions from the contributions this meeting:

* **Alt 3-1: 1st PUSCH repetition within PUCCH slot is selected :** ZTE, Ericsson, Nokia, Intel
  + **Advantage: proponents say that this ensures a well-defined UE behavior. Note that network would need to schedule PUCCH resource by the time PUSCH is scheduled i.e. UE needs to know PUCCH resource at time DCI for PUSCH is received.**
* **Alt 3-2: UE does not multiplex HARQ-ACK in any of the PUSCH repetitions:** CATT, QC
  + **Advantage: proponents say that this option follows the agreement in RAN1 #94 for slot-level case as shown below:**

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

Note that if there is no consensus, the fallback position would be to accept Nokia’s suggestion that there is no simultaneous support for UL CA and PUSCH repetition.

### Proposal 1-1: Repetition for Rel-15 Ues

For a Rel. 15 UE, when a PUSCH scheduled by DCI is repeated and the corresponding UL grant indicates UL-TDAI but a PUCCH with HARQ-ACK is absent throughout the PUSCH repetition, the UE behavior is up to UE implementation

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | OK |
| LG | OK |
| MTK | OK |
| ZTE | OK for Rel-15. |
| Huawei, HiSilicon | Support |
| Intel | We are fine for Rel-15. |
| QC | This proposal is against Rel-15 spec. Rel-15 spec is clear that UE does not mux A/N on PUSCH in this case. We don’t support this proposal. |
| Apple | OK |
| Ericsson | OK.  QC: In fact, the behavior is not defined. We have checked with some UE vendors and the feedback was different. Some multiplex, some don’t. |

### Question 2: Repetition for Rel-16 UEs

Please indicate preference and why:

For a Rel-16 UE, when a PUSCH scheduled by DCI is repeated and the corresponding UL grant indicates UL-TDAI but a PUCCH with HARQ-ACK is absent throughout the PUSCH repetition,

* Alt 3-1: 1st PUSCH repetition within PUCCH slot is selected
* Alt 3-2: UE does not multiplex HARQ-ACK in any of the PUSCH repetition

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | We slightly prefer Alt 3-1.  BTW, this question should be after section 2.1.14, right? Repetition issue seems discussed under section 2.1.13. |
| LG | We prefer Alt 3-2 to respect the previous relevant agreement. |
| MTK | We prefer Alt 3-2 to respect the previous relevant agreement; but we understand some NW vendors may prefer Alt 3-1 and we are willing to further discuss if there are clear benefits for NW to choose Alt 3-1. |
| CATT | We prefer Alt 3-2 which is inline with previous agreement and the existing specification. Alt 3-1 introduced additional complexity at gNB side. |
| Samsung | Slightly prefer Alt. 3-2 since PUSCH selection rule should be re-designed in case of multiple cells if Alt. 3-1 is considered. |
| ZTE | We don’t support Alt 3-2 because it against the design when PUSCH repetition is not configured. We think it is easy to keep the same UE behavior for single PUSCH transmission and PUSCH repetition. In addition, the network can ensure first PUSCH repetition is on the UL slot in TDD band for dynamic scheduling. Therefore, the UE should multiplex the HARQ-ACK in the first PUSCH repetition, which is similar as the scenario that PUSCH repetition is not configured.  The benefit is clear that gNB does not need to perform bind detection. It can assume the HARQ-ACK is multiplexed in the first PUSCH repetition. Of course, gNB should schedule the PUCCH to overlap with the first PUSCH repetition. Anyway, it is the gNB implementation. On the contrary, there is no benefit for Alt 3-2. |
| Huawei, HiSilicon | We prefer Alt 3-2. |
| vivo | We prefer Alt 3-2 to respect the previous relevant agreement. |
| Intel | We prefer Alt 3-1. It would be more appropriate to consider a unified solution for both PUSCH with and without repetitions. |
| Moderator | Moved question to correct section with document |
| QC | We support Alt 3-2, which by the way is current specification in our understanding. |
| Apple | We prefer Alt 3-2. |
| Ericsson | We prefer Alt 3-1.  As Intel commented. It is consistent with the rest of story. UL-TDAI is present. Then UE can’t just ignore it. It seems we are back to square one. |

# 1st Round Summary

### Issue 1: R16 Unified Solution

### Issue 1.1 UE behavior

#### Question 1: Alt-1 vs Alt-2

**Company positions:**

* **Alt 1:** All the PUSCHs within the PUCCH slot are candidates
  + **LG, Nokia/NSB, QC, Apple, Ericsson (5)**
* **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
  + **NTT Docomo, MTK, CATT, Samsung, ZTE, Huawei/HiSilicon, Vivo, Intel, Apple, (9)**

**Highlighted Discussions and Answers:**

* CATT: We would like to clarify the timeline requirement for Alt 1. Is it correct understanding that all the DCIs associated with the PUSCHs within the PUCCH slot should meet the multiplexing timeline with respect to the earliest PUSCH, i.e. multiplexing timeline needs to be satisfied for the DCIs associated with PUSCHs which do not overlap with the PUCCH?
  + Samsung: Yes, handled by gNB implementation.
* Samsung: My question is which clause a UE should follow if proposed TP for Alt-1 is included in the specification. Again, the clause that I cited is saying that **the UE doesn’t multiplex** HARQ-ACK if UL-TDAI=4. While, the proposed TP is saying that **the UE multiplexes** HARQ-ACK regardless of UL-TDAI values. Is it correct understanding that the UE follows NO multiplexing behavior if the UE doesn’t report the new UE capability, otherwise the UE follows multiplexing behavior?
  + Ericsson: clause 9 selects the PUSCH and clause 9.1.2.1 performs the multiplexing
* QC: Maybe I missed something. But I’d like to understand how Alt 2 works in Type 2 codebook. TDAI = 4 does not necessarily mean 0 bit A/N, it can mean 4 bits A/N as well. Since UE missed all DL grant in this case, UE cannot distinguish these two cases. We don’t see why TDAI=4 should be used as a criteria to filter candidate PUSCHs.
  + Huawei: From the UE perspective, the probability of missing 4 consecutive PDCCH can be assumed to be sufficiently low

**Moderator:**

* Given the situation, we have 9 companies supporting Alt-2 and 5 supporting Alt-1. Can we go with the majority (Alt-2) to be able to make progress ? It does not seem that we will have a unanimous alternative.

#### Recommendation 1: CR capability

**Company positions**:

* Support: NTT DOCOMO, LG, MTK, CATT, Samsung, ZTE, Huawei/HiSilicon, Vivo, Intel, Nokia/NSB, QC, Apple (12)
* Compromise based support: Ericsson (1)

**Moderator:**

* Conclusion: Accept capability indicating that a Rel-16 UE can implement this CR

### Issue 1.2 : Network Behavior: NW set TDAI value

**Company Position:**

* Alt 2-1: LG, CATT, Samsung, Vivo, Nokia/NSB, QC, Apple, Ericsson (8)
* Alt 2-2: NTT Docomo, MTK, ZTE, Huawei/Hi-Silicon, Intel (5)

**Moderator:**

* Conclusion: No consensus on this topic. As such, no change to existing specification.
* @ Alt 2-2 supporters: although this seems to support Alt 2-1, given the lack of consensus, we cannot mandate gNB behavior either way and as such have to stay with the default. Hope that you can accept this.

### Summary Proposal: Rel-16 UE behavior

In summary, the following is the Rel-16 UE behavior:

|  |
| --- |
| 1. Selection of the candidate PUSCH for multiplexing    1. Candidate PUSCHs: 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. 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**.**   NOTE: a capability corresponding the specified behavior shall be with the NW behavior the same regardless of whether the UEs indicate the corresponding capability or not. |

### Issue 2: Text Proposals for Agreements

### Issue 2.1: TP for agreement in RAN1 #107-e

**Company positions:**

* No replies

**Moderator :**

* Assume this is fine ?

### Issue 2.2: CR cover page

**Company positions**:

* No replies

**Moderator :**

* Assume this is fine ?

### Issue 2.3/2.4: TP for Alt 1/Al-2 proposal

**Company positions:**

* Modifications proposed to both Alt-1 and Alt-2.

**Moderator:**

* Agree on alternative and then clean up TP.

### Issue 3: Repetition

### Summary of Proposal 1-1: Repetition for Rel-15 Ues

**Company positions:**

* Up to UE implementation:
  + NTT DOCOMO, LG, MTK, ZTE, Huawei/HiSilicon, Intel, Apple, Ericsson (8)
* Does not multiplex A/N:
  + QC (1)

**Moderator:**

* given the current status, we should go with “up to UE implementation”. @QC, hope that yu can agree to this as this proposals will cover you even if you do not multiplex.

### Summary of Question 2: Repetition for Rel-16 UEs

Rel-16 UE behavior:

* Alt 3-1: 1st PUSCH repetition among all PUSCHs of the repetition ~~within PUCCH slot~~ is selected
  + NTT Docomo, ZTE, Ericsson (3)
* Alt 3-2: UE does not multiplex HARQ-ACK in any of the PUSCH repetitions:
  + LG, MTK, CATT, Samsung, Huawei/HiSilicon, Vivo, Intel, Qualcomm, Apple (9)

**Moderator:** Given the status we could do one of the following:

1. Go with the minority i.e. Alt 3-1
2. Go with the majority i.e. Alt 3-2
3. Assume no consensus and leave undefined. As mentioned by ZTE, the issue also exists for TBoMS so this could be packaged into one larger issue and brought back for discussion.
4. Agree that the standard does not support UL CA and PUSCH repetition.
   1. Note that it may not be a good option to disable support for this feature based on an error case that may not occur often.

I will present a proposal for option (b) i.e. go with the majority.

# 2nd Round Summary

### Proposal 2-1: Rel-16 UE behavior

**For Rel-16 UEs, for a unified design, the following should be specified**:

|  |
| --- |
| 1. Selection of the candidate PUSCH for multiplexing    1. Candidate PUSCHs: 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. 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**.**   NOTE: A UE that is capable of implementing this CR shall indicate a capability corresponding the specified behavior. The NW behavior will be the same regardless of whether the UEs indicate the corresponding capability or not. |

Please comment if you have an issue (if stable after this round, I will recommend to chair):

