3GPP TSG RAN WG1 #106bis-e R1-211xxxx

e-Meeting, October 11th – 19th, 2021

Source: Moderator (OPPO)

Title: Summary#3 of email thread [106bis-e-NR-R17-IIoT-URLLC-04]

Agenda Item: 8.3.3

Document for: Discussion and Decision

# Introduction

In this paper, discussions under the following email thread in RAN1#106-e are summarized.

[106bis-e-NR-R17-IIoT-URLLC-04] Email discussion on intra-UE multiplexing/prioritization – Jia (OPPO)

* 1st check point: October 14
* Final check point: October 19

# Framework for intra-UE multiplexing/prioritization (order, slot/sub-slot mux, >2 channels)

## Agreements in previous meetings

Agreements:

*For multiplexing UCIs of different priorities in a PUCCH in R17,*

* *Support of multiplexing between different resources not confined within a sub-slot if conditions are met*
  + *FFS: Details*
* *Support multiplexing in case a PUCCH overlaps with more than one PUCCH if conditions are met*
  + *FFS details*

Working Assumption

*For handling overlapping PUCCHs/PUSCHs with different priorities in R17*

* *Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority*
* *Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities*

*Note: Avoid recursive pseudo-code to implement this procedure*

*Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable*

## Proposals from Tdocs

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 19: Decoupled UE capabilities should be supported on Rel-16 inter-priority prioritization and Rel-17 inter-priority multiplexing.***  ***Proposal 20: For the Rel-17 multiplexing order of multiple PUCCHs/PUSCHs, confirm the working assumption that the overlap of intra-priority PUCCHs and/or PUSCHs is handled followed by inter-priority PUCCH/PUSCH overlap handling.***   * ***For long LP PUCCH overlapping with multiple short HP PUCCHs in step 2, recursion can be avoided by multiplexing LP UCI into the HP PUCCH resource.*** * ***For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, recursion can be avoided by dropping the LP PUSCH.*** * ***Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs should be avoided.***   ***Observation 3: If simultaneous PUCCH/PUSCH transmission of different PHY priorities over different cells is configured, the prioritization of LP PUCCH/PUSCH can be performed as follows.***   * ***Step 1: Perform the multiplexing of LP PUCCH(s)/PUSCH assuming no overlapping HP UL channels and determine the final LP PUCCH/PUSCH;*** * ***Step 2: Judge whether the final LP PUCCH/PUSCH is overlapping with any HP UL channels before and/or after multiplexing of HP UL channels, and if an overlapping happens on the same serving cell or cells within the same band, the LP PUCCH/PUSCH is dropped.*** |
| Ericsson | [Observation 1 The multiplexing/prioritization procedure needs to handle cases with sub-slot HARQ feedback overlapping with low priority channels that do not meet the Rel-15 multiplexing timelines.](#_Toc84034960)  [Observation 2 For Rel-17, one new scenario (i.e., MAC delivers PDU for two overlapping grants) is added on top of scenarios handled by Rel-16 (i.e., MAC delivers one PDU for two overlapping grants). The gNB hypothesis testing has to handle one more scenario.](#_Toc84034961)  [Proposal 1 Confirm the framework working assumption.](#_Toc84035001)  [Proposal 2 Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.](#_Toc84035002)  [Proposal 3 When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003)  [Proposal 4 Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004)  [Proposal 5 When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005)  [Proposal 12 MAC may send two PDUs to two overlapping grants only if the later grant has higher PHY priority than the earlier grant.](#_Toc84035012)  [Proposal 13 DG/CG prioritization is performed before Step 1 of the framework WA for multiplexing/prioritization.](#_Toc84035013)  [Proposal 14 Identification of PUSCH for UCI multiplexing is performed after CG-vs-DG prioritization.](#_Toc84035014)  [Proposal 15 When *lch-basedPrioritization* is configured, Rel-16 UL skipping related procedure is not enabled in Rel-17.](#_Toc84035015)  [Proposal 18 If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.](#_Toc84035018) |
| ZTE | ***Proposal 11:*** *Confirm the working assumption:*  *For handling overlapping PUCCHs/PUSCHs with different priorities in R17*   * *Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority* * *Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities*   *Note: Avoid* ***recursive pseudo-code*** *to implement this procedure*  *Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable*  ***Proposal 12:*** *To determine an associated HP PUCCH time unit for the LP HARQ-ACK PUCCH if the LP HARQ-ACK PUCCH overlaps with multiple HP PUCCH time units, the low priority PUCCH performs multiplexing or dropping procedure in the first overlapping time unit that contains high priority PUCCH if overlapped low priority PUCCH and high priority PUCCH meet the multiplexing timeline.*  ***Proposal 26:*** *If simultaneous PUCCH/PUSCH over different cells is configured, the processing order between multiplexing/prioritizing and simultaneous-transmissions is proposed to be:*   * *The PUCCH/PUSCH on a same cell or on different cells under intra-band CA are multiplexed or prioritized, following the same procedure with simultaneous PUCCH/PUSCH disabled.* * *The PUCCH/PUSCH on different cells within the same PUCCH group under inter-band CA are transmitted simultaneously at least when PUCCH/PUSCH have different priorities*   + *FFS: whether to apply simultaneous PUCCH/PUSCH transmissions when PUCCH/PUSCH have the same priority.* |