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei, HiSilicon | The original discussion is about the abnormal case (PUCCH is not present), we think if we are going to specify the UE behavior for this abnormal case, we should find the most relevant scenarios. We have not received any feedback on how likely this would happen that a UE will has no issue with receiving multiple UL DCIs with different UL DAIs (assuming this is allowed by the specification) but keep missing DL DCIs in between. For this perspective, we believe the following case is more relevant, i.e. a UE receives multiple UL DCIs with same UL DAIs and the DL DCI is only missing before receiving the multiple UL DCIs.  In addition, it seems that the critical point for Issue 1.2 is still whether the NW can set the same or different UL DAI values for the multiple PUSCHs overlapping with the PUCCH slot regardless of normal or abnormal case. Clearly there are different views among companies due to understanding of the current specification. Therefore, we would like suggest to a compromise to introduce another Rel-16 UE capability. This capability indicates whether the UE can be scheduled with multiple PUSCHs (overlapping with the same PUCCH) by DCI formats that include DAI field with different UL DAI values.  Example TP below [the last sub-bullet is newly added]  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the multiple PUSCHs overlap in the slot with a PUCCH carrying HARQ-ACK information or at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE determines the PUSCH for UCI multiplexing by applying the following procedure:   * If the ~~a UE transmits~~ multiple PUSCHs ~~in a slot on respective serving cells that include~~ 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 ~~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 the UE does not determine any PUCCH carrying HARQ-ACK information in the slot and ~~the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling~~ at least one the multiple PUSCHs is scheduled by a DCI format with a DAI field, the UE multiplexes the UCI in the PUSCH if the UE indicates the corresponding capability [the name of the capability]. * If at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field and the UE indicates a corresponding capability 2, [the name of the capability], the UE expects that the DCI formats that include DAI fields scheduling the multiple PUSCHs can have the different DAI values. |
| MTK | We are fine with Moderator’s proposal. Also fine with Huawei’s version. |
| LG | We are still supportive to Alt 1 for consistent UE behavior regardless of DAI values.  Regarding Alt 2, if it is intended to also exclude CG PUSCH or PUSCH scheduled by fallback DCI from candidate PUSCHs, there would be misunderstanding between UE and gNB, for example, in case where the CG PUSCH or fallback PUSCH is earlier than other PUSCHs with DAI n.e. 4 or 1. Specifically in this case, the gNB may expect HARQ-ACK is multiplexed on the CG PUSCH or fallback PUSCH, but the UE would multiplex the HARQ-ACK on one of other PUSCHs with DAI n.e. 4 or 1.  On the other hand, if Alt 2 is revised to include CG PUSCH or fallback PUSCH as candidate PUSCHs to address the above case, there seems no reason not to go with Alt 1 since there would be the case where CG PUSCH and PUSCH with DAI e. 4 or 1 and PUSCH with DAI n.e. 4 or 1 are located sequentially in a slot. |
| ZTE | We are fine with this proposal. |
| Samsung  Ericsson msg to Samsung: please see the follow-up on your Q in 1st round below. Thanks! | We are fine with the proposal. On the issue raised by LG, our understanding is that CG PUSCH and fallback PUSCH are included in the procedure.  Regarding Huawei’s proposal, it is not preferable to us since it complicates specification with marginal benefits. |
| LG2 | There is a typo in our earlier comment in above (fixed now).  @Samsung: I guess your understanding on Alt 2 is that CG PUSCH and fallback PUSCH are also included as candidate PUSCHs for multiplexing, together with the PUSCHs without DAI=4 for Type-2 or without DAI=0 for Type-1. Is this correct understanding? |
| vivo | We are fine with this proposal. |
| Ericsson | We still prefer Alt 1 for the same reasons as LG.  We also appreciate proponents of Alt-2 answer the questions we raised in 1st round. At least, as a proponent of Alt-1 we try our best to answer the questions.  We do not support HW update of TP since it defines two new behaviors for the normal case, one with capability and one without.  @HW: Thanks for the comments. Few clarifications below:   * On the scenarios, and statement “We have not received any feedback on how likely…”, at least we have elaborated many scenarios explicitly last meeting, including to have 2 UL grant and one DL assignment. It is not abnormal that one DL assignment is missed. * On the addition of last bullet, it is clearly seen that it defines two new behaviors for normal case. In this discussion, we don’t think we should change the behavior for normal case.   @Samsung: This is a follow-up on your message for round 1.  What I tried to explain is that for the normal case our understanding the way Editor has captures the procedures is as follow:   * The Editor used in clause 9, “the UE multiplexes …. “. Then since it says the UE multiplexes UCI, it implies we have to follow the clause for HARQ-ACK mux in PUSCH. Then, in that clause there are few conditions that may lead to the case that the UE doesn’t multiplex, like the one you mentioned.   Now, for Alt-1, we do exactly the same. We select a PUSCH in clause 9. To align with normal case, we used “the UE multiplexes… “. But if it is issue here, it is also issue for normal case. Then we go to clause to HARQ-ACK mux in PUSCH. And then as you pointed out, if UL-DAI=4, it doesn’t multiplex, and it does otherwise.  I hope this clarifies. |
| Intel | We are fine with the proposal. Regarding the mixed solution proposed by Huawei, we think it is better to avoid introducing UE capability at this stage. |
| Huawei2 | We appreciated the efforts from all the companies especially the initiative from the proponent of Alt.1.  I think there are two issues:   * **Issue#1: What is UE behavior under normal case?** * **Issue#2: What is UE behavior under abnormal case?**   @Ericsson  For Issue 1, it is true that there will be two UE behaviors based on our previous proposal. However, the fundamental reason for this is that there are different interpretations of the current specification.  *A UE does not expect to detect a DCI format scheduling a PDSCH reception or having associated HARQ-ACK information report without scheduling a PDSCH reception, 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.*  **Interpretation 1:** A UE cannot be scheduled with PDSCH transmissions indicating PUCCH transmission in a slot if the UE previously detects a UL DCI scheduling a PUSCH in the slot and HARQ-ACK is multiplexed in the PUSCH.  **Interpretation 2:** A UE can still be scheduled with PDSCH transmissions indicating PUCCH transmission in a slot even if the UE previously receives a UL DCI scheduling a PUSCH in the slot with HARQ-ACK multiplexed in the PUSCH as long as the UE is scheduled with another PUSCH and the HARQ-ACK is multiplexed into the new PUSCH.  One may argue that interpretation 2 is the correct interpretation since the specification does not prohibit such case. However, one may also argue that the specification does not explicitly allow this either. Our proposal to introduce a new UE capability is an attempt to solve this ambiguity in Rel-16, i.e. confirm that interpretation 2 is right one but at the same time introduce a new UE capability considering that there is already Rel-16 commercial UEs in the market. We can accept the UE behavior only when a new capability is introduced.  @E///, LG  For issue#2, Alt.2 makes more sense. As responded earlier, for type 2 HARQ-ACK codebook, the probability of missing 4 consecutive PDCCH should be sufficiently low. For the normal case, we agree there is no need to exclude any PUSCHs. We understand the desire to keep same and different UE behavior for both normal and abnormal cases. However, since the sub-bullet 3 in TP1 is only for abnormal case, we don’t see why we should not focus on the case with a relatively higher probability. Otherwise, why should anything be specified at all?  In addition, our understanding of Atl.2 is that CG PUSCH or fallback PUSCH as candidate PUSCHs are also included. It only excludes the PUSCH with DAI=0 for type 1 HARQ-ACK codebook and DAI=4 for type 2 codebook. I guess the confusion could be due to whether you are looking at the normal case or the abnormal case (no PUCCH).  Again, we provide some example TP below based on TP1 [last two sub-bullets]  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the multiple PUSCHs overlap in the slot with a PUCCH carrying HARQ-ACK information or at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE determines the PUSCH for UCI multiplexing by applying the following procedure:   * If the ~~a UE transmits~~ multiple PUSCHs ~~in a slot on respective serving cells that include~~ 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 ~~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 the UE does not determine any PUCCH carrying HARQ-ACK information in the slot and at least one of the multiple PUSCHs is scheduled by a DCI format with a DAI field not equal to 4 for type 2 HARQ-ACK codebook or not equal to 0 for type 1 HARQ-ACK codebook, the UE multiplexes the UCI in one of the PUSCHs excluding the PUSCH scheduled by a DCI format with a DAI field equal to 4 for type 2 HARQ-ACK codebook or equal to 0 for type 1 HARQ-ACK codebook, if the UE indicates the corresponding capability [the name of the capability]. * If at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field and the UE indicates a corresponding capability 2, [the name of the capability], the UE expects that the DCI formats that include DAI fields scheduling the multiple PUSCHs can have the different DAI values. |
| QC | @FL, we suggest to clearly capture in the above proposal that a new Rel-16 UE capability is adopted, as all companies are fine with such a capability. We are also not sure the agreement needs to capture NW behavior. Therefore, we suggest to update the note as the following.  “~~NOTE:~~ ~~A UE that is capable of implementing this CR shall indicate a capability corresponding the~~ The above specified behavior is supported subject to a Rel-16 UE capability [**Multiplexing-HARQ-ACK-without-PUCCH-in-a-PUSCH**]. ~~The NW behavior will be the same regardless of whether the UEs indicate the corresponding capability or not~~.”  On Alt 1 vs Alt 2. We still prefer Alt 1, because Alt 2 is an incomplete solution. We don’t think Alt 2 can work when gNB indeed want to use UL-TDAI=4 to tell UE feedback 4 bits HARQ-ACK on a PUSCH. Huawei’s answer to our concern is not convincing.  Huawei answer: “From the UE perspective, the probability of missing 4 consecutive PDCCH can be assumed to be sufficiently low”  QC response: We are discussing a scenario where UE missed **ALL** DL grant! Conditioning on this, how can we claim the probability of missing 4 PDCCH is low? With UE missed 3 DL grants, it is likely the DL is serious broken. In this case, we cannot assume each DCI reception is uncorrelated and the prob of missing DCI is iid events. They must be correlated events due to some block fading or interference. In this case, it is likely the 4th DCI will be missed as well. So we fully disagree with Huawei’s above statement for the particular issue we are fixing. Then, Alt 2 can work with UE missing 1, 2, 3, 5, 6, 7, 9 DL grants, while it just does not work with UE missed 4, 8, 12 DL grants. So 75% of the problem is solved and we like to left 25% unsolved. It is very puzzled to us why we don’t solve the rest 25%. |
| Samsung2 | Thanks LG and Ericsson for follow-up discussion.  @LG: your understanding is correct.  @Ericsson: Thank you for clarification. Now, we are on the same page. With this, we are okay with Alt. 1. BTW, it seems that companies may have different understanding on what behavior a UE follows based on the proposed TP of Alt. 1. This is because Huawei and Qualcomm seems to have understanding that a UE would multiplex HARQ-ACK codebook if the selected PUSCH has UL-DAI=4 for Type-2 codebook. While, you mentioned that “We select a PUSCH in clause 9. To align with normal case, we used “the UE multiplexes… “. But if it is issue here, it is also issue for normal case. Then we go to clause to HARQ-ACK mux in PUSCH. And then as you pointed out, if UL-DAI=4, it doesn’t multiplex, and it does otherwise.” So, I think that this point should be more clear in the group.  Regarding TP of Alt. 1, I have one question to the proponent of alt. 1. From Ericsson’s reply, if the selected PUSCH is UL-DAI=4, UE doesn’t multiplex. However, following sentence doesn’t imply this behavior although 9.1.3.2 has covered this case. Perhaps, it may need some update for example, “the UE **may** multiple the UCI”. Actually, this is not our first preference, but we want to discuss better sentence.   * If the UE does not determine any PUCCH carrying HARQ-ACK information in the slot and the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling at least one the multiple PUSCHs, the UE multiplexes the UCI in the PUSCH if the UE indicates the corresponding capability [the name of the capability]. |

### Proposal 2-2: TP for agreement in RAN1 #107-e

Please comment if you have an issue (if stable after this round, I will recommend to chair):

This proposal is based on an update from the version in R1-2204554 [5]. In RAN1#107-e, the following agreement was made:

**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.

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| UE procedure for reporting control information  <unchanged text omitted>  A UE does not expect to detect a DCI format scheduling a PDSCH reception or a SPS PDSCH release,a DCI format 1\_1 indicating Scell dormancy, or a DCI format including a One-shot HARQ-ACK request field with value 1, and indicating a resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot if the UE previously detects a DCI format scheduling a PUSCH transmission in the slot and if the UE multiplexes HARQ-ACK information in the PUSCH transmission.  If a UE transmits one PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions and the UE does not determine any PUCCH carrying HARQ-ACK information in the slot, the UE multiplexes HARQ-ACK information in the PUSCH transmission. |

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| 9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel  <unchanged text omitted>  A UE determines  HARQ-ACK information bits, for a total number of  HARQ-ACK information bits, of a HARQ-ACK codebook for transmission in a PUCCH or a PUSCH according to the following pseudo-code. In the following pseudo-code, if the UE does not receive a transport block or a CBG, due to the UE not detecting a corresponding DCI format 1\_0 or DCI format 1\_1, the UE generates a NACK value for the transport block or the CBG. The cardinality of the set  defines a total number  of occasions for PDSCH reception or SPS PDSCH release for serving cell  corresponding to the HARQ-ACK information bits.  <unchanged text omitted> |

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| 9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel  <unchanged text omitted>  If the UE transmits HARQ-ACK information in a PUSCH or a PUCCH in slot  with reference to slots for PUCCH transmission  and for any PUCCH format, the UE determines the , for a total number of  HARQ-ACK information bits, according to the following pseudo-code:  <unchanged text omitted> |

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| --- | --- |
| **Company** | **Comments** |
| Moderator | More precise wording:  If a UE transmits a single ~~one~~ PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions, without any other PUSCH to transmit on any serving cell in the slot, and the UE does not determine any PUCCH carrying HARQ-ACK information in the slot, the UE multiplexes HARQ-ACK information in the PUSCH transmission. |
| NTT DOCOMO | Just for clarification, does ‘that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions’ reflect ‘if the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook)’ in the agreement?  The proposed wording seems for me to mean that HARQ-ACK is multiplexed when the corresponding DCI includes DAI field regardless of the UL DAI value.. |
| MTK | Similar question as DOCOMO. |
| ZTE | We have the same question with NTT DOCOMO. It should be clearly captured in the spec. |
| Samsung | We are wondering why “a PUSCH” should be added in the following sections because these sections are related to PUCCH only.  9.1.2.1 Type-1 HARQ-ACK codebook in **physical uplink control channel** 9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel |
| vivo | Similar question as DOCOMO. |
| Ericsson | @DCM, MTK, ZTE, vivo/**all**: Thanks for the questions. I try to explain again (I think I explained that before in offline, and also discussion. Perhaps not clear 😊 The explanation is similar to my clarification to Samsung in previous question.  We tried to write the TP following exactly the procedures for normal case. That is the whole idea.   * For normal case, clause 9 only determines whether a PUSCH is going to be multiplexed with HARQ-ACK. Then clause 9, says “UE multiplexes HARQ-ACK in the PUSCH..”, it means we have to follow the clauses that the corresponding behavior is defined (9.1.2.2 and 9.1.3.2).Then, in those clauses there are few conditions that may lead to the case that the UE doesn’t multiplex, like the one you mentioned.   + It doesn’t matter if in clause 9 we are talking about multiple or single PUSCH. * Therefore, for the abnormal case (when PUCCH is absent), we try to say that for this single PUSCH, we are multiplex HARQ-ACK in PUSCH. Therefore, here there is no need to talk about the value of the UL TDAI (consistent with the current spec for normal case). Then, similarly to normal case, we say “UE multiplexes HARQ-ACK in the PUSCH..”, it means we have to follow the clauses that the corresponding behavior is defined (9.1.2.2 and 9.1.3.2).Then, in those clauses there are few conditions that may lead to the case that the UE doesn’t multiplex, like the one you mentioned.   @Samsung/**all**: Thanks for the good question. I think I explained before, but it is good to clarify again.  Now, following the story that we go from clause 9, to clause 9.1.2.2 and 9.1.3.2. In these clauses it refer to 9.1.2.1 and 9.1.3.1 for codebook generation.  9.1.2.2:  If a UE multiplexes HARQ-ACK information in a PUSCH transmission that is scheduled by DCI format that includes a DAI field, the UE generates the HARQ-ACK codebook as described in clause 9.1.2.1 when a value of the DAI field is except that *harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*. The UE does not generate a HARQ-ACK codebook for multiplexing in the PUSCH transmission when unless the UE receives only a SPS PDSCH release, or only SPS PDSCH(s), or only a PDSCH that is scheduled by DCI format 1\_0 with a counter DAI field value of 1 on the PCell in the occasions for candidate PDSCH receptions in which case the UE generates HARQ-ACK information only for the SPS PDSCH release or only for the PDSCH reception as described in clause 9.1.2. if the PUSCH is scheduled by a DCI format that includes a DAI field and the DAI field is set to ‘0’; otherwise, .  9.1.3.2:  If a UE multiplexes HARQ-ACK information in a PUSCH transmission that is scheduled by a DCI format that includes a DAI field, the UE generates the HARQ-ACK codebook as described in clause 9.1.3.1, with the following modifications:  - For the pseudo-code for the HARQ-ACK codebook generation in clause 9.1.3.1, after the completion of the and loops, the UE sets where is the value of the DAI field according to Table 9.1.3-2  - For the case of first and second HARQ-ACK sub-codebooks, the DCI format includes a first DAI field corresponding to the first HARQ-ACK sub-codebook and a second DAI field corresponding to the second HARQ-ACK sub-codebook  *- harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*.  If a UE is not provided *PDSCH-CodeBlockGroupTransmission* and the UE is scheduled for a PUSCH transmission by DCI format that includes a DAI field with value and the UE has not received any PDCCH within the monitoring occasions for PDCCH with DCI format scheduling PDSCH receptions or SPS PDSCH release or indicating Scell dormancy on any serving cell and the UE does not have HARQ-ACK information in response to a SPS PDSCH reception to multiplex in the PUSCH, as described in clause 9.1.3.1, the UE does not multiplex HARQ-ACK information in the PUSCH transmission.  Then, as you see in TPs for 9.1.2.2 and 9.1.3.2, the pseudo code for CB generation in 9.1.2.1 and 9.1.3.1 has **the condition of PUCCH is present.** So, there is a risk that code is not run. Therefore, we added PUSCH, so all the procedures flow nicely. If there are better suggestions, we can discuss.  I hope that clarifies. |
| Intel | We tend to agree with DOCOMO that this should be captured in the specification. “a single PUSCH” seems better wording. |
| QC | To be honest, I am totally confused about the TP we are discussing.  Is the above TP only addressing the case of ONE SINGLE PUSCH in a PUCCH slot? But I thought we are discussing the issue of MULTIPLE PUSCH in a PUCCH slot in this meeting. Isn’t that the TP should mainly address the MULTIPLE PUSCH scenario, because the SINGLE PUSCH case was settled long time back.  Or, do we intend to use the TP to cover both SINGLE and MULTIPLE PUSCHs cases? If so, I have many comments on the TP that will share later. But one major comment is that the new capability is missing for multiple PUSCHs case.  Or, are we taking a two step approach. Step 1: agree the TP for single PUSCH case. Step 2: agree the TP for multiple PUSCHs case?  I appreciate if someone can clarify the above general procedure. |
| Samsung 2 | @Ericsson. Thanks a lot for detailed explanation. We understand your intention. So, we are okay adding “a PUSCH”. |
| Moderator | We are working on the single PUSCH case that had been agreed upon in the previous meeting. Essentially the 2 step approach. The title explicitly says that it is for the agreement in RAN1 #107. Given the road-blocks on the new TP, this is for the best. |