| Nokia | **Proposal 3.15: For handling the scenarios where a PUCCH of a given priority crosses the sub-slot boundary of the PUCCH config of another priority and overlaps with a PUCCH of another priority, adopt the following procedure:**   * **Multiplexing of low-priority PUCCH and high-priority PUCCH, is allowed only if this multiplexing is done on a high-priority PUCCH resource. In addition:**    + **UE does not expect an overlap between the resulting PUCCH resource to be used for multiplexing and another high-priority PUCCH;**   + **and if the resulting PUCCH resource overlaps with a low-priority PUCCH, the low-priority PUCCH is then dropped.**   + **Additional conditions are FFS.**   **Proposal 3.16: For handling the scenarios with more than two overlapping PUCCHs of different priorities, adopt the following procedure:**   * **Allow a single checking/multiplexing step between channels of different priorities, where in case multiplexing is feasible:**    + **UE does not expect an overlap between the resulting resource to be used for multiplexing and a high-priority PUCCH;**   + **and if the resulting PUCCH resource overlaps with a low-priority PUCCH, the low-priority PUCCH is then dropped.**   **Proposal 3.27: Multiplexing of more than one PUCCH carrying HARQ-ACK on a PUSCH of different priorities should not be supported, as the multiplexing is also not supported for the scenario where PUSCH and HARQ-ACK are with the same priority.**  **Proposal 3.28:Multiplexing of more than one high-priority PUCCH, where one of them is carrying HARQ-ACK and the other one carrying SR, on a low-priority PUSCH could be supported.**  ***Observation 3.4: Potential multiplexing restrictions or partial UCI dropping for low-priority UCI of more than one overlapping PUCCH multiplexed on an overlapping high-priority PUSCH may be acceptable, whereas partial dropping or multiplexing restrictions of high-priority UCI is not acceptable.***  **Proposal 3.29: RAN1 needs to take the cases of more than two overlapping channels (involving at least one PUSCH) of different priorities into account when deciding whether to support certain multiplexing enhancements in first place. This is specifically important when considering the support of multiplexing high-priority UCI on low-priority PUSCH.**  **Proposal 4.1: RAN1 to clarify the intention of the support of simultaneous PUCCH / PUSCH, namely what to improve in terms of e.g. LP channel or information dropping, latency, reliability, efficiency, or the like.**  ***Observation 4.1: For the scenario of only having PUCCH for a certain priority, the support of simultaneous PUCCH/PUSCH transmission of different PHY priorities on different serving cells at least for inter-band CA requires changes to the overlapping determination and related cancelation behaviour of Rel-16 PHY prioritization operation.***  ***Observation 4.2: When considering more than two overlapping channels, the support of simultaneous PUCCH/PUSCH transmissions of different PHY priorities on different serving cells at least for inter-band CA to reduce the LP channel dropping in Rel-17 requires changes to all logical steps of the Rel-16 PHY prioritization operation, namely (i) the order of LP multiplexing and PHY prioritization, (ii) the order of PHY prioritization and HP UL multiplexing, (ii) the overlapping determination and (iv) the related cancelation behaviour of Rel-16 PHY prioritization operation.***  ***Observation 4.3*: *The support of simultaneous PUSCH/PUCCH transmission of the same PHY priority would increase low-priority information and channel dropping when taking the PHY prioritization into account.* *Moreover, multiplexing enhancements of the same PHY priority are not in scope of the WI objective.***  **Proposal 4.2: RAN1 to discuss and clarify, for which cases simultaneous PUCCH / PUSCH operation of different priorities should be supported with respect to the required changes to the PHY prioritization operation / behavior, including at least:**   * **Are changes to the processing order of LP multiplexing and PHY prioritization in scope?** * **Are changes to the processing order of PHY prioritization and HP UL channel multiplexing in scope?** * **Is the intention to support case-specific optimized solutions to enable simultaneous PUSCH/PUCCH of different PHY priorities for all possible overlapping cases or instead a generic enhancement of the PHY prioritization framework / procedure (with limitations for some cases)?** |
| CATT | ***Proposal 1: The time unit of high priority PUCCH is used as the time unit for multiplexing.***  ***Proposal 2: For a low priority PUCCH which goes across multiple time units for multiplexing, the low priority PUCCH joins the multiplexing procedure in each of the overlapping time units for multiplexing from the first overlapping time unit, unless the low priority PUCCH is determined to be dropped or multiplexed with other channels.***  ***Proposal 3: Rel-15 multiplexing timeline is reused for overlapping PUCCHs and/or PUSCHs with the same priority and overlapping PUCCHs and/or PUSCHs with different priorities when multiplexing would be applied.***  ***Proposal 4: The following working assumption can be confirmed.***  ***Working Assumption***  ***For handling overlapping PUCCHs/PUSCHs with different priorities in R17***   * ***Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority*** * ***Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities***   ***Note: Avoid recursive pseudo-code to implement this procedure***  ***Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable***  ***Proposal 15: For overlapping between PUCCH and multiple PUSCHs with different priorities, it is proposed that UCI of PUCCH is multiplexed on a PUSCH with a different priority only when there is no PUSCH with same priority overlaps with the PUCCH.*** |
| QC | **Proposal 3: when a UE is configured with simultaneous PUCCH/PUSCH transmission and Rel-17 intra-UE multiplexing, take the following steps to resolve collision between overlapping of two or more uplink channels**:   * **Step 1: Resolve overlapping PUCCH(s) and/or PUSCH(s) with the same priority**   + **Step 1.1: Overlapping PUCCHs of same priority are first resolved to obtain one final PUCCH for a given priority**   + **Step 1.2: Resolve overlapping between PUCCH and PUSCH(s) of the same priority:**      - **If all overlapping channels are of the same priority**        * **If the remaining PUCCH and PUSCH can be transmitted simultaneously, then**          + **Step 1.2.1: transmit the PUCCH and PUSCH(s) simultaneously**       * **Otherwise**         + **Step 1.2.2: multiplex the UCI on a PUSCH of the same priority**     - **Otherwise (i.e., if the remaining overlapping channels are with different priorities),**        * **Step 1.2.2: multiplex the UCI on a PUSCH of the same priority** * **Step 2: Resolve overlapping PUCCH(s) and/or PUSCH(s) with different priorities**    + **Step 2.1: resolving overlapping between HP PUCCH and LP PUCCH**   + **Step 2.2: resolving overlapping between PUCCH and PUSCH(s) of different priorities**      - **If the remaining PUCCH and PUSCH(s) can be transmitted simultaneously**       * **Step 2.2.1: transmit PUCCH and PUSCH(s) simultaneously**     - **Otherwise**       * **Step 2.2.2: multiplex the UCI on a PUSCH with different priority**   ***Proposal 21:* The Rel-17 intra-UE multiplexing feature is enabled/disabled via RRC configuration on per UE basis.** |
| Samsung | **Proposal 6: RRC separately configures enabling multiplexing of HP HARQ-ACK and LP HARQ-ACK for HP HARQ-ACK with and without a PDCCH.**  **Proposal 9: The time unit for resolving a collision of PUCCHs with different L1 priority indexes is the HP PUCCH time unit. Put LP HARQ-ACK PUCCH in the set Q of an associated overlapping HP PUCCH time unit and then run Rel-15 pseudo-code for PUCCH multiplexing.**   * **The associated overlapping HP PUCCH time unit is the first HP time unit with HP HARQ-ACK.**   **Proposal 10: Down select from the following options for multiplexing LP HARQ-ACK PUCCH, HP HARQ-ACK PUCCH and HP SR PUCCH in a PUCCH.**   * **Option 1) All PUCCHs are viewed with same priority – Rel-15 multiplexing applies.** * **Option 2) First, resolve overlapping of LP/HP PUCCHs with HARQ-ACK and then overlapping of resulting PUCCH and SR PUCCH (if any)**   **Proposal 13: RRC separately configures enabling multiplexing of HP PUSCH and LP HARQ-ACK for HP DG PUSCH and HP CG PUSCH.**  **Proposal 15: Confirm the following Working Assumption.**  **Working Assumption**  **For handling overlapping PUCCHs/PUSCHs with different priorities in R17**   * **Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority** * **Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities**   **Note: Avoid recursive pseudo-code to implement this procedure**  **Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable**  **Proposal 16: For handling overlapping PUCCHs/PUSCHs with different priorities in R17, cancel PUSCHs with semi-static DL conflict before intra UE multiplexing/prioritization.**  **Proposal 17: For handling overlapping PUCCHs/PUSCHs with different priorities in R17, Step 2 can consist of the following sub-steps.**   * **Sub-step 2-1: Resolve overlapping PUCCHs with different priorities.** * **Sub-step 2-2: Resolve overlapping PUSCHs with different priorities on a same cell.** * **Sub-step 2-3: Resolve overlapping PUCCHs and PUSCHs.**   **Proposal 18: A UE does not expect to multiplex a HP HARQ-ACK in a LP PUSCH which would be canceled by HP SR.**  **Proposal 19: RRC separately configures enabling multiplexing of LP PUSCH and HP HARQ-ACK for LP DG PUSCH and LP CG PUSCH.**  **Proposal 22: If a HP/LP HARQ-ACK PUCCH overlaps with multiple LP/HP PUSCHs, the priority for PUSCH selection can be PUSCH without UCI > PUSCH with UCI.**  **Proposal 23: If a PUCCH with HP HARQ-ACK and LP HARQ-ACK overlaps with both LP andHP PUSCHs, the priority for PUSCH selection can be HP PUSCH > LP PUSCH.**   * **FFS: LP DG PUSCH > HP CG PUSCH**   **Proposal 24: For PUSCH power allocation in case of CA, a LP PUSCH with HP HARQ-ACK should be prioritized over a PUSCH without HP HARQ-ACK.**  **Proposal 25: For UCI to be multiplexed on a PUSCH, the following conditions should be satisfied.**   * **Simultaneous PUSCH and PUCCH transmission does not apply.** * **The PUSCH satisfies the reliability requirements of the UCI.** |
| LGE | **Proposal #6: Consider to confirm the following working assumption on the overall procedure for the inter-priority multiplexing of UCIs on PUCCH/PUSCH.**   * **The overlapping PUCCHs and/or PUSCHs with the same priority are resolved first (Step 1), then the overlapping PUCCHs and/or PUSCHs with different priorities are resolved (Step 2)** * **It is desirable to proceed the multiplexing and transmission at least for HP PUCCH/PUSCH (if the timeline requirements among the HP PUCCH/PUSCH are met) even in case when the timeline requirements with LP are not met.**   **Proposal #18: Consider simultaneous PUCCH+PUSCH transmission together with the inter-priority multiplexing on PUCCH/PUSCH.**   * **The overall UL multiplexing/transmission behaviors could be different according to the outcome of Step 1 (“Resolve overlapping PUCCHs and/or PUSCHs with the same priority”) and enabling/disabling of three features as {inter-priority multiplexing on PUCCH, inter-priority multiplexing on PUSCH, simultaneous PUCCH+PUSCH transmission}.** |
| IDC | ***Proposal 1: For intra-UE multiplexing and prioritization, focus efforts on multiplexing transmissions of different priorities on same resource (first priority) and physical layer prioritization between DG and CG PUSCH (second priority).*** |