### Proposal 2-3: CR cover page

Please comment if you have an issue (if stable after this round, I will recommend to chair):

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| **Consequences if not approved:**   * This CR completes an incompletely specified Rel-15 functionality for multiplexing HARQ-ACK in a PUSCH in a PUCCH slot when the UE misses any HARQ-ACK to transmit in any PUCCH but receives UL grant(s) with UL-TDAI field to transmit a single PUSCH or multiple PUSCHs in the PUCCH slot.A UE implemented based on an earlier version of the specification, and for case of multiple PUSCHs not able to indicate the new UE capability, may still be compliant with this CR, while a UE not compliant with the CR has unknown behavior. See isolated impact analysis.   **Isolated impact analysis**   * If a gNB is implemented according to the CR, but the UE is not, the UE behavior is unclear when HARQ-ACK is to be multiplexed in a PUSCH on a PUCCH slot where the UE transmits one or more PUSCHs scheduled by UL grant(s) with UL-TDAI in the PUCCH slot on one or more than 1 carrier, potentially leading to loss of UCI as well as loss of PUSCH. * If the UE is implemented according to the CR, but the gNB is not, the gNB assumption on where it expects to find the UCI is unclear when HARQ-ACK is to be multilplexed in a PUSCH on a PUCCH slot where the UE transmits ne or more PUSCHs scheduled by UL grant(s) with UL-TDAI in the PUCCH slot on one or more than 1 carrier, potentially leading to loss of UCI as well as loss of PUSCH. |

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| **Company** | **Comments** |
| MTK | Fine with the CR cover page. |
| QC | The CR cover page seems mentioning this is for both single and multiple PUSCHs. But the TP only covers only single PUSCH? There is some inconsistency. |

### Proposal 2-4 : Repetition for Rel-15 Ues

For a Rel. 15 UE, when a PUSCH scheduled by DCI is repeated and the corresponding UL grant indicates UL-TDAI but a PUCCH with HARQ-ACK is absent throughout the PUSCH repetition, the UE behavior is up to UE implementation .

Please comment if you have an issue (if stable after this round, I will recommend to chair):

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG | OK |
| ZTE | OK |
| vivo | Originally, we think the UE behavior is clear, no multiplexing. But after reading Ericsson’s comment, we are fine with the proposal. |
| Ericsson | OK |
| Intel | Okay |
| QC | We don’t support the proposal.  The following highlighted Rel-15 is crystal clear. It says UE does not multiplexing for this case. The proposal overturns Rel-15 spec and introduce NBC change at this very late stage. So we cannot accept it.  @Ericsson: if someone implement something wrong, not following the spec. I have to say it is not RAN1’s job to change existing spec to allow such an implementation. Furthermore, what difference does it make with or without agreeing on the proposal? Unless the intention if to change the spec (which we would disagree), whatever UE deployed is deployed. If it is inconsistent with the spec, it is inconsistent. From gNB perspective, gNB needs to deal with different UE implementation anyway, with or without the proposal.  “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 and in a 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 Subclause 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.” |
| CATT | We share the same view as QC. |

### Proposal 2-5: Repetition for Rel-16 UEs

*When a PUSCH scheduled by DCI is repeated and the corresponding UL grant indicates UL-TDAI but a PUCCH with HARQ-ACK is absent throughout the PUSCH repetition, the UE does not multiplex HARQ-ACK in any of the PUSCH repetitions*

Please comment if you have an issue (if stable after this round, I will recommend to chair):

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| --- | --- |
| **Company** | **Comments** |
| LG | OK |
| ZTE | We still prefer that the UE can multiplex the HARQ-ACK in the PUSCH by following the UL T-DAI. But it seems that we cannot achieve a consensus. Then we think it would be better to align with the Rel-15 to avoid spec impact for this scenario. That is the UE behavior is up to UE implementation. |
| vivo | OK |
| Ericsson | Similar to ZTE, we prefer to multiplex in first PUSCH.  We raised a question in last round that how this approach, goes against unified solution. And also, the principal of ignoring UL-DAI. We would like to hear at least companies feedback how they reason.  We can bundle this as part of the capability for multiple PUSCH (one capability covering both multiple PUSCH and repetition if that is the concern). |
| Intel | Actually, we support multiplexing HARQ-ACK on the first PUSCH repetition. It seems moderator wrongly captured our position.  As mentioned in the first round, it is not reasonable design to ignore the TDAI in the UL grant for PUSCH repetition, which is the essential design principle for the whole topic. It is not clear to us why unified solution cannot be considered for both PUSCH with and without repetition. |
| QC | We don’t support the proposal.  Current spec is clear. No need to agree on something that is exactly aligned with current spec. |

# 2nd Round Summary

Note that a set of recommendations are made with the associated TPs in the 3rd round (Section 6)

### [TPs for ALTs, UE TDAI capability] Summary for Proposal 2-1: Rel-16 UE behavior

Company Positions:

* Proposal (Alt-2)
  + Support proposal: MTK, ZTE, Samsung, Vivo, Intel, Huawei (?)
  + Not Support proposal: LG (Alt-1), Ericsson (Alt-1), QC
* UE capability for same/different TDAI
  + Support: Huawei, MTK
  + Not support: Samsung, Ericsson, Intel
* LG: I guess your understanding on Alt 2 is that CG PUSCH and fallback PUSCH are also included as candidate PUSCHs for multiplexing, together with the PUSCHs without DAI=4 for Type-2 or without DAI=0 for Type-1. Is this correct understanding?
  + Moderator: This is the correct understanding. Although as you point out, both Alt-1 and Alt-2 would work in this case, given the majority, with this understanding, can you accept the proposal ?
* Ericsson: We also appreciate proponents of Alt-2 answer the questions we raised in 1st round. At least, as a proponent of Alt-1 we try our best to answer the questions
  + Moderator: On you question about the order in the first round, there is a change in the order of operation compared with the existing specification. A TP is presented below to show the effect of these changes. Hope that based on the overall effect of the change on the specification, you may be able to make an agreement.
* Huawei:: TP text: “If at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field and the UE indicates a corresponding capability 2, [the name of the capability], the UE expects that the DCI formats that include DAI fields scheduling the multiple PUSCHs can have the different DAI values.”
* Moderator: Thank you for proposing the new TP text to clarify your position. This TP results in a change in behavior for both case where there is a PUCCH overlapping with the PUSCH and the case we have been discussing i.e. there is no PUCCH overlapping with the PUSCH. As such, it addresses a scope that is beyond the current discussion with the extension to the case of a PUCCH overlapping the PUSCH(s). The proposed solution changes the behavior for this extension case which has a clearly defined behavior in the specification and as such, may be NBC. To address this new issue, I will create a separate proposal/TP that addresses this question to see if there any appetite to adopt this change to both the overlapping and non-overlapping cases. If none, you can bring the issue to RAN1 as an independent issue.

**Recommendation 2-1: Alt-2 with an updated TP.**

**Recommendation 2-2: New question/TP on behavior of UE with same or different TDAI**

### [Stable] Summary of Proposal 2-2: TP for agreement in RAN1 #107-e

* Clarification Questions: NTT DOCOMO, MTK, ZTE, Samsung, Vivo, QC
* Okay: Ericsson, Apple
* Q1: [NTT Docomo]: Just for clarification, does ‘that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions’ reflect ‘if the UL-TDAI is not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook)’ in the agreement?
  + Answer (Ericsson): Please see Ericsson’s answer in the second round [Ericsson].
* Q2: [QC] Is this for the single or multiple case:
  + We are working on the single PUSCH case that had been agreed upon in the previous meeting. Essentially the 2 step approach. The title explicitly says that it is for the agreement in RAN1 #107. Given the road-blocks deciding the Alternative, this is for the best.

Moderator: Thank you very much for the comments. Although the comments from Ericsson seem to address the issue, we present a TP with the condition explicitly stated within brackets and agree to this. We can discuss the removal of brackets later.

**Recommendation 2-3: Add condition in brackets**

### [STABLE] Summary Proposal 2-3: CR cover page

Company positions:

* All okay
* Recommendation 2-4: Accept CR cover page

### [Discussion based on Spec] Proposal 2-4 : Repetition for Rel-15 Ues

Company positions:

* All except QC
* However, QC points out the following from the specification (38.213, Section 9):
  + “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 and in a 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 Subclause 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.”
* **Recommendation 2-5: Given the specification above, unless anyone can show that this is wrong, the behavior should be not to multiplex. If we cannot agree on this, then the only conclusion is that “there is no consensus” as opposed to “up to UE implementation”**

### [No Consensus] Proposal 2-5: Repetition for Rel-16 UEs

Company positions:

* Okay : LG, Vivo
* Not okay: ZTE, Ericsson, QC

**Recommendation 2-6: No consensus. As mentioned by ZTE, the issue also exists for TBoMS so this could be packaged into one larger issue on repetitions in general and brought back for discussion in the future.**

# Final Round

### Rel-16 UE behavior

**Note that Section 6.11 and 6.12 are to highlight the two alternatives separately, allow companies to review their respective TPs and suggest changes till we get a stable TP for each case. Section 6.1.2 makes the moderator recommendation.**

### Alternatives and TPs

The proposals and corresponding TPs for each of the alternatives are shown below:

#### [STABLE] Alt 1 Agreement: with TP updated based on Ericsson/Docomo exchange:

**For Rel-16 UEs,** in the scenario with more than one PUSCH (overlapping and non-overlapping)and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA, **for a unified design, the following should be specified**:

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| --- |
| 1. Selection of the candidate PUSCH for multiplexing    1. All the PUSCHs within the PUCCH slot are candidates 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**.**   ~~NOTE:~~ The above specified behavior is supported subject to a new Rel-16 UE capability [**xxxxx**]   * FFS: the details of the capability signaling |

##### [CLOSED] Alt 1 TP: updated based on Ericsson/Docomo exchange:

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| UE procedure for reporting control information  <unchanged text omitted>  If a UE multiplexes aperiodic CSI in a PUSCH and the UE would multiplex UCI that includes HARQ-ACK information in a PUCCH that overlaps with the PUSCH and the timing conditions for overlapping PUCCHs and PUSCHs in clause 9.2.5 are fulfilled, the UE multiplexes only the HARQ-ACK information in the PUSCH and does not transmit the PUCCH.  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the multiple PUSCHs overlap in the slot with a PUCCH carrying HARQ-ACK information or at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE determines the PUSCH for UCI multiplexing by applying the following procedure:   * [If the UE determines that there is a PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot, the UE selects candidate PUSCHs with UCI multiplexing as all the PUSCHs overlapping with the PUCCH. If the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot, the UE selects the candidate PUSCHs with UCI/HARQ multiplexing as all the PUSCHs overlapping with the PUCCH slot.] * If the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot and ~~the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling~~ at least one the ~~multiple~~ candidate PUSCHs is scheduled by a DCI format with a DAI field, the UE multiplexes the UCI in the PUSCH if the UE indicates the corresponding capability [the name of the capability]. * If the ~~a UE transmits multiple~~ candidate PUSCHs ~~in a slot on respective serving cells that include~~ 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~~ candidate PUSCHs, and the ~~multiple~~ candidate 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 ~~If a UE transmits multiple PUSCHs in a slot on respective serving cells and~~ the UE would multiplex UCI in one of the ~~multiple~~ candidate PUSCHs and the UE does not multiplex aperiodic CSI in any of the ~~multiple~~ candidate 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.   <unchanged text omitted> |

##### [UPDATED] Alt 1 TP: parallel to Alt-2:

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| Alt-1  9 UE procedure for reporting control information  <unchanged text omitted>  If a UE multiplexes aperiodic CSI in a PUSCH and the UE would multiplex UCI that includes HARQ-ACK information in a PUCCH that overlaps with the PUSCH and the timing conditions for overlapping PUCCHs and PUSCHs in clause 9.2.5 are fulfilled, the UE multiplexes only the HARQ-ACK information in the PUSCH and does not transmit the PUCCH.  //: Moderator comment: with overlapping PUCCH  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmissions and the multiple PUSCHs overlap with a PUCCH carrying HARQ-ACK information in the slot, the UE selects all the PUSCHs overlapping with the PUCCH as the candidate PUSCHs for UCI multiplexing within the slot.    //: Moderator comment: without overlapping PUCCH {new case with capability}  If the UE indicates the corresponding capability [the name of the capability], when a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmissionsand the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot and at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE selects all the multiple PUSCHs in the slot as the candidate PUSCHs for UCI multiplexing within the slot.    //: Moderator comment: common operations for both cases on “candidate PUSCHs”  The UE determines the PUSCH for UCI multiplexing by applying the following procedure on the candidate PUSCHs as described in this clause:  -          If the ~~a UE transmits multiple~~ candidate PUSCHs~~in a slot on respective serving cells that include~~ 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~~ candidate PUSCHs, and the ~~multiple~~ candidatePUSCHs fulfil the conditions in clause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in a PUSCH from the first PUSCHs.  -          If ~~If a UE transmits multiple PUSCHs in a slot on respective serving cells and~~the UE would multiplex UCI in one of the ~~multiple~~ candidate PUSCHs and the UE does not multiplex aperiodic CSI in any of the ~~multiple~~ candidate 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.  <unchanged text omitted> |