| Quectel | **Proposal 1**: Confirm the working assumption for the multiplexing framework achieved at RAN1#106-e.  **Proposal 3: In step 1 of 2-step procedure, overlapping PUCCHs and/or PUSCHs with the same priority is resolved by reusing Rel-15 procedure with Rel-15 timeline for each priority without the interaction between different priorities.**  **Proposal 4: In step 2 of 2-step procedure,**   * **Overlapping between PUSCH/PUCCHs of different priority is handled after resolving overlapping among channels of each priority in step 1, i.e., without the consideration of intermediate UL channel in step 1.** * **HP channel is transmitted, and LP channel is cancelled, if (1) LP channel carries UCI type not allowed to multiplex into a HP UL channel, or (2) LP channel ends later than HP PUCCH, if HP PUCCH would be multiplexed into the LP channel, or (3) Multiplexing timeline is not met, or (4) Multiplexing between different priority is disabled by gNB. Otherwise, multiplexing between LP and HP channel is performed.** * **A UE does not expect a resultant PUCCH/PUSCH of step 2 to be overlapped with a resultant PUCCH/PUSCH of step 1 with same priority to avoid recursive procedure (go back to step 1 again).**   **Proposal 5: In step 2 of 2-step procedure, UL channel multiplexing/cancellation is performed in time sequence (without prioritization of PUCCH multiplexing):**   * **A pair of overlapped UL channels with different priorities are checked at a time. Multiplexing/cancellation is determined by the rules provided by proposal 4.** |
| Intel | **Proposal 3: In step 1 of 2-step procedure, overlapping PUCCHs and/or PUSCHs with the same priority is resolved by reusing Rel-15 procedure with Rel-15 timeline for each priority without the interaction between different priorities.**  **Proposal 4: In step 2 of 2-step procedure,**   * **Overlapping between PUSCH/PUCCHs of different priority is handled after resolving overlapping among channels of each priority in step 1, i.e., without the consideration of intermediate UL channel in step 1.** * **HP channel is transmitted, and LP channel is cancelled, if (1) LP channel carries UCI type not allowed to multiplex into a HP UL channel, or (2) LP channel ends later than HP PUCCH, if HP PUCCH would be multiplexed into the LP channel, or (3) Multiplexing timeline is not met, or (4) Multiplexing between different priority is disabled by gNB. Otherwise, multiplexing between LP and HP channel is performed.** * **A UE does not expect a resultant PUCCH/PUSCH of step 2 to be overlapped with a resultant PUCCH/PUSCH of step 1 with same priority to avoid recursive procedure (go back to step 1 again).**   **Proposal 5: In step 2 of 2-step procedure, UL channel multiplexing/cancellation is performed in time sequence (without prioritization of PUCCH multiplexing):**   * **A pair of overlapped UL channels with different priorities are checked at a time. Multiplexing/cancellation is determined by the rules provided by proposal 4.**   **Proposal 20: If UE is configured with both simultaneous PUSCH and PUCCH transmissions over different carriers and Rel-16 or Rel-17 intra-UE prioritization, option of simultaneous transmissions should take precedence over the intra-UE prioritization/multiplexing in step 2.** |
| Apple | **Proposal 2-1: Step 2 consists of two steps:**  **In step 2-1, inter-L1 PUCCH multiplexing is performed.**  **HP PUCCH resources Z are arranged according to starting time. The earliest unprocessed HP PUCCH resource Z is scanned first, and any overlapping LP PUCCH resources Z are identified and the resulted HP PUCCH is the same as the PUCCH resource Z.**  **In Step 2-2: inter-L1 priority PUCCH/PUSCH multiplexing is performed.**   * + **For HP PUCCH and LP PUSCH:**     - **If simultaneous PUCCH/PUSCH is not supported by the UE or inter-band simultaneous PUCCH/PUSCH transmission is not configured by the gNB,**       * **LP PUSCHs on all CCs are candidates for UCI multiplexing over PUSCH, and the PUSCH selection rule is the same as in RAN1 #97 clarification;**     - **Otherwise**        * **Only LP PUSCH(s) which reside on a CC(s) at the same band of the PUCCH cell’s are candidates for UCI multiplexing over LP PUSCH.**   + **For LP PUCCH and HP PUSCH:**     - **If simultaneous PUCCH/PUSCH is not supported by the UE or inter-band simultaneous PUCCH/PUSCH transmission is not configured by the gNB,**       * **HP PUSCHs on all CCs are candidates for UCI multiplexing over PUSCH, and the PUSCH selection rule is the same as in RAN1 #97 clarification;**     - **Otherwise**        * **Only HP PUSCH(s) which reside on a CC(s) at the same band of the PUCCH cell’s are candidates for UCI multiplexing over HP PUSCH.** |
| MTK | 1. Multiplexing allowed only if the resulted PUCCH is confined within the sub-slot of the HP-PUCCH sub-slot. |
| vivo | ***Proposal 18: To avoid the dropping of LP UCI, the multiplexing order may need be reconsidered.***  ***Proposal 19: When simultaneous PUCCH/PUSCH over different cells is only configured, the following multiplexing procedure can be considered.***   * + ***Step 1: Perform PUCCH multiplexing per priority per PUCCH group.***   + ***Step 2: If an overlap happens between HP PUSCH and LP PUSCH on the same cell, the LP PUSCH is canceled.***   + ***Step 3: If LP PUCCH is overlapped with HP PUCCH, perform PUCCH/PUSCH multiplexing for LP or HP channel per PUCCH group.***     - ***If there is HP PUSCH or LP PUSCH, the UCI of HP or LP PUCCH would be multiplexed on the PUSCH with the same priority.***     - ***If there are both HP PUSCH and LP PUSCH, the UCI on LP PUCCH would be multiplexed on the LP PUSCH.***     - ***Otherwise, LP PUCCH is cancelled.***   + ***Step 4: The PUCCH/PUSCH on different cells are transmitted simultaneously.***   ***Proposal 20: It should be clarified whether and how the two mechanisms i.e., simultaneous PUCCH/PUSCH of different priorities and multiplexing of different priorities can be configured to work together.*** |
| OPPO | ***Proposal 8: If*** ***multiple PUCCHs carrying HP HARQ-ACK overlap with a PUCCH carrying LP HARQ-ACK, LP HARQ-ACK should be multiplexed with the HP HARQ-ACK transmitted on the earliest HP PUCCH which is in response to a DCI and satisfies the multiplexing timeline conditions.***   * ***A PUCCH resource in the PUCCH resource set configured for HP HARQ-ACK should be used.***   ***Proposal 9: If*** ***a PUCCH carrying HP dynamic HARQ-ACK overlaps with multiple PUCCHs carrying LP HARQ-ACK,***   * ***HP HARQ-ACK should be multiplexed with the LP HARQ-ACK transmitted on the LP PUCCHs satisfying the multiplexing timeline conditions, and a PUCCH resource in the PUCCH resource set configured for HP HARQ-ACK should be used;*** * ***Cannel the LP PUCCH does not satisfy the multiplexing timeline conditions (Rel-16 cancellation timeline should be satisfied).***   ***Proposal 10: The PUCCH resource for multiplexing HP dynamic HARQ-ACK and LP HARQ-ACK is determined based on the PRI indicated in the last HP DCI and an offset.***   * ***If the value of C-DAI in the last LP DCI is even or no LP DCI is received, ;*** * ***Otherwise, .***   ***Proposal 11: To determine the PUCCH resource set Q, described in TS 38.213 section 9.2.5, in a slot/subslot:***   * ***If a set of overlapping PUCCHs contains a first PUCCH carries HP HARQ-ACK and a second PUCCH carrying CSI or LP SR, delete the second PUCCH from set Q.*** * ***If a set of overlapping PUCCHs contains a first PUCCH carries HP SR and a second PUCCH carrying CSI, delete the second PUCCH from set Q.*** |
| DCM | **Proposal 11:**  *For step 2, if one PUCCH overlaps with multiple LP PUSCHs, multiplexing condition (e.g. latency and/or reliability condition) is considered before multiplexed LP PUSCH selection.*  **Proposal 12:**  *For step 2, when there are both PUCCH/PUCCH and PUCCH/PUSCH overlapping for different priorities, handling for collision of PUCCH/PUCCH overlapping with different priorities first, then handling for collision of PUCCH/PUSCH overlapping.*  **Proposal 13:**  *For the case when one PUCCH including HP and LP UCI (i.e. resulted from HP and LP UCI multiplexing) overlaps with multiple HP and LP PUSCHs, HP and LP UCIs can be multiplexed separately to different PUSCHs with corresponding priority.*  **Proposal 14:**  *For multiplexing of HP and LP PUCCHs across sub-slot boundary, HP sub-slot is determined as multiplexing time unit. LP PUCCH will be input for only one HP sub-slot for the pseudo code application.*   * *If the low priority HARQ-ACK PUCCH overlaps with any HP HARQ-ACK PUCCH, the first overlapping HP sub-slot in which the LP HARQ-ACK PUCCH overlaps with HP HARQ-ACK is selected.* * *Otherwise (if the LP HARQ-ACK PUCCH doesn’t overlap with any HP HARQ-ACK PUCCH), the first overlapping HP sub-slot in which the LP HARQ-ACK PUCCH overlaps with HP PUCCH is selected.*   **Proposal 15:**   * *Discuss processing order of intra-UE multiplexing with different priorities and cancellation due to dynamic SFI/UL CI/semi-static TDD and SSB.* |
| Spreadtrum | 1. ***According to multiplexing unit for HP/LP PUCCHs, use the HP PUCCH time unit, and the low priority PUCCH performs multiplexing or dropping procedure in the first overlapping time unit that contains high priority PUCCH (Option 1).*** |
| NEC | *different priorities on a same cell in Rel-17,*   * *Step 0: Resolve the overlapping between the PUSCHs with different priorities* * *Step 1: Resolve overlapping between PUCCHs and/or PUSCHs with the same priority* * *Step 2: Resolve overlapping between PUCCHs with different priorities and/or overlapping between PUCCHs and PUSCHs with different priorities* |
| TCL | **Proposal 1: Confirm the working assumption that for handling overlapping PUCCHs/PUSCHs with different priorities in R17**   * **Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority** * **Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities**   **Note: Avoid recursive pseudo-code to implement this procedure**  **Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable**  **Proposal 2: Regarding the scenario of multiplexing more than two overlapping channels, allow a single checking/multiplexing step between channels of different priorities after multiplexing (if any) between overlapping channels of the same priority is already done.** |
| Xiaomi | ***Proposal 2: If a slot based low priority PUCCH overlaps with multiple subslot based high priority PUCCH resources, and each subslot based PUCCH resources are contained in separate subslots, only multiplex the slot based PUCCH and the first subslot PUCCH resource, but not to multiplex both the two subslot based high priority PUCCH together.*** |
| ETRI | **Proposal 1: Confirmed the above working assumption about the multiplexing framework.**  **Proposal 2: If some LP UCI (i.e., CSI or SR) is dropped, then it is dropped as a payload.**  **Proposal 3: No special handling for multiplexing two or more LP ULCHs with a HP ULCH.** |
| Sharp | **Proposal 1: Confirm the working assumption for handling overlapping PUCCHs/PUSCHs with different priorities in R17**   * **Resolve overlapping channels of the same priority first, before resolve overlapping channels with different priorities.**   **Proposal 2: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH with total payload greater than 2 bits,**   * **The coding method can be configured between separate coding and joint coding.**   **Proposal 3: LP HARQ-ACK payload reduction can be configured by higher layer signaling, and be applied if the total payload exceeds the PUCCH capacity**   * **FFS the supported payload reduction methods.** |
| ITRI | **Proposal 1:**  Confirm the following working assumption:  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   Note: Avoid recursive pseudo-code to implement this procedure  Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable  **Proposal 5:**  Not support multiplexing of more than one PUCCH carrying HP HARQ-ACK on a LP PUSCH. |