##### Company views

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| **Company** | **Comments** |
| CATT | Do we intend to agree on the proposal at the beginning of this section of Alt 1 is agreed? If so, we need to make it clear that it is for the case without PUCCH.  In addition, one question for the timeline requirement in 3b. What does “after step 1” mean? Is the timeline requirement that all the PUSCHs within the PUCCH slot have to satisfy Rel-15 UCI multiplexing timeline defined with respect to the starting symbol of the earliest PUSCH transmission in the PUCCH slot? If so, the timeline requirement is different from the existing timeline requirement and needs to be captured in the specification. The following case would be error case.    From gNB’s perspective, given that gNB does not know whether UE would miss DL grant, gNB should also ensure the new timeline is met.  Similar as observed by Samsung, we think companies still have misunderstanding of Alt.1. At least it seems that QC’s understanding is that UE would multiplex HARQ-ACK even when UL-DAI=4 for Type-2 HARQ-ACK codebook and think it is the advantage of Alt.1 over Alt. 2. But actually, the UE will not multiplex HARQ-ACK in this case which is the same as Alt. 2. |
| Moderator | @CATT: The first paragraph captures both cases:  “and the multiple PUSCHs overlap in the slot with a PUCCH carrying HARQ-ACK information” for the case with overlapping PUCCH  “or at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field” For the case without overlapping PUCCH  After Step 1 means that the multiplexing timeline of all the PUSCHs selected have to satisfy 9.2.5 essentially the diagram you have drawn.  This is captured implicitly in the TP.   1. We have defined the multiple PUSCHs as all PUSCHs 2. They have to satisfy 9.2.5 “. If one of the PUCCH transmissions or PUSCH transmissions is in response to a DCI format detection by the UE, the UE expects that the first symbol of the earliest PUCCH or PUSCH, among a group overlapping PUCCHs and PUSCHs in the slot, satisfies the following timeline conditions” |
| QC | Comment 1: Regarding this note: “NOTE: The above specified behavior is supported subject to a Rel-16 UE capability [**xxxxx**]”. I think it is better to clearly say it is a new capability, while not based on any existing UE capability. Also, we need FFS the details of the new capability such as whether it is per UE/band/FS/FSPC. With the FFS, I think it is not just a note. So I suggest the following change  **For Rel-16 UEs, for a unified design, the following should be specified**:   |  | | --- | | 1. Selection of the candidate PUSCH for multiplexing    1. All the PUSCHs within the PUCCH slot are candidates 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**.**   ~~NOTE:~~ The above specified behavior is supported subject to a new Rel-16 UE capability [**xxxxx**]   * FFS: the details of the capability signaling   A comment on the TP, since we are talking about missing DL grants, I think the following should be added.   * If the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot and ~~the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling~~ at least one the multiple PUSCHs is scheduled by a DCI format with a DAI field, the UE multiplexes the UCI in the PUSCH if the UE indicates the corresponding capability [the name of the capability]. | |
| Huawei, HiSilicon | We have a similar question as CATT. There is a mismatch between the proposed agreed solution (Atl.1) and TP1, in particular regarding the new UE capability. The proposed solution seems to imply the new capability is applicable for both cases regardless of whether the PUCCH is present or not. However, TP1 seems that imply that the new UE capability only covers the case when there is no PUCCH presence.  Despite of above, we don’t think one cannot separate the discussion between original issue#1.1 and original issue#1.2. For issue#1.1, it seems that the default assumption (for both normal case and abnormal case) is that a UE can expect that the UL DAI values may be different for both Alt.1 and Alt.2. This implies that a UE can be scheduled with PDSCH transmissions indicating PUCCH transmission in a slot even if the UE previously receives a UL DCI scheduling a PUSCH in the slot with HARQ-ACK multiplexed in the PUSCH as long as the UE is scheduled with another PUSCH and the HARQ-ACK is multiplexed into the new PUSCH. Our understanding is that allowing this operation might provide some scheduling flexibility to the gNB (at the cost of some scheduler complexity) but at the same time bring some additional complexity to the UE implementation since the UE must be prepared that the HARQ-ACK codebook size and the PUCCH resource might also change after an UL grant scheduling a PUSCH which is supposed to carry HARQ-ACK at that moment.  @Moderator  We acknowledge that our proposal will introduce two UE behaviors for the normal case. However, we don’t think it is NBC since there has been no discussion on whether the UL DAI values for the overlapping PUSCHs can be same or different in Rel-15. Cleary there are different interpretations of the current specification hence it is up to UE implementation in Rel-15. Since we are discussing this in Rel-16, we can solve this ambiguity in Rel-16.  In summary, we still think it is reasonable to introduce a new UE capability since the allowing different DAI values would require some additional implementation complexity for both the gNB and the UE. Again, we can accept either Alt.1 or Alt.2 (first preference) ONLY when a new capability is introduced. |
| Ericsson | **@QC:** Agree to add a bullet for capability. But let’s not unnecessarily complicate it. The discussion can be Per UE/per band. No need in our view for BC/FS.  Ok to add yellow highlighted.  **@HW/HiSi, CATT/Moderator:** It is “explicitly” mentioned in the TP that the timeline condition applies to all the candidate PUSCHs. Please see 1st and 2nd sub-bullets. In case when PUCCH is present, timeline is applied to PUSCHs overlapping with PUCCH, and it case PUCCH is absent, timeline is applicable to PUSCHs in the PUCCH slot.  **@HW/HiSi**: Could you please clarify when new TP implies the new capability covers the normal case? Definitely that is not the intention, and I am not able to see, that is the case, either. I try to explain the structure.   1. The text in yellow, in the context to determine candidate PUSCHs: To include both normal case (only PUSCHs overlapping with PUCCH), and abnormal case (all PUSCHs in the slot). 2. Then, text in blue, is the PUSCH prioritization rule as in legacy is applied on the candidate PUSCHs. 3. Then, text in gray, describes the condition for abnormal case that the UE should indicate the capability.   What is unclear?  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the multiple PUSCHs overlap in the slot with a PUCCH carrying HARQ-ACK information or at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE determines the PUSCH for UCI multiplexing by applying the following procedure:   * If the ~~a UE transmits~~ multiple PUSCHs ~~in a slot on respective serving cells that include~~ 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 ~~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 the UE does not determine any PUCCH carrying HARQ-ACK information in the slot and ~~the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling~~ at least one the multiple PUSCHs is scheduled by a DCI format with a DAI field, the UE multiplexes the UCI in the PUSCH if the UE indicates the corresponding capability [the name of the capability].   **@HW/HiSi:** On same or different UL-TDAI discussion:  I think it is related to Issue#1,2 and Interpretation#1,#2 you mentioned before.  Let me start with that we, together with HW, criticized the scheduling restrictions you mentioned in TEI-Rel-17 but as you know, our efforts to relax the scheduling restrictions have failed.  Now, I see HW thinks these two are related. The way I see the relation is as the following:   * The restriction you mentioned, is for UL grants where gNB expects in normal case, the UE schedules HARQ-ACK in (let’s call them PUSCHs A). Now, if gNB schedules another PUSCHs that doesn’t overlap with HARQ-ACK PUCCH (let’s call them PUSCHs B), the restriction doesn’t apply. That means the UL-TDAI can be same or different. It is just not specified which way to be.   + I think here we are on the same page.   + Here, there is no restriction to have same or different Ul-DAI for normal case. * Now, for abnormal case: The key point as I mentioned before is that the gNB set’s UL-TDAI based on normal case. But also knows about the PUSCHs prioritization rules. So, gNB implementations takes both information into account if wants to handle the abnormal cases. For example, schedules PUSCHs B such that they will be deprioritized. So, that means the UL-TDAI can be same or different between PUSCHs A and PUSCH B given that we don’t change current spec.   I hope that clarifies that for abnormal case, while complying with the current restrictions, the UL-TDAI can be left as it is in the current spec.  Still the new capability proposed by HW, definitely improve the situation for the normal case**. But, the description of the capability should not be based on UL-TDAI. It should reflect the scheduling restriction whether the UE would except DL assignment after UL grant to multiplex corresponding HARQ-ACK in the PUSCH (together with previous ones).**  We hope, the progress for the abnormal case, does not depend on this one. In fact, by Alt-1 in pace for abnormal case, we can discuss the new capability for normal case. We think, with Alt-2, applying the new capability for normal case would be complicated. |
| Moderator | 1. Updated introduction to agreement to say specifically that this a unified solution for the case without PUCCH (case 0,1,2 and 3 from our previous discussions). I believe CATT was asking about this 2. Added text “with a corresponding PDCCH” into TP 3. Explicit statement of the PUSCHs that will be selected in each of the cases 4. Move of the capability paragraph to the top of the procedure to prevent the UE from executing the procedure before checking for the capability. |
| MTK | We are generally fine with the TP, while we think QC’s suggestion to indicate this is a “new” R16 UE capability should be included. |
| CATT2  (Ericsson: Please see clarification below). | 1. @Ericsson, Regarding your following comments, can you please point out to me where in the TP the timeline is explicitly mentioned. My understanding is that the timeline is defined in clause 9.2.5 while the current TP seems to be for Clause 9. Maybe I missed something. Anyway, I appreciate if you can clarify.  |  | | --- | | **@HW/HiSi, CATT/Moderator:** It is “explicitly” mentioned in the TP that the timeline condition applies to all the candidate PUSCHs. Please see 1st and 2nd sub-bullets. In case when PUCCH is present, timeline is applied to PUSCHs overlapping with PUCCH, and it case PUCCH is absent, timeline is applicable to PUSCHs in the PUCCH slot. |  1. With the following red texts added with “and”, it only covers the case after the “and”. Then for other cases, e.g. if there is only a PUCCH with CSI overlapping with multiple PUSCHs, how should UE select PUSCH for UCI multiplexing?   When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the multiple PUSCHs overlap in the slot with a PUCCH carrying HARQ-ACK information or at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE determines the PUSCH for UCI multiplexing by applying the following procedure:   1. We would like to confirm that UE may not multiplex HARQ-ACK in the PUSCH in the end depending on the value of DAI in UL grant.  * If the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot and ~~the UCI includes HARQ-ACK information due to a DAI field in a DCI format scheduling~~ at least one the ~~multiple~~ candidate PUSCHs is scheduled by a DCI format with a DAI field, the UE multiplexes the UCI in the PUSCH if the UE indicates the corresponding capability [the name of the capability]. |
| Moderator | @ MTK: Added QC’s  @ CATT: have modified the TP from Alt-1 to be exactly the same as the TP from Alt-2 (which seems to be stable) while changing the condition. Hope this addresses your concern.  See 6.1.1.1.2 [UPDATED] |
| CATT3  (Ericsson: Please see clarification below). | For TP in section 6.1.1.1.2, I still fail to find where the timeline is explicitly mentioned. My understanding is that the timeline is defined in clause 9.2.5 while the current TP seems to be for Clause 9. Still clarification from companies is appreciated.  nt |
| Ericsson (to CATT2 and CATT3 for timeline) | On timeline, your question should be both for Alt-1 and Alt-2. Not clear to me why only for Alt-1. Regardless, it is explicitly mentioned using the description of normal behavior in the sub-bullet, see below please. I hope it is clearer now 😊 If that is the issue, that issue is common for both normal case , Alt-1 and Alt-2.   |  | | --- | | The UE determines the PUSCH for UCI multiplexing by applying the following procedure on the candidate PUSCHs as described in this clause:  -          If the ~~a UE transmits multiple~~ candidate PUSCHs~~in a slot on respective serving cells that include~~ 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~~ candidate PUSCHs, and the ~~multiple~~ candidatePUSCHs fulfil the conditions in clause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in a PUSCH from the first PUSCHs.  -          If ~~If a UE transmits multiple PUSCHs in a slot on respective serving cells and~~the UE would multiplex UCI in one of the ~~multiple~~ candidate PUSCHs and the UE does not multiplex aperiodic CSI in any of the ~~multiple~~ candidate 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 | |
| moderator | @ CATT, for item 2, it has been identified by LG and QC and we are working on a fix for this at the moment.  For item 1, |

#### [STABLE] Alt 2 Agreement: With associated TP

**For Rel-16 UEs,** in the scenario with more than one PUSCH (overlapping and non-overlapping)and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA, **for a unified design, the following should be specified**:

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| 1. Selection of the candidate PUSCH for multiplexing    1. Candidate PUSCHs: 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. 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**.**   ~~NOTE:~~ The above specified behavior is supported subject to a new Rel-16 UE capability [**xxxxx**]   * FFS: the details of the capability signaling |