## 1st round discussion

Proposal for 1st round discussion:

For handling overlapping PUCCHs/PUSCHs with different priorities in R17

* Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority
* Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities
  + [Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.](#_Toc84035002)
  + [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003)
  + [Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004)
  + [When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005)
  + If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.

To avoid recursive pseudo-code to implement this procedure,

* For long LP PUCCH overlapping with multiple short HP PUCCHs in step 2, multiplex LP UCI into the HP PUCCH resource.
* For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH.
* Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs should be avoided.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | The Working Assumption does not contain any of the sub-bullets in Step 2. We should firstly confirm the WA as it is and then try to iron out the sub-steps. That is we confirm the following:  *For handling overlapping PUCCHs/PUSCHs with different priorities in R17*   * *Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority* * *Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities*   *Note: Avoid recursive pseudo-code to implement this procedure*  *Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable* |
| Apple | Here are our views on the round 1 proposal in Section 2.3:  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority   + Hand the cases with/without simultaneous PUCCH/PUSCH transmission separately * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   + [~~Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.~~](#_Toc84035002)   + [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003)   + [~~Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.~~](#_Toc84035004)   + [~~When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.~~](#_Toc84035005) ~~(~~Apple: no need to single out sub-slot HARQ codebook, the solution to avoid recursive processing can handle the sub-slot HARQ codebook and other cases)   + If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.     - One procedure is conducted for LP PUCCH and HP PUSCH(s), another procedure is conducted for HP PUCCH and LP PUSCH(s)   + If inter-band simultaneous PUCCH and PUSCH transmission is NOT supported/configured, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.     - One procedure is conducted for LP PUCCH and HP PUSCH(s), another procedure is conducted for HP PUCCH and LP PUSCH(s)   To avoid recursive pseudo-code to implement this procedure,   * For HP PUCCH overlapping with multiple LP PUCCHs in step 2, multiplex eligible LP UCI(s) into the HP PUCCH resource of the HP PUCCH. * ~~For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH.~~ * ~~Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs should be avoided.~~ |
| Intel | Thanks for the good discussion in 1st GTW  **Agreement**  The following working assumption is confirmed.  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority   + Reuse existing procedure for low priority PUCCH / PUSCH and high priority PUCCH / PUSCH separately * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   Note: Avoid recursive pseudo-code to implement this procedure  Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable  Based on the agreement in GTW, we think it is better to align companies understanding for each note, before we go to details for each step, because different understanding of these notes would lead to different design for each step.  1. *Note: Avoid recursive pseudo-code to implement this procedure*  In our understanding, “avoid recursive pseudo-code” means not going back to step 1 after step 2. To achieve this goal, it is reasonable to consider that the resultant UL channel in step 2 with one priority does not overlap with another UL channel with same priority, if these two UL channels are not overlapped after step 1.  2. *Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable*  In our understanding, in step 1, within each priority, Rel-15 intra-UE UCI multiplexing timeline will be applicable. In step 2, it is possible that UCI multiplexing timeline is not met for different priorities. If the timeline is not met, LP is dropped.  It is noted that if we restrict that UCI multiplexing timeline is always met for different priorities, it leads to material performance degradation for HP transmission. Apparently, it does not make sense to improve LP performance at the cost of material degradation for HP.  It is also important to consider the interaction between simultaneous PUSCH/PUCCH transmission and UCI multiplexing. Considering RAN1 only agreed to support simultaneous PUSCH/PUCCH for different priority, we think there is no need to consider it in step 1 now. If RAN1 finally agreed to support simultaneous PUSCH/PUCCH for same priority, we can come back to check whether any modification in step 1 is needed. |
| QC | For the Proposal, first, we have a few high level comments.   1. Separate the discussion between “baseline” - which is slot based operation, with “enhancement” – which is mixed slot and sub-slot operation. We think RAN1 should settle down the baseline first before working on scenario with mixed slot and sub-slot operations. Therefore, we suggest to prioritize the discussion on baseline framework with slot based operation by filling in detailed sub-steps under both step 1&2, taking the consideration of interaction of simultaneous transmission and PUCCH/PUSCH multiplexing. Once we have a baseline framework for slot based operation, we can consider how to modify the framework to accommodate mixed slot and sub-slot based operation. 2. As we commented on GTW today, in Rel-15, it is base station’s responsibility to check timeline and make sure the scheduled overlapping channels compliant with the timeline requirements. UE does not check timeline and UE just run the multiplexing procedure assuming timeline is met. We think the same principle should be kept for Rel-17. Therefore, we don’t accept introducing timeline check at UE, i.e., if timeline meet, UE does behavior A; otherwise, UE does behavior B. This would impose large implementation change to UE. Unless there is a huge benefit is identified and justified, otherwise we don’t see the need to introduce this new behavior in Rel-17.   In the following, we insert some low level comments.  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority   [QC] detailed subs-steps should be added such as: step 1.1 mux between overlapping PUCCHs with same priority; step 1.2 mux between overlapping PUCCHs and PUSCHs with same priority, including procedures to handle potential simultaneous transmissions of PUCCH/PUSCH.   * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   + [Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.](#_Toc84035002)   [QC] detailed subs-steps should be added such as: step 2.1 mux between overlapping PUCCHs with different priorities; step 2.2 mux between overlapping PUCCHs and PUSCHs with different priorities, including procedures to handle potential simultaneous transmissions PUCCH/PUSCH.   * + [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003)   [QC] This sub-bullet should be removed for now, as we commented earlier, RAN1 should focus on finalizing baseline framework with slot based operation only. Mixture of slot and sub-slot based operation can be considered later.   * + [Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004)   [QC] As we commented before, we object the above sub-bullet.   * + [When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005)   [QC] This sub-bullet should be removed for now, as we commented earlier, RAN1 should focus on finalizing baseline framework with slot based operation only. Mixture of slot and sub-slot based operation can be considered later.   * + If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.   To avoid recursive pseudo-code to implement this procedure,   * For long LP PUCCH overlapping with multiple short HP PUCCHs in step 2, multiplex LP UCI into the HP PUCCH resource.   [QC] For the first bullet, we suggest to leave this scenario as FFS; First of all, there maybe a typo in the FL proposal. Did FL mean “multiplex LP UCI into the **first** HP PUCCH”? The proposal is ad hoc. The logic to pick the first HP PUCCH is not clear. Also, The proposed solution from the FL may work when all PUCCH contain HARQ-ACK, but it may be need more discussions when at least one of the PUCCH is with SR or CSI.   * For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH.   [QC] For the second bullet, we prefer to make it as an error case to let gNB avoid it, as in Rel-16.   * Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs should be avoided.   [QC] We are fine with the third bullet. |
| Ericsson | We support the proposal as a useful step forward.  Further details are needed to make a full procedure.   * Step 1 can include two sub-steps below. “Existing procedure” refers to Rel-16 procedure in our view, since Rel-16 procedure is a superset of Rel-15 and includes sub-slot also.   + Step 1(a). Reuse existing procedure for multiplexing low priority PUCCH and/or PUSCH, when high priority PUCCH or PUSCH is ignored.   + Step 1(b). Reuse existing procedure for multiplexing high priority PUCCH and/or PUSCH, when low priority PUCCH or PUSCH is ignored. * Step 2 can include two sub-steps below, similar to QC comment.   + Step 2(a). Resolve collision between LP PUCCH and HP PUCCH.   + Step 2(b). Resolve collision between PUCCH and PUSCH of different priorities.   Also: the PHY PUCCH/PUSCH multiplexing/cancellation procedure in Rel-15 and Rel-16 assumes no collision of two PUSCH on a cell. When two overlapping UL grants exist, only one PUSCH with MAC PDU is delivered to PHY. This principle should be followed in Rel-17. Thus, the prioritization of DG-PUSCH vs CG-PUSCH of different priorities should be handled before the PUCCH/PUSCH multiplexing/cancellation procedure in Rel-17. |
| DOCOMO | Our views for the proposal are added below:   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority   [DCM] in Step 1, the Rel-15 multiplexing procedure should be applied for the same priority PUCCHs and/or PUSCHs. In other words, for each priority, PUCCHs are multiplexed first by following the rule defined in 9.2.5 of 38.213 and then, if the final PUCCH overlaps with PUSCHs, it is piggybacked on one of the PUSCH by following the rule defined in 9 of 38.213.   * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   + Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.   [DCM] This should be deleted as it is not clear what Rel-15 procedure is. The remaining overlapping PUCCHs and/or PUSCHs are of different priorities in Step 2. Rel-17 multiplexing procedure should be applied rather than Rel-15.   * + When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.   [DCM] we prefer to add UCI type condition on top of the starting symbol condition. Specifically, as the figure below shows, if LP HARQ-ACK overlaps with two sub-slot based HP PUCCH, and the earlier HP PUCCH carries SR and the later HP PUCCH carries HARQ-ACK, the LP HARQ-ACK is multiplexed on the HP PUCCH carrying HP HARQ-ACK. The motivation is simplicity. As observed from discussions so far, behavior for “multiplexing for HP HARQ-ACK and LP HARQ-ACK” is easier and clearer than “multiplexing for HP SR and LP HARQ-ACK”  图示  描述已自动生成   * + Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.   + When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.   + If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands. |
| LG | As commented in 1st GTW session, it is better to discuss line by line.  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   [LG] Our view is that above Step 2 consists of two sub-steps: sub-step 2-1) resolve overlapping PUCCHs with different priority, and sub-step 2-2) resolve overlapping PUCCHs and PUSCHs with different priority.  Before the sub-step 2-1 (or after Step 1), it needs to check whether different priority UCIs on PUCCH is enabled. After the sub-step 2-1 (or before sub-step 2-2), it needs to check whether UCI on PUSCH with different priority is enabled and also whether simultaneous PUCCH+PUSCH TX is enabled.   * + [Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.](#_Toc84035002)   + [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003)   [LG] It seems to need some clarification. If the intention is to select the first overlapping HP sub-slot/PUCCH with HP HARQ-ACK satisfying the multiplexing timeline, we are fine with the way.   * + [Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004)   + [When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005)   [LG] It seems premature to be captured for now. It needs more discussion including other proposals such as based on comparison of ending symbol between HP HARQ-ACK PUCCH and LP PUSCH.   * + If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.   [LG] We don’t think performing Step 2 is required per band. As mentioned in above, simultaneous PUCCH+PUSCH TX is to be checked before the above sub-step 2-2 (resolve overlapping PUCCHs and PUSCHs with different priority) since the feature is applied for PUCCH and PUSCH with different priority as agreed.  To avoid recursive pseudo-code to implement this procedure,   * For long LP PUCCH overlapping with multiple short HP PUCCHs in step 2, multiplex LP UCI into the HP PUCCH resource. * For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH. * Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs should be avoided.   [LG] We prefer to leave the above cases as FFS points for now. It may need more considerations including mixed SCS case. |
| vivo | For the proposal, we have the following comments.   1. We cann’t understand why it is divided into slot-based HARQ codebooks and sub-slot based HARQ codebooks. If it is because we have to consider the case that one HP HARQ-ACK PUCCHs is overlapped with multiple LP PUCCH/PUSCH, or the case, multiple HARQ-ACK PUCCHs are overlapped with one LP PUCCH/PUSCH. We think it is also possible when different numerologies are used for PUCCH and PUSCH on different cells. So, we think the question is not slot based HARQ-ACK codebooks or sub-slot HARQ-ACK codebooks. It is one HP PUCCH is overlapped with one LP PUCCH/PUSCH, or it is one HP PUCCH is overlapped with more than one LP PUCCH/PUSCH, or it is more than one HP PUCCH is overlapped with one LP PUCCH/PUSCH. We think we can discuss the basic case, i.e, one HP PUCCH overlaps with one LP PUCCH/PUSH first. 2. For the interaction between simultaneous PUSCH/PUCCH transmission and UCI multiplexing, they are different UE features and are supported based on different UE capabilities. UE supports UCI multiplexing of different priorities may not support simultaneous PUCCH/PUSCH transmission. In addition, there seems no additional benefit is identified for UE to support both simultaneous PUSCH/PUCCH transmission and UCI multiplexing of different priorities comparing with only supporting UCI multiplexing of different priorities. So, we suggest to consider UCI multiplexing of different priorities only first. |