##### [CLOSED] Alt 2 TP :

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| UE procedure for reporting control information  <unchanged text omitted>  If a UE multiplexes aperiodic CSI in a PUSCH and the UE would multiplex UCI that includes HARQ-ACK information in a PUCCH that overlaps with the PUSCH and the timing conditions for overlapping PUCCHs and PUSCHs in clause 9.2.5 are fulfilled, the UE multiplexes only the HARQ-ACK information in the PUSCH and does not transmit the PUCCH.  //: Moderator comment: with overlapping PUCCH  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the multiple PUSCHs overlap with a PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot the UE selects the candidate PUSCHs with UCI~~/HARQ~~ multiplexing as all the PUSCHs overlapping with the PUCCH  //: Moderator comment: without overlapping PUCCH {new case with capability}  If the UE indicates the corresponding capability [the name of the capability], when a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot and at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE selects the candidate PUSCHs for multiplexing as all PUSCH transmissions except for the PUSCH transmissions by DCI format that includes a DAI field with value in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook-r1*, and value in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static* within the PUCCH slot  //: Moderator comment: common operations for both cases on “candidate PUSCHs”  The UE determines the PUSCH for UCI multiplexing by applying the following procedure on the candidate PUSCHs as described in this ~~C~~clause 9:   * If the ~~a UE transmits multiple~~ candidate PUSCHs ~~in a slot on respective serving cells that include~~ 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~~ candidate PUSCHs, and the ~~multiple~~ candidate 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 ~~If a UE transmits multiple PUSCHs in a slot on respective serving cells and~~ the UE would multiplex UCI in one of the ~~multiple~~ candidate PUSCHs and the UE does not multiplex aperiodic CSI in any of the ~~multiple~~ candidate 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.   <unchanged text omitted> |

##### [UPDATED] Alt 2 TP :

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| 9 UE procedure for reporting control information  <unchanged text omitted>  If a UE multiplexes aperiodic CSI in a PUSCH and the UE would multiplex UCI that includes HARQ-ACK information in a PUCCH that overlaps with the PUSCH and the timing conditions for overlapping PUCCHs and PUSCHs in clause 9.2.5 are fulfilled, the UE multiplexes only the HARQ-ACK information in the PUSCH and does not transmit the PUCCH.  //: Moderator comment: with overlapping PUCCH  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmissions and the multiple PUSCHs overlap with a PUCCH carrying HARQ-ACK information ~~with a corresponding PDCCH~~ in the slot, the UE selects the candidate PUSCHs ~~with~~ for UCI multiplexing as all the PUSCHs overlapping with the PUCCH.    //: Moderator comment: without overlapping PUCCH {new case with capability}  If the UE indicates the corresponding capability [the name of the capability], when a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot and at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE selects all the multiple PUSCHs in the slot as the candidate PUSCHs for UCI multiplexing within the slot~~as all PUSCH transmissions~~ except for ~~the~~any PUSCH among the multiple PUSCHs that is scheduled  ~~transmissions~~ by a DCI format that includes a DAI field with value in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook-r16*, ~~and~~ or value in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static* ~~within the PUCCH slot~~    //: Moderator comment: common operations for both cases on “candidate PUSCHs”  The UE determines the PUSCH for UCI multiplexing by applying the following procedure on the candidate PUSCHs as described in this ~~C~~clause 9:  -          If the ~~a UE transmits multiple~~ candidate PUSCHs~~in a slot on respective serving cells that include~~ 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~~ candidate PUSCHs, and the ~~multiple~~ candidate 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 ~~If a UE transmits multiple PUSCHs in a slot on respective serving cells and~~the UE would multiplex UCI in one of the ~~multiple~~ candidate PUSCHs and the UE does not multiplex aperiodic CSI in any of the ~~multiple~~ candidate 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.  <unchanged text omitted> |

##### Company views

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| **Company** | **Comments** |
| DCM | OK |
| CATT | Do we intend to agree on the proposal at the beginning of this section of Alt 2 is agreed? If so, we need to make it clear that it is for the case without PUCCH.  The first paragraph only includes PUCCH carrying HARQ-ACK? What about PUCCH carrying CSI? In addition, what does “UCI/HARQ” mean? |
| Moderator | @ CATT: The first paragraph is for the case with PUCCH (current specification), the second paragraph is for the case without PUCCH (new behavior), the third paragraph describes the behavior.  Have removed the UCI/HARQ and made it UCI only. |
| QC | Similar comment and suggested update on the note.  **For Rel-16 UEs, for a unified design, the following should be specified**:   |  | | --- | | 1. Selection of the candidate PUSCH for multiplexing    1. Candidate PUSCHs: 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. 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**.**   ~~NOTE:~~ The above specified behavior is supported subject to a new Rel-16 UE capability [**xxxxx**]   * FFS: the details of the capability signaling   A question on the TP: If UE missed all DL grant, while it has SPS A/N to transmit, UE should follow which case, with overlapping PUCCH or without overlapping PUCCH? I think UE should follow still follow the case of without overlapping PUCCH to build the candidate set. So the following changes are suggested.  //: Moderator comment: with overlapping PUCCH  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the multiple PUSCHs overlap with a PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot the UE selects the candidate PUSCHs with UCI~~/HARQ~~ multiplexing as all the PUSCHs overlapping with the PUCCH  //: Moderator comment: without overlapping PUCCH {new case with capability}  If the UE indicates the corresponding capability [the name of the capability], when a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot and at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE selects the candidate PUSCHs for multiplexing as all PUSCH transmissions except for the PUSCH transmissions by DCI format that includes a DAI field with value in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook-r1*, and value in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static* within the PUCCH slot | |
| Huawei, HiSilicon | First, similar to the above response, there is a mismatch between the proposed agreed solution (Atl.2) and TP2, in particular regarding the new UE capability. The proposed solution seems to imply the new capability is applicable for both cases regardless of whether the PUCCH is present or not. However, TP2 seems that imply that the new UE capability only covers the case when there is no PUCCH presence.  Secondly, we still would like to clarify the default assumption for Rel-16 Ues, i.e. whether a UE can expect the UL DAI values can be same or different. We do understand the whole discussion start from the abnormal case but it is also important to clarify the normal case. Hence, we suggest to introduce a new UE capability as suggested above and proposed TP is same as the previous round  If at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field and the UE indicates a corresponding capability 2, [the name of the capability], the UE expects that the DCI formats that include DAI fields scheduling the multiple PUSCHs can have the different DAI values |
| Ericsson | Agree with CATT to clarify this TP corresponds to Alt-2.  The TP looks fine with us.  But we don’t support Alt-2 for the reasons explained.  The gNB sets the UL-TDAI values for normal case. To protect some PUSCHs, gNB can use prioritization rules as well as UL-TDAI.  But assuming UL-TDAI implies no multiplexing in PUSCH, is simply incorrect.  Also, it means two different behaviors for normal case (not considering UL-TDA value), and abnormal case (considering UL-TDAI value).  Regarding the new capability for normal case, please see our comments in previous response where we explain Alt-1 is a better framework to adding the new behavior, as Alt-2. |
| Moderator | 1. Updated introduction to agreement to say specifically that this a unified solution for the case without PUCCH (case 0,1,2 and 3 from our previous discussions). I believe CATT was asking about this 2. Updated description to agreed on capability. 3. Added text “with a corresponding PDCCH” into TP 4. Change “Clause 9” to “this clause” |
| MTK | We are generally fine with the TP, while we think QC’s suggestion to indicate this is a “new” R16 UE capability should be included. |
| CATT2 | The “with” highlighted in yellow should be changed to “for”  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the multiple PUSCHs overlap with a PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot the UE selects the candidate PUSCHs with UCI~~/HARQ~~ multiplexing as all the PUSCHs overlapping with the PUCCH |
| Moderator | @ MTK: Updated based on QC  @ CATT: made modification  @ Ericsson: updated based on email thread  See 6.1.1.2.2 |
| DCM | I’m not sure exact intention of adding ‘s’ as below, but in this case I guess that the same addition should be applied for the next paragraph.  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmissions and |
| Ericsson to DCM | Not very important to add ¨s¨¨, but it reads better as it makes is general. OK without ‘s’. |

### Recommendation: Alt-2 and associated TP

From Recommendation 2-1, we propose to use Alt-2 and the associated TP

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| **Company** | **Comments** |
| DCM | Support |
| CATT | We are in general fine with Alt-2. |
| QC | Like we commented in email, as the TPs are complicated with many details, we need to more time to check the TPs. We prefer to extend the discussing to next week. |
| ZTE | We support to Alt-2.  Even though we can be flexible to accept Alt-1 as expressed in the first round, we would like to share our thoughts for Alt-1, especially for some questions raised by proponents of Alt-1.  Here we discuss the case that the UE misses the DL DCI. From understanding, T-DAI=4 actually means 0 bit A/N, and there is no PDSCH or corresponding PUCCH. If it is interpreted as 4, 8,..., bits A/N, it means that the current spec is wrong since it says the UE does not multiplex HARQ-ACK if the T-DAI=4 and no PDSCH detected.   |  | | --- | | If a UE is not provided *PDSCH-CodeBlockGroupTransmission* and the UE is scheduled for a PUSCH transmission by DCI format that includes a DAI field with value and the UE has not received any PDCCH within the monitoring occasions for PDCCH with DCI format scheduling PDSCH receptions or SPS PDSCH release or indicating SCell dormancy on any serving cell and the UE does not have HARQ-ACK information in response to a SPS PDSCH reception to multiplex in the PUSCH, as described in clause 9.1.3.1, the UE does not multiplex HARQ-ACK information in the PUSCH transmission. |   In addition, regarding PUSCH candidates determination, in the normal case, the PUCCH is used as reference to determine the PUSCH candidates. It should be noted, only the PUSCHs overlapping with PUCCH are the candidate instead of all the PUSCHs in the slot. If PUCCH is absent, another reference is needed to determine the PUSCH candidates. In Alt-2, the UL-DAI is the best choice. If using UL-DAI for PDSCH candidate determination is regarded as a new behavior, then all the PUSCH within the slot being candidates in Alt-1 is also a new behavior because the PUSCH overlapping with PUCCH and all the PUSCH within the slot are also different. On the contrary, using T-DAI to determine the PUSCH candidate is more in line with the current principle (PUCCH resource for PUSCH candidate determination) because there is association between UL-DAI and PUCCH resource to some extent. The PUCCH resource is determined by the PRI indication and the HARQ-ACK bits determined by the DL-DAI, where UL-DAI should be the same as DL-DAI.  For the CG PUSCH included in the slot, if we go with Alt-1 and the CG PUSCH is selected, whether the UE perform HARQ-ACK multiplexing in the CG PUSCH since there is no UL-DAI for CG PUSCH. If yes, how many bits is assumed by the UE? |
| Huawei, HiSilicon | We are fine with Alt.2. |
| Vivo  (Ericsson: please see our comment below) | We are fine with Alt.2. we share similar view with ZTE that for alt 1, candidates PUSCHs for abnormal case is different from that of normal case, which is new behavior and will increase gNB’s complexity for bland decoding since gNB does not know it is normal case or abnormal case from UE side. For alt.2, this can be avoided by gNB’s scheduling, e.g., only indicate UL-DAI without 4 for the PUSCHs overlapped with HARQ-ACK PUCCH. |
| Ericsson | But we don’t support Alt-2 for the reasons explained.  **@ZTE:** We disagree. UL-TDAI =4 doesn’t mean 0 bit A/N. In the cited text from spec, there are other condition that PDCCH is absent (no PUCCH is present).  **@ZTE/vivo/all**: The gNB sets the UL-TDAI values for normal case. To protect some PUSCHs, gNB can use prioritization rules as well as UL-TDAI.  But assuming UL-TDAI implies no multiplexing in PUSCH, is simply incorrect.  Also, it means two different behaviors for normal case (not considering UL-TDA value), and abnormal case (considering UL-TDAI value).  **@ZTE**: It is not clear to me how CG PUSCH is related. Let me ask this? Do you exclude the case in the normal case that HARQ-ACK to be multiplexed in CG-PUSCH at the presence of dynamically scheduled PUSCHs? That can happens based on prioritization rule. How that is different in this case? |
| MTK | We are fine with Alt. 2, while we can also accept Alt. 1 if that’s the only way we can move forward. |
| ZTE2 | @Ericsson, From the UE perspective, it cannot distinguish the case that PDCCH is absent and the case that PDCCH is missing if the T-DAI=4 and no PDCCH is detected. So the only assumption is 0 bit A/N.  From our understanding, we think the normal case that HARQ-ACK is multiplexed in the CG PUSCH is not excluded. It may be possible that the CG PUSCH is selected according to the PUSCH prioritization rule. |
| DCM | Support. |
| Ericsson | **@ZTE**: On CG-PUSCH, HARQ-ACK mux on CG-PUSCH is not excluded in aLt-1 either. It was not clear to me how that makes a difference in these two alt.  **@ZTE/propoents of Alt-2:** Correct, the UE cannot distinguish and that is fine.  CATT had also mentioned “Similar as observed by Samsung, we think companies still have misunderstanding of Alt.1. At least it seems that QC’s understanding is that UE would multiplex HARQ-ACK even when UL-DAI=4 for Type-2 HARQ-ACK codebook and think it is the advantage of Alt.1 over Alt. 2. But actually, the UE will not multiplex HARQ-ACK in this case which is the same as Alt. 2.”  This is a misunderstanding.  We are saying that when gNB schedules e.g. 4 PDSCHs, it can set UL-TDAI=4. So, UL-TDAI=4 doesn’t mean no HARQ-ACK multiplexing. Then QC said in case of busty error, it can be the case that UE misses all 4 DL assignments. Then, in this case, in Alt-1, UE doesn’t multiplex anything in PUSCH. In Alt-2, UE would multiplex in another PUSCH. Which causes gNB blind detection and lost of PUSCH at gNB.  So, Alt-2 is not good for NW vendors. We are not interested in timeline optimization. It is more important to have same behavior for normal and abnormal cases. |

### Question: UE capability for same/different TDAI

From Recommendation 2-1, we raise the question on UE capability for same/different TDAI.

For the scenario in which we have a PUCCH overlapping with one or more overlapping PUSCH(s) and for scenario where we do not have a PUCCH overlapping with one or more overlapping PUSCH(s), can we introduce a capability for the UE to expect that the PUSCHs can have the same or different TDAI values ?

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| If at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field and the UE indicates a corresponding capability 2, [the name of the capability], the UE expects that the DCI formats that include DAI fields scheduling the multiple PUSCHs can have the different DAI values |

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| **Company** | **Comments** |
| DCM | Is this capability is the same as that in TP for Alt 1 or Alt 2?  If different, why such a new capability is necessary? The first capability would be sufficient. |
| CATT | We do not think the UE capability is needed. |
| Moderator | @ DCM: This is a new capability to address the fact that even if we have a capability for the CR, a company has proposed this as some UEs may expect all the TDAIs to be the same while some may expect them to be different. |
| QC | We don’t think UE capability on same/different T-DAI is needed. This is totally up to NW. It has nothing to do with UE. UE just follow whatever value of T-DAI NW set. |
| Huawei, HiSilicon | As commented in section 6.1.1, this should not be a separate discussion. It is important to clarify the default assumption for normal case. Given that allowing different T-DAIs would require some additional complexity for the both gNB and UE. It is reasonable to introduce a new UE capability which provides some implementation flexibility. |
| Vivo | We slightly prefer no additional capability for different T-DAI. We don’t see the need, but we are fine to discuss. |
| Ericsson | We understand HW intention to improve the situation for normal case. As explained in previous question, this is fine but a separate issue.  Still the new capability proposed by HW, improves the situation for the normal case**. But the description of the capability should not be based on UL-TDAI. It should reflect the scheduling restriction whether the UE would expect DL assignment after UL grant to multiplex corresponding HARQ-ACK in the PUSCH (together with previous ones), etc.**  We hope, the progress for the abnormal case, does not depend on this one. In fact, by Alt-1 in pace for abnormal case, we can discuss the new capability for normal case. We think, with Alt-2, applying the new capability for normal case would be complicated. |
| MTK | We slightly prefer to introduce this capability, but we are willing to discuss any solution that can move us forward. |
| DCM | Still we do not think this new capability is necessary. If the intention is to address issue that was discussed in Rel-17 TEI, it should be discussed in Rel-18 TEI or others. No need to discuss it here. |

### [CLOSED] Recommendation: TP for agreement in RAN1 #107-e

* Based on Recommendation 2-3, agree to the following TP (finalize brackets next week):

If a UE transmits a single ~~one~~ PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions [and if the in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook-r1*, and in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static]*, without any other PUSCH to transmit on any serving cell in the slot, and the UE does not determine any PUCCH carrying HARQ-ACK information in the slot, the UE multiplexes HARQ-ACK information in the PUSCH transmission.

* **Updated May 16**

If a UE transmits a single ~~one~~ PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions [and if the value of in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook-r1*, and in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static]*, without any other PUSCH to transmit on any serving cell in the slot, and the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot, the UE multiplexes HARQ-ACK information in the PUSCH transmission.

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| **Company** | **Comments** |
| DCM | OK  We understand Ericsson’s intention (DAI-related text is mentioned in 9.1.2.2/9.1.3.2 and after applying section 9, these sections follows. So detailed condition should not be mentioned here).  But if we use text in 9.1.3.2, the issue on whether HARQ-ACK is multiplexed when DAI = 1/2/3 is still a bit unclear. So the current text is preferred.  Alternatively, it might be possible that TP can be added not in 9 but in 9.1.2.2/9.1.3.2. |
| QC | Similar comment on SPS A/N. If UE has SPS A/N to transmit, while it missed all DL grant, UE should follow the above TP for single PUSCH case, right? If so, the following change seems needed.  Besides, suggest to change the notation <> to = “value of … not equal to”.  If a UE transmits a single ~~one~~ PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions [and if the value of in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook-r1*, and in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static]*, without any other PUSCH to transmit on any serving cell in the slot, and the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot, the UE multiplexes HARQ-ACK information in the PUSCH transmission. |
| Moderator | DCM’s proposal seems reasonable and accepted QC’s edits. |
| Ericsson | We don’t think the text in [] should be there. We tried to provide explanations. We appreciate if companies explain why in this case, we need to mention the text. What is it that is unclear? At least, if we understand, we would definitely be OK.  **@DCM:** Can you explain why HARQ-ACK is multiplexed when DAI = 1/2/3 is still a bit unclear?  **@All:** One aspect that it is good to keep in mind, is to avoid repetition in specification. That cause the maintenance of the spec difficult.  If majority prefers to keep the text, we don’t object. But we appreciate if we understand why it is needed. |
| MTK | We are fine with the proposal and prefer to keep the text in []. The intention is simple, for people who are not very familiar with 38.213 Clause 9, removing the text in [] may create confusion on how to match the RAN1 #107e agreement to new 38.213 text here without the text in []. Keeping the text in [] may introduce some repetition, but we see the spec clear in this way and to us it is worth the redundancy. |

### [CLOSED] Rel-15 Repetition

* (38.213, Section 9):
  + “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 and in a 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 Subclause 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.”

Option 1: Do not multiplex

Option 2: No consensus on UE behavior

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| --- | --- |
| **Company** | **Comments** |
| QC | Given the spec is clear, I think no further discussion on this is needed. We can just close the discussion without any conclusion. And the spec stays as it is. |
| ZTE | Here we discuss the scenario is that the PUSCH repetition is transmitted. In TS 38.213, the condition for the highlighted UE behavior is that the PUSCH transmission was absent. It means that the PUSCH repetition is actually not transmitted, for example, due to the collision of the slot format. It is obviously that they are different scenarios.  Therefore, we don’t think the current spec states the UE behavior for the scenario we discuss. We support Option 2. |
| Vivo | Option 1. |
| Ericsson | We copy our response on the reflector.   * + The text cited by UE is implemented in Rel-15 (v15.3.0) to reflect the following agreement in RAN1#94 as Yi mentioned.  (I have been searching to find supporting discussions/agreements in UL control channel and UCI multiplexing discussions but it was actually in CA sessions 😊).  |  | | --- | | **Friday session**  **R1-1809988         CA Offline Session 3       Samsung**  **Decision:** The document is noted. Companies are encouraged to check slide 4 of R1-1809988.  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 | | 38.213 . v15.3.0 (where the , are removed in next version of spec, i.e. v15.4.0).  If a UE transmits a PUSCH over multiple slots and the UE would transmit a PUCCH with HARQ-ACK information over a single slot and in a 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 Subclause 9.2.5 for multiplexing the HARQ-ACK information, the UE multiplexes the HARQ-ACK information in the PUSCH transmission in the one or more slots. The UE does not multiplex HARQ-ACK information in the PUSCH transmission in a slot from the multiple slots if, in case the PUSCH transmission was absent, the UE would not transmit a single-slot PUCCH with HARQ-ACK information in the slot. |   I think the spec text, was intended to address timeline issues. Without knowing that background, the text “in case the PUSCH transmission was absent “ is a bit strange. Also, as we know, timeline should be met not only for only HARQ, but also UCI multiplexing timeline should be met. So, I would say “in case the PUSCH transmission was absent “, is a bit irrelevant, although it is in the spec. So, I can’t make out sense of “in case the PUSCH transmission was absent “, but then “the UE would not transmit a single-slot PUCCH with HARQ-ACK information in the slot.” Is very clear.  To me it is gray area. I think it is fine to go to with Yi suggests, but don’t you think we need to remove “in case the PUSCH transmission was absent”? Does it make sense there? |
| MTK | With QC’s explanation in the email thread, we think it should be Option 1. |
| CATT | We think the spec is clear and it is Option 1. |
| Moderator | Consensus seems to be Option 1. Will make recommendation based on this option  **Conclusion:**  For a Rel. 15 UE, when a PUSCH scheduled by DCI is repeated and the corresponding UL grant indicates UL-TDAI but a PUCCH with HARQ-ACK is absent throughout the PUSCH repetition, the UE does not multiplex on any of the PUSCHs . |

# Final Round Summary

### Recommendation Summary

* Rel-16 abnormal case (no PUCCH overlapping any PUSCH) with unified solution
  + Down-select Alt-1 (TP1-almost stable) vs Alt-2 (TP2-almost stable)
  + ***[Recommendation to chair] : Chair to assist in down-selection in Section*** 7.2.1
* Rel-16 normal case (PUCCH overlapping PUSCH)
  + capability for TDAI (TP3) vs capability for scheduling restriction (TP4) vs Future discussion
  + ***[Recommendation to chair] : Chair to assist in resolving in Section*** 7.3.1
* Rel-16 abnormal case (no PUCCH overlapping any PUSCH) with single PUSCH
  + Agreement in RAN1 #107-e, TP stable
  + **[Recommendation to chair] : Agree to Text Proposal in Section** 7.4.1
* Rel-15 and beyond abnormal case (no PUCCH overlapping any PUSCH) with repetition
  + Conclusion is that the UE does not multiplex based on existing specification
  + **[Recommendation to chair] : proposed conclusion in Section 7.5.1**

### Summary on Rel-16 UE behavior with Unified Solution

Alt 1:

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| --- | --- |
| Preference | Ericsson, Nokia/NSB, LG, QC (4) |
| Flexible if majority | Apple , NTT DOCOMO, Samsung, Huawei/HiSilicon (conditional on TP3/TP4), MTK (5) |
| Object |  |

Alt 2:

|  |  |
| --- | --- |
| Preference | NTT DOCOMO, CATT, ZTE, Vivo, MTK, Intel, Samsung, Huawei/HiSilicon (conditional on TP3/TP4) (8) |
| Flexible if majority | Apple (1) |
| Object |  |

### **[Recommendation 1 to chair] : Need assistance in down-selection**

### [FINAL] Proposal on Rel-16 UE behavior

**Proposal: Down-select Alt-1/Alt-2**

For Rel-16 UEs, in the scenario with more than one PUSCH (overlapping and non-overlapping) and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA, 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 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**.**   The above specified behavior is supported subject to a new Rel-16 UE capability [**xxxxx**]   * FFS: the details of the capability signaling |

### [ALMOST STABLE] Alt-1 Text Proposal on Rel-16 UE behavior

* Status: Almost stable
  + Outstanding issue to be resolved for both alternatives: PUCCH carrying SPS HARQ-ACK only (based on text in blue)

|  |
| --- |
| 9 UE procedure for reporting control information  <unchanged text omitted>  If a UE multiplexes aperiodic CSI in a PUSCH and the UE would multiplex UCI that includes HARQ-ACK information in a PUCCH that overlaps with the PUSCH and the timing conditions for overlapping PUCCHs and PUSCHs in clause 9.2.5 are fulfilled, the UE multiplexes only the HARQ-ACK information in the PUSCH and does not transmit the PUCCH.  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmissions and the multiple PUSCHs overlap with a PUCCH carrying HARQ-ACK [and/or CSI] information in the slot, the UE selects all the PUSCHs overlapping with the PUCCH as the candidate PUSCHs for UCI multiplexing within the slot.    If the UE indicates the corresponding capability [the name of the capability], when a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmissions and the UE does not determine any PUCCH carrying HARQ-ACK information ~~[with a corresponding PDCCH]~~ in the slot and at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE selects all the multiple PUSCHs in the slot as the candidate PUSCHs for UCI multiplexing within the slot.    The UE determines the PUSCH for UCI multiplexing by applying the following procedure on the candidate PUSCHs as described in this clause:  -          If the ~~a UE transmits multiple~~ candidate PUSCHs~~in a slot on respective serving cells that include~~ 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~~ candidate PUSCHs, and the ~~multiple~~ candidate 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 ~~If a UE transmits multiple PUSCHs in a slot on respective serving cells and~~the UE would multiplex UCI in one of the ~~multiple~~ candidate PUSCHs and the UE does not multiplex aperiodic CSI in any of the ~~multiple~~ candidate 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.  <unchanged text omitted> |

### [ALMOST STABLE] Alt-2 Text Proposal on Rel-16 UE behavior

* Status: Almost stable
  + Outstanding issue to be resolved for both alternatives: PUCCH carrying SPS HARQ-ACK only (based on text in blue)

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| --- |
| 9 UE procedure for reporting control information  <unchanged text omitted>  If a UE multiplexes aperiodic CSI in a PUSCH and the UE would multiplex UCI that includes HARQ-ACK information in a PUCCH that overlaps with the PUSCH and the timing conditions for overlapping PUCCHs and PUSCHs in clause 9.2.5 are fulfilled, the UE multiplexes only the HARQ-ACK information in the PUSCH and does not transmit the PUCCH.  When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmissions and the multiple PUSCHs overlap with a PUCCH carrying HARQ-ACK information in the slot, the UE selects the candidate PUSCHs for UCI multiplexing as all the PUSCHs overlapping with the PUCCH.    If the UE indicates the corresponding capability [the name of the capability], when a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the UE does not determine any PUCCH carrying HARQ-ACK information [with a corresponding PDCCH] in the slot and at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE selects all the multiple PUSCHs in the slot as the candidate PUSCHs for UCI multiplexing within the slot except for any PUSCH among the multiple PUSCHs that is scheduled   by a DCI format that includes a DAI field with value in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook-r16*, and value  in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static.*  The UE determines the PUSCH for UCI multiplexing by applying the following procedure on the candidate PUSCHs as described in this clause:  -          If the ~~a UE transmits multiple~~ candidate PUSCHs~~in a slot on respective serving cells that include~~ 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~~ candidate PUSCHs, and the ~~multiple~~ candidatePUSCHs fulfil the conditions in clause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in a PUSCH from the first PUSCHs.  -          If ~~If a UE transmits multiple PUSCHs in a slot on respective serving cells and~~the UE would multiplex UCI in one of the ~~multiple~~ candidate PUSCHs and the UE does not multiplex aperiodic CSI in any of the ~~multiple~~ candidate 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.  <unchanged text omitted> |

### Summary on Rel-16 normal case with additional capability

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| Support/ open | Huawei, ZTE (open to TP3 or TP4), MTK (TP3), |
| Do not support | CATT, QC, Intel, LG, Ericsson (TP3), NTT DOCOMO (Rel-18-TEI), Nokia |
| Separate Issue | Ericsson (In principle, open to TP4), QC (open to discuss), Nokia (need to understand what the intended behaviour for UEs without the capability mean, but the case can be discussed) |

### **[Recommendation 2 to chair] : Chair to assist in resolving.**

#### TP3: based on TDAI restriction

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| <unchanged text omitted>  //: Moderator comment: common operations for both cases on “candidate PUSCHs”  The UE determines the PUSCH for UCI multiplexing by applying the following procedure on the candidate PUSCHs as described in this clause:  -          If the ~~a UE transmits multiple~~ candidate PUSCHs~~in a slot on respective serving cells that include~~ 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~~ candidate PUSCHs, and the ~~multiple~~ candidate 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 ~~If a UE transmits multiple PUSCHs in a slot on respective serving cells and~~the UE would multiplex UCI in one of the ~~multiple~~ candidate PUSCHs and the UE does not multiplex aperiodic CSI in any of the ~~multiple~~ candidate 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 at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field and the UE indicates a corresponding capability 2, [the name of the capability], the UE expects that the DCI formats that include DAI fields scheduling the multiple PUSCHs can have the different DAI values. |

#### TP4: based on scheduling restriction

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| <unchanged text omitted>  A UE does not expect to detect a DCI format scheduling a PDSCH reception or having associated HARQ-ACK information report without scheduling a PDSCH reception, 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.  If a UE indicates the new capability 2 [the name of the capability], a UE can detect a DCI format scheduling a PDSCH reception or having associated HARQ-ACK information report without scheduling a PDSCH reception , and indicating a resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot if the following conditions are satisfied  -          if the UE previously detects a DCI format scheduling a first PUSCH transmission in the slot and if the UE multiplexes HARQ-ACK information in the first PUSCH transmission.  -          if the UE later detects a second DCI format scheduling a PUSCH transmission and if the UE multiplexes HARQ-ACK information in the second PUSCH and not in the first PUSCH according to the procedure of UCI multiplexing in PUSCH as described in this clause. |

### [STABLE] TP for agreement in RAN1 #107-e

RAN1 #107-e  
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.

### **[Recommendation 3 to chair]: Adopt Text Proposal**

**Proposal:** Adopt the following text proposals for Clause 9, Clause 9.1.2.1 and Clause 9.1.3.1 to capture the Rel-16 behavior for a single PUSCH with no overlapping PUCCH based on the agreement in RAN1 #107-e agreement.

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| --- |
| 9 UE procedure for reporting control information  <unchanged text omitted>  A UE does not expect to detect a DCI format scheduling a PDSCH reception or a SPS PDSCH release,a DCI format 1\_1 indicating Scell dormancy, or a DCI format including a One-shot HARQ-ACK request field with value 1, and indicating a resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot if the UE previously detects a DCI format scheduling a PUSCH transmission in the slot and if the UE multiplexes HARQ-ACK information in the PUSCH transmission.  If a UE transmits a single  PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions without any other PUSCH to transmit on any serving cell in the slot and if the value of the DAI field is not equal to 4 in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook-r16*, or is equal to 1 in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static*, and the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot, the UE multiplexes HARQ-ACK information in the PUSCH transmission. |

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| 9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel  <unchanged text omitted>  A UE determines  HARQ-ACK information bits, for a total number of  HARQ-ACK information bits, of a HARQ-ACK codebook for transmission in a PUCCH or a PUSCH according to the following pseudo-code. In the following pseudo-code, if the UE does not receive a transport block or a CBG, due to the UE not detecting a corresponding DCI format 1\_0 or DCI format 1\_1, the UE generates a NACK value for the transport block or the CBG. The cardinality of the set  defines a total number  of occasions for PDSCH reception or SPS PDSCH release for serving cell  corresponding to the HARQ-ACK information bits.  <unchanged text omitted> |

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| 9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel  <unchanged text omitted>  If the UE transmits HARQ-ACK information in a PUSCH or a PUCCH in slot  with reference to slots for PUCCH transmission  and for any PUCCH format, the UE determines the , for a total number of  HARQ-ACK information bits, according to the following pseudo-code:  <unchanged text omitted> |

### [STABLE] Rel-15/Rel-16 Repetition

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| --- |
| Friday session  **R1-1809988 CA Offline Session 3 Samsung**  Decision: The document is noted. Companies are encouraged to check slide 4 of R1-1809988.  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 |
| **Specification:**  38.213 . v15.3.0 (where the , are removed in next version of spec, i.e. v15.4.0).  If a UE transmits a PUSCH over multiple slots and the UE would transmit a PUCCH with HARQ-ACK information over a single slot and in a 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 Subclause 9.2.5 for multiplexing the HARQ-ACK information, the UE multiplexes the HARQ-ACK information in the PUSCH transmission in the one or more slots. The UE does not multiplex HARQ-ACK information in the PUSCH transmission in a slot from the multiple slots if, in case the PUSCH transmission was absent, the UE would not transmit a single-slot PUCCH with HARQ-ACK information in the slot.  Latest version - 38.213 . v15.14.0:  • 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 and in a 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. |

To be recommended to chair:

For a Rel. 15 UE, when a PUSCH scheduled by DCI is repeated and the corresponding UL grant indicates UL-TDAI but a PUCCH with HARQ-ACK is absent throughout the PUSCH repetition, the UE does not multiplex on any of the PUSCHs. Based on this, there is no need to address the Rel-16 behavior issue.

### **[Recommendation 4 to chair] : Agree on the following proposed conclusion:**

*NOTE : request by company to update specification.*

**Proposed conclusion:**

*In line with RAN1 understanding, for a Rel. 15 UE, when a PUSCH scheduled by DCI is repeated and the corresponding UL grant indicates UL-TDAI but a PUCCH with HARQ-ACK is absent throughout the PUSCH repetition,* ***the UE does not multiplex on any of the PUSCHs****.*

# Final Discussion

To summarize  the status so far on Issue 4 [repetition] and issue 3 [TP for RAN1 #107-e agreement] only:

### Issue 4: Repetition

**No comments for over 24 hours on the recommendation**

### [Issue 3]: TP for RAN1 #107 agreement:

Summary:

- add “would transmit”

- remove updates to 9.1.2.1 and 9.1.3.1

- remove typos

Updated TP:

**Proposal**

The following text proposals for TS 38.213 Clause 9, Clause 9.1.2.1 and Clause 9.1.3.1 to capture the Rel-16 behavior for a single PU~~C~~SCH with no overlapping PU~~S~~CCH based on the agreement in RAN1 #107-e agreement..

|  |
| --- |
| 9 UE procedure for reporting control information  <unchanged text omitted>  A UE does not expect to detect a DCI format scheduling a PDSCH reception or a SPS PDSCH release,a DCI format 1\_1 indicating Scell dormancy, or a DCI format including a One-shot HARQ-ACK request field with value 1, and indicating a resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot if the UE previously detects a DCI format scheduling a PUSCH transmission in the slot and if the UE multiplexes HARQ-ACK information in the PUSCH transmission.    If a UE would transmit~~s~~ a single  PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions without any other PUSCH would be transmitted ~~to transmit~~  on any serving cell in the slot and if the value of the DAI field is not equal to 4 in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic*or with *pdsch-HARQ-ACK-Codebook-r16*, or is equal to 1 in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static*, and the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot, the UE multiplexes HARQ-ACK information in the PUSCH transmission. |

#### Proposal correction [Qualcomm] : Accept

[Qualcomm comment]: I suggested change to correct the typo

**Proposal**

The following text proposals for TS 38.213 Clause 9, Clause 9.1.2.1 and Clause 9.1.3.1 to capture the Rel-16 behavior for a single PU~~C~~SCH with no overlapping PU~~S~~CCH based on the agreement in RAN1 #107-e agreement.

#### Typo correction [Samsung]: Accept

[Samsung comment]: There is a typo in “dynamicor”, it should be “dynamic or”

#### since a PUSCH can be cancelled by HP PUSCH/PUCCH or SFI, “would” should be added before transmission, [Samsung]: Accept

[Samsung comment]: Actually, since a PUSCH can be cancelled by HP PUSCH/PUCCH or SFI, “would” should be added before transmission, for example, “If a UE would transmit a single PUSCH scheduled by a DCI format”. Similarly, “without any other PUSCH to transmit” should be changed to “without any other PUSCH that would be transmitted” since these PUSCHs can be cancelled.

**[Ericsson]** • Then the TP checks if this PUSCH is validated for UCI multiplexing. If we actually multiplex or not, depends on the other clause. Therefore, saying “would” is in fact more appropriate.

• Whether this PUSCH is transmitted or not, is another story, and general for all.

**[Moderator]** On reviewing 38.213, the specification uses “transmits” in the case where there are multiple PUSCHs (e.g. with repetition) or when it is selecting multiple candidate PUSCHSs. It uses “would transmit” in the only paragraph in which it transmitting a single PUSCH. As such, adding the word “would” does make sense.

**Updated TP**

If a UE would transmit~~s~~ a single  PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions without any other PUSCH that would be transmitted ~~to transmit~~ on any serving cell in the slot and if the value of the DAI field is not equal to 4 in case the UE is configured with pdsch-HARQ-ACK-Codebook = dynamic or with pdsch-HARQ-ACK-Codebook-r16, or is equal to 1 in case the UE is configured with pdsch-HARQ-ACK-Codebook = semi-static, and the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot, the UE multiplexes HARQ-ACK information in the PUSCH transmission.

#### Why do we need to include the PUSCH in the TP for the RAN1 #107-e agreement? [CATT/Samsung]; Accept

[CATT comment]: Regarding the TPs, we do not think the following TPs are needed. It should be clear from the titles that both sections are for HARQ-ACK in PUCCH. Why do we need to include PUSCH?

[Samsung] For the last 2 TPs (about adding “a PUSCH”), I would like to echo Yanping’s concern. Although I understand the reason you kindly explained before (i.e., it is due to a kind of procedure correction), I’m not a little bit convinced on whether this is really essential change or not because the following is saying a UE would multiple HARQ-ACK in case of missing DL DCI in section 9. Therefore, I think that there is no critical problem of generating HARQ-ACK information although 9.1.2.1/9.1.3.1 are not explicitly saying “a PUSCH”. Note that we are here discussing abnormal case, not general situation.

|  |
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| If a UE transmits a single  PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions without any other PUSCH to transmit on any serving cell in the slot and if the value of the DAI field is not equal to 4 in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic*or with *pdsch-HARQ-ACK-Codebook-r16*, or is equal to 1 in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static*, and the UE does not determine any PUCCH carrying HARQ-ACK information with a corresponding PDCCH in the slot, the UE multiplexes HARQ-ACK information in the PUSCH transmission. |

[reply by Ericsson]  • On two TPs for 9.1.2.1, 9.1.3.1: Thanks Sungjin for explanations. I expressed my rational. If you think there is no reason to worry, I am totally fine not to include them. The less the change, the better. It is good to hear companies view.

#### case of different SCSs and sub-slot configuration [Samsung]: Not needed and reason accepted by Samsung

[Samsung comment]: “in a slot with reference to slots for PUCCH transmissions” seems not clear for the case of different SCSs and sub-slot configuration. For example, PUCCH slot is 15kHz and PUSCH slot is 30kHz. Does the TP cover this case? Current TP seems to assume PUCCH’s SCS is larger than PUSCH’s SCS due to this point.

**From discussion, by Ericsson:** This expression “in a slot with reference to slots …” is used by Editor in 38.213 to address different SCS, as well as sub-slot. Basically it says, for granularity of the slot, we consider the cell with PUCCH transmissions on. For example, if you have PCell of 30 kHz and SCell of 15 kHz, the slot of 0.5 ms with timing of PCell are reference and we look at the PUSCH transmissions within using PCell slots time granularity.  Please note again that is the same for normal case.

**[Samsung Reply]**: "Thanks for the point. I understood well.”

#### “one PUSCH” is the number of actually transmitted PUSCH or the number of actually scheduled PUSCH [Samsung]: Not needed. Additional scenarios addressed by Alt-1/Alt-2. Reason accepted by Samsung.

[Samsung Comment]: Having said that, we need to first clarify the following agreement regarding whether “one PUSCH” is the number of actually transmitted PUSCH or the number of actually scheduled PUSCH. In that sense, we would like to hear other companies’ views on this one.

**From discussion by Ericsson**“ My understanding of the agreement is that there is only one PUSCH in the slot .That is “the number of actually scheduled PUSCH = 1 😊”.  Not that there is only one PUSCH that would be transmitted in the slot, and there might be other PUSCHs. That is the scenario of multiple PUSCHs that we are discussing between Alt-1/Alt-2. So, here, the scenario that we have to capture is there is only one PUSCH in the slot.

#### we would like to understand how/when UE determines the condition for a single is satisfied considering that UE can be scheduled by a later UL DCI to transmit another PUSCH [CATT]: Needs discussion

[Ericsson reply]:  • On the question for clarifying there is only single PUSCH in the slot, regarding timeline, I understand Yanping point and I was thinking about that. But I think this should be understood from specifications. If I read clause 9, we are defining procedures saying there is PUSCH overlapping with PUCCH, etc… In none of them, we start saying this scenario is valid given that the last DCI before the time line, and then we get this scenario, and let’s see what the procedure is. So, to me, this should be understood. But if companies share different views, it is good to have some alternative wording to work on (deadline is approaching 😊 )

[CATT] For the second question, I need to understand companies’ views first before suggesting TP update

#### Resolution of 8.2.1.7: merger of the single and multiple cases in the same agreement

[LGE] Regarding the TP for Issue 3 (single PUSCH case), I think the single PUSCH case could be covered by the following TP for Alt-1/2, with slight modification in yellow as below.

In TP 1

If a UE transmits a single PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions without any other PUSCH would be transmitted on any serving cell in the slot and the UE does not determine any PUCCH carrying HARQ-ACK information in the slot, or if ~~If~~ a ~~the~~ UE indicates the corresponding capability [the name of the capability] and~~, when~~ the ~~a~~ UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmissions and the UE does not determine any PUCCH carrying HARQ-ACK information in the slot and at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE selects the single PUSCH or all the multiple PUSCHs in the slot as the candidate PUSCHs for UCI multiplexing within the slot.

In TP2

If a UE transmits a single PUSCH scheduled by a DCI format that includes a DAI field on a serving cell in a slot with reference to slots for PUCCH transmissions without any other PUSCH would be transmitted on any serving cell in the slot and the UE does not determine any PUCCH carrying HARQ-ACK information in the slot, or if ~~If~~ a ~~the~~ UE indicates the corresponding capability [the name of the capability] and~~, when~~ the ~~a~~ UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmission and the UE does not determine any PUCCH carrying HARQ-ACK information in the slot and at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE selects the single PUSCH or all the multiple PUSCHs in the slot as the candidate PUSCHs for UCI multiplexing within the slot except for any PUSCH among the multiple PUSCHs that is scheduled by a DCI format that includes a DAI field with value  in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook-r16*, and value  in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static.*

*[Ericsson] I*n merging two TPs (single and multiple), I did some thinking.

* From spec text it can work it we say “one or multiple PUSCHs” instead of  “multiple PUSCHs” in the paragraph that PUCCH is absent.
* **But,** we have the issue that the new capability is only for multiple PUSCHs, and not single PUSCH. Then, we need to separate any way these two cases

### [Issue 1: Alt-1 vs Alt-2]

Key arguments in the Alt-1/Alt-2 discussion:

**Select Alt-1:** [Ericsson] There may be different abnormal cases (e.g. missing of UL DCI) apart from the one we are addressing (lmissing DL DCI and associated PUCCH). Having the same behavior from a single UE (as opposed to variation in behavior between the normal and one single abnormal case) leads to increased gNB implementation complexity. We would rather take the timeline restriction than the complexity increase…

**Select Alt-2:**[CATT] Alt-1 introduces an additional timeline requirement where the timeline requirement is required to be met for all PUSCHs within the PUCCH slot which includes PUSCH(s) that are more overlapping with the PUCCH. gNB cannot predict or know whether DL DCI is missed, so effectively, Alt. 1 changes the timeline requirement from for overlapping channels to include PUSCH(s) which are not overlapped with PUCCH. To impose additional timeline requirement at gNB side for the abnormal case is not justified from our perspective.

***Conclusion: Alt-2 selected***

CRs:

* Rel-16: R1-2205628, CR# 0316 - [R1-2205628 CR -Correction for HARQ-ACK multiplexing on PUSCH in the absence of PUCCH-v04.docx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_109-e/Inbox/drafts/7.1/%5B109-e-NR-CRs-01%5D/CR/R1-2205628%20CR%20-Correction%20for%20HARQ-ACK%20multiplexing%20on%20PUSCH%20in%20the%20absence%20of%20PUCCH-v04.docx)
* Rel-17: R1-2205629, CR# 0317 - [R1-2205629 CR - Correction for HARQ-ACK multiplexing on PUSCH in the absence of PUCCH-v04.docx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_109-e/Inbox/drafts/7.1/%5B109-e-NR-CRs-01%5D/CR/R1-2205629%20CR%20-%20Correction%20for%20HARQ-ACK%20multiplexing%20on%20PUSCH%20in%20the%20absence%20of%20PUCCH-v04.docx)
* Draft LS to RAN2: R1-2205634 - [R1-2205634 LS on New UE Feature for HARQ-ACK multiplexing on PUSCH in the absence of PUCCH.docx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_109-e/Inbox/drafts/7.1/%5B109-e-NR-CRs-01%5D/Draft%20LS/R1-2205634%20LS%20on%20New%20UE%20Feature%20for%20HARQ-ACK%20multiplexing%20on%20PUSCH%20in%20the%20absence%20of%20PUCCH.docx)

*Capability:*

**Agreement**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Features** | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Need for the gNB to know if the feature is supported** | **Applicable to the capability signalling exchange between UEs (V2X WI only)”.** | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | **Need of FDD/TDD differentiation** | **Need of FR1/FR2 differentiation** | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | **Note** | **Mandatory/**  **Optional** |
| 22. NR Others | 22-12 | Multiplexing HARQ-ACK without PUCCH on PUSCH | 1.      multiplexing HARQ-ACK in a PUSCH in a PUCCH slot when the UE misses any HARQ-ACK to transmit in any PUCCH but receives UL grant(s) with UL-TDAI field to transmit **multiple**PUSCHs in the PUCCH slot |  | Yes | N/A |  | Per UE | N/A | N/A | N/A |  | Optional |

#### Clarification of TP

[CATT] For multiple PUSCH case, we are wondering for the case there is only PUCCH with CSI in a PUCCH slot from UE perspective, which paragraph below should UE follow?

When a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmissions and the multiple PUSCHs overlap with a PUCCH carrying UCI in the slot, the UE selects all the PUSCHs overlapping with the PUCCH as the candidate PUSCHs for UCI multiplexing within the slot.

If the UE indicates the corresponding capability [the name of the capability], when a UE transmits multiple PUSCHs on respective serving cells in a slot with reference to slots for PUCCH transmissions and the UE does not determine any PUCCH carrying HARQ-ACK information in the slot and at least one of the multiple PUSCHs is scheduled by a DCI format that includes a DAI field, the UE selects all the multiple PUSCHs in the slot as the candidate PUSCHs for HARQ-ACK multiplexing within the slot except for any PUSCH among the multiple PUSCHs that is scheduled by a DCI format that includes a DAI field that is equal to 4 in case the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook-r16*, or is equal to 0 in case the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static*.

*[Qualcomm]*

I just want to say that the point that Yanping raised on CSI PUCCH triggers me to wonder whether the group has the same understanding of the TP on how to handle the following cases. Based on Sorour’s answer, the following is my understanding of the TP. I hope everyone is on the same page, which I am not 100% sure given the issue was brought up a little late.

* PUCCH with CSI follow the first paragraph in the TP and mux on PUSCH 1 (regardless its TDAI value). The second paragraph of the TP is also executed, and UE build the candidate set of PUSCHs for HARQ-ACK multiplexing.
  + The candidate set for case 1 and case 2 are different according to the TP.

**In summary, QC is fine with all the three latest proposals from Kome, based on Sorour’s answer to Yanping’s question (3) is the common understanding in RAN1.** However, due to the issue brought by Yanping was not sufficiently discussed among all companies, if the group want to be more cautious to avoid any potential confusion, we are also fine to endorse the first two proposals and leave the CR endorsement to next RAN1 meeting.

Graphical user interface, text, application

Description automatically generated

# Conclusions

**Conclusion**In line with RAN1 understanding, for a Rel. 15 UE, when a PUSCH scheduled by DCI is repeated and the corresponding UL grant indicates UL-TDAI but a PUCCH with HARQ-ACK is absent throughout the PUSCH repetition, the UE does not multiplex on any of the PUSCHs.

**Agreement**

For Rel-16 UEs, in the scenario with more than one PUSCH (overlapping and non-overlapping) and no overlapping PUCCH with HARQ-ACK within a span on one PUCCH slot (both single carrier and UL CA), for a unified design, the following should be specified:

1. 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
2. Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213
3. Limitations for multiplexing
   * UE expects to multiplex HARQ-ACK on only 1 PUSCH selected based on step 2 in the PUCCH slot.
   * 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.

The above specified behavior is supported subject to a new Rel-16 UE capability [Multiplexing HARQ-ACK without PUCCH on PUSCH]

* FFS: the details of the capability signaling

**Agreement**

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| **Features** | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Need for the gNB to know if the feature is supported** | **Applicable to the capability signalling exchange between UEs (V2X WI only)”.** | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | **Need of FDD/TDD differentiation** | **Need of FR1/FR2 differentiation** | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | **Note** | **Mandatory/**  **Optional** |
| 22. NR Others | 22-12 | Multiplexing HARQ-ACK without PUCCH on PUSCH | 1.      multiplexing HARQ-ACK in a PUSCH in a PUCCH slot when the UE misses any HARQ-ACK to transmit in any PUCCH but receives UL grant(s) with UL-TDAI field to transmit **multiple**PUSCHs in the PUCCH slot |  | Yes | N/A |  | Per UE | N/A | N/A | N/A |  | Optional |

LS to RAN2 on the new UE capability is endorsed in R1-220XXXX.

**Agreement**

The correction for HARQ-ACK multiplexing on PUSCH in the absence of PUCCCH is endorsed in R1-2205628 (TS38.213, Rel-16, CR#0316, Cat. F) and R1-2205629 (TS38.213, Rel-17, CR#0317, Cat. A).

LS to RAN2 on the new UE capability is endorsed in R1-2205634.

# References

1. R1-2203104 Discussion on HARQ-ACK multiplexing on PUSCH without PUCCH, Huawei/Hi-Silicon RAN1 #109-e
2. R1-2203182 Discussion on HARQ-ACK multiplexing on PUSCH, ZTE, RAN1 #109-e
3. R1-2203415 Discussion on HARQ-ACK multiplexing in PUSCH without PUCCH CATT, RAN1 #109-e
4. R1-2204196 On Remaining Issues for PUSCH UCI Multiplexing without HARQ-ACK Apple, RAN1 #109-e
5. R1-2204554 HARQ-ACK multiplexing on PUSCH without PUCCH Ericsson, Nokia/NSN, RAN1 #109-e
6. R1-2204760 Discussion on HARQ-ACK multiplexing on PUSCH, Intel, RAN1 #109-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. R1-2112859, Summary for [107-e-NR-7.1CRs-6] Issue #10 Discussion on HARQ-ACK multiplexing on PUSCH, Moderator (Apple), RAN1 #107-e
14. R1-2202835, Summary for [108-e-NR-CRs-06] Issue #8: Discussion on HARQ-ACK multiplexing on PUSCH, Moderator (Apple)

# 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:

### Huawei: R1-2203104 [1]

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| ***Proposal 1: In case of more than one non-overlapping PUSCHs without PUCCH within a span on one PUCCH slot (both single carrier and UL CA), if more than one PUSCHs with UL-TDAI not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), UE selects one PUSCH to multiplex following the rules:***   * ***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. ***The DAI field value of multiple PUSCH(s) should be the same*** * ***Prioritization rules to select PUSCH for multiplexing. Prioritization rules are identical to 38.213.*** |

### ZTE R1-2203182 [2]

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| ***Proposal 1:*** *Option 1 with Alt-2 should be adopted.*   * *For multiple PUSCHs 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.*   ***Proposal 2:*** *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 : R1-2201755 [3]

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| **Proposal: For one or multiple PUSCHs and no PUCCH with HARQ-ACK within a span of one PUCCH slot, UE selects one PUSCH from the PUSCHs with UL-TDAI not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), if any, according to the PUSCH selection rule defined in TS39.213 Clause 9.**   * **If none of the PUSCHs is with UL-TDAI not equal to 4 (for Type 2 codebook) or equal to 1 (for Type 1 codebook), UE does not multiplex HARQ-ACK in any PUSCH;** * **Otherwise if the selected PUSCH is not with repetition, UE multiplexes HARQ-ACK in the selected PUSCH according to the UL-TDAI for the selected PUSCH;** * **Otherwise if the selected PUSCH is with repetition, UE does not multiplex HARQ-ACK in the selected PUSCH repetition.** * **Note: it is up to gNB to decide whether to set the same UL-TDAI for all the PUSCHs overlapping with a same HARQ-ACK.** |

### Apple R1-2204196 [4]

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| ***Proposal 1:*** *For Rel-16 UEs, introduce a virtual PUCCH, select candidate UEs based on the virtual PUCCH and reuse the multiplexing procedure in Rel-15.*  ***Proposal 2:*** *This can be captured by the following:*   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/****differen****t] 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.*    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****.*** 4. *For item 1.a and 1.b, RAN1 can select either Alt-1 or Alt-2 with a slight preference for Alt-1* 5. *For item 1.c, RAN1 should allow the network to set the TDAI values that overlap with the PUCCH to* ***different*** *values when TDAI n.e. 4* 6. *To mitigate the effect of the agreement on already implemented UEs, a* ***UE capability*** *may be introduced to indicate to the gNB if the UE implements the procedure.*   *NOTE: This does not over-ride the agreements made in RAN1 #107-e and RAN1#108-e.* |

### Ericsson/Nokia/NSN R1-2204554 [5]

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| 1. Aiming for a unified solution including the multiple PUSCHs cases is crucial to not compromise the performance of UL CA deployments. 2. Different solutions for Rel16 and Rel-17 should be avoided. The NW would behave according to the specified behavior and does not change its behavior for this feature whether the UE indicates Rel-15/16/17, etc. 3. The unified solution to specify behavior for the case that PUCCH is absent should not diverge from the specified behavior when a PUCCH would be present. Any optimization is matter of implementation and not specification. 4. Introduction of capability for the solution can ease the UE implementations concern. While the earliest the behaviour is specified and implemented by UEs, improves the system performance due to less UEs with unknown behaviour in the NW.   [Proposal 1 For the case when multiple PUSCHs with no overlapping PUCCH with HARQ-ACK within a span of one PUCCH slot, the corresponding UE behavior is subject to indicating a capability and specified based on the following procedures (i.e. Option 1 with Alt-1 and no constraint on UL-TDAI):](#_Toc101723648)  [Proposal 2 Adopt the following Text proposals and corresponding descriptions for consequences and inter-operability analysis to implement the agreement for single PUSCH case as well as the proposal for multiple PUSCHs case for Rel-16 CR (being mirrored to Rel-17 CR)](#_Toc101723649)  [Proposal 3 When a PUSCH scheduled by DCI is repeated and the corresponding UL grant indicates UL-TDAI but a PUCCH with HARQ-ACK is absent throughout the PUSCH repetition, the first PUSCH of the repetition is considered as a candidate PUSCH for HARQ-ACK multiplexing following the unified solution.](#_Toc101723650) |

### Intel R1-2204760 [6]

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| **Proposal 1: To select 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, and N/W sets all TDAI values that overlap with PUCCH to the same value with TDAI n.e. 4.**  **Proposal 2: RAN1 to clarify that PUSCHs within a PUCCH slot includes PUSCHs overlapping with the PUCCH slot.**   * **If the UE identifies more than one PUCCH with HARQ-ACK to be multiplexed in the same PUSCH due to uncertainty of miss-detected PUCCH, UE only multiplexes HARQ-ACK from one PUCCH onto the PUSCH.**   **Proposal 3: For PUSCH repetition case, 1st PUSCH repetition within a PUCCH slot is selected for HARQ-ACK multiplexing.**  **Proposal 4: If a UE fails to receive any PDCCH for a PUCCH with HARQ-ACK in a PUCCH slot, UE multiplexes CSI in the same PUSCH for HARQ-ACK.** |