| Nokia/NSB | We support the proposal in principle.  In the following, we provide our understanding/views (in blue) on each of Steps 1 and 2.   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority   + Reuse existing procedure for low priority PUCCH / PUSCH and high priority PUCCH / PUSCH separately   🡨 Reuse Rel-15 multiplexing procedures for overlapping PUCCHs and/or PUSCH within each priority, i.e. handle overlapping PUCCHs first and then handle resulting PUCCH(s) overlapping with PUSCH.   * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   + We have similar view as Ericsson and QC, i.e. first handle overlapping PUCCHs of different priorities then handle resulting PUCCH(s) overlapping with PUSCH of different priorities.   + For overlapping PUSCHs of different priorities, we are open to further discuss when (i.e. after or before which sub-step) to handle such overlap. E.g. one way would be to consider Ericsson’s suggestion.   About the sub-steps under Step 2, we have the following comments:   * + [Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.](#_Toc84035002) 🡨 this sub-step is not fully clear, e.g. Rel-15 procedures cannot be really reused for all the cases.   + [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003) 🡨 We have similar suggestion as QC to first focus on slot-based operations.   + [Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004) 🡨 It should be noted that with the dynamic indication for enabling/disabling mux, the gNB can control the timeline to be met thus simplifying the specification handling.   + [When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005) 🡨 similar to above, we suggest to first focus on slot-based operations. It should be noted that with the dynamic indication for enabling/disabling mux, the gNB can control the timeline to be met thus simplifying the specification handling.   + If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands. 🡨 we should first clarify the interaction between the simultaneous PUCCH and PUSCH transmission and the intra-UE multiplexing/prioritization. |
| ZTE | For the sub-bullets of step 2, can we assume the 5 sub-bullets have processing order or no processing order should be followed?  It seems the last three sub-bullets do not intend to avoid recursive procedure but to solve the same issue for Rel-16 if we replace the inter-priority to intra-priority. |
| Sharp | With the confirmed working assumption, there are open issues for each step and should be further discussed.  Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority  In principle, Rel-15 methods can be reused for each priority separately. But some new cases need to be considered. For example, HP PUSCH has no subslot restriction, thus, a HP PUSCH may overlap with more than one HP PUCCH with HARQ-ACK. RAN1 should clarify how to handle this case, and whether the case should be avoided by gNB implementation.  Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities.  Using the subslot for HP PUCCH as unit for multiplexing, after Step 1, each subslot will have a maximum of one HP and one LP channel for collision resolution.  It is better to finalize on the details on two channel collision cases, e.g.   * HP SR + LP HARQ-ACK on PUCCH * HP HARQ-ACK on LP PUSCH * HP SR + LP PUSCH, etc.   Especially on the UCI multiplexing timing and symbol restrictions. If the UCI multiplexing is determined based on the timeline, and the HP UCI is multiplexed within the same subslot of the original HP PUCCH, there will be no recursive procedures. |
| Huawe/Hisi | To reduce the complexity for R17 multiplexing, it should avoid using timeline as the condition to judge whether to prioritize or multiplexing. In addition, it has been agreed in the last meeting that “*It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable*”. Therefore, the 2nd and the 3rd bullet should be removed. For the rest bullets, we would like to provide our views in-line.  “  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority   [HW] We share a similar view with Nokia that **R15** procedure should be adopted for per priority, respectively. For per priority, PUCCH/PUCCH overlapping is handled followed by PUCCH/PUSCH overlapping.   * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   [HW] We have a different view point from QC, E, LG, and Nokia, where LP PUCCH vs HP PUCCH is performed in prior to PUCCH vs PUSCH. Regarding there is a long LP PUCCH overlapping with multiple subslot based channels including a HP PUSCH at an earlier subslot and a HP PUCCH at a later subslot, the UE cannot look ahead the later subslot and perform the multiplexing between the long PUCCH in advance. In this sense, the simple way is to perform the multiplexing between LP channel and HP channel in the time order, i.e., the resulting LP channel is multiplexed with the earliest overlapped HP channel. If the three channels are all slot based, it can be FFS, and we prefer to adopt the same rule as the subslot based.     * + [Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.](#_Toc84035002)   [HW] It is not totally clear to us, since there is no inter-priority handling in R15.   * + [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003)   [HW] As mentioned, the above bullet should be removed.   * + [Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004)   [HW] As mentioned, the above should be removed.   * + [When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005)   [HW] Doing the dropping/multiplexing depending the PUSCH length is a bit complex, maybe a simple way is to avoid the overlapping case of one LP PUSCH with multiple HP PUCCHs by gNB.   * + If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.   [HW] Our preference is to perform the intra-priority multiplexing across bands; afterwards if the inter-band simultaneous Tx is enabled, the resulting channels with different priorities over different bands can be transmitted simultaneously; otherwise Step 2 is performed. Maybe it can be FFS after the multiplexing rule is more clear. |
| Samsung | Not support the proposal.  As we commented in GTW, the details of the proposal should be separately discussed, otherwise, it seems not possible to agree on anything.  For simplicity, simultaneous PUCCH and PUSCH transmission is enabled/disabled can be separately discussed. We suggest to first focus on the case where simultaneous PUCCH and PUSCH transmission is not enabled because this case cannot be avoided anyway based on the following conclusion.  **Conclusion**  Simultaneous PUCCH/PUSCH transmission on the same cell is not supported in Rel-17.  After the case where simultaneous PUCCH and PUSCH transmission is not enabled is solved, we can further discuss simultaneous PUCCH and PUSCH transmission. Simple solutions are preferred. For example, first remove the PUSCHs supporting simultaneous transmission before resolving the PUCCHs/PUSCHs overlapping. The removed PUSCHs can be transmitted if they are not canceled by a HP PUSCH.  **Proposal 1: If simultaneous PUCCH and PUSCH transmission is enabled, PUSCHs supporting simultaneous transmission are removed from the overlapping PUCCHs/PUSCHs group before multiplexing/prioritization of the overlapping PUCCHs/PUSCHs.**  For step 1, it should be easy to be agreed for the case where simultaneous PUCCH and PUSCH transmission is not enabled. In Rel-16, we first resolve overlapping PUCCHs/PUSCHs of the same priority and then we do prioritization of different priorities, if any.  **Proposal 2: For handling overlapping PUCCHs/PUSCHs with different priorities in R17**   * **Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority**   + **Reuse existing Rel-16 procedure if simultaneous PUCCH and PUSCH transmission is not enabled.**   As we discussed in our contribution, HP HARQ-ACK can be dropped after multiplexing in a LP PUSCH, such situation should clearly be avoided.  **Proposal 3: For handling overlapping PUCCHs/PUSCHs with different priorities in R17, dropping HP HARQ-ACK should be avoided.** |
| Intel | Thanks for the discussion. Please find some more comments (in blue) and suggested modification (in red) for the proposal provided by FL.  Proposal for 1st round discussion:  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority   Step 1a: For each priority, resolve overlapping PUCCHs as Rel-15.  Step 1b: For each priority, resolve overlapping resultant PUCCHs of step 1a and PUSCH as Rel-15.  [Intel] We share the same view with NOKIA and HW that R15 procedure should be adopted for each priority respectively. Based on this understanding, two sub-steps for step 1 are added.   * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities * Resolving overlapping PUCCHs and/or PUSCHs with different priorities can be multiplexing or prioritization, depending on the conditions.   + FFS conditions, e.g., HP UCI latency, timeline, UCI type eligible for multiplexing.   [Intel] We suggest to add this sub-bullet, because we think it is important to clarify that not only multiplexing but also prioritization (cancellation) as Rel-16 may happen in step 2. We can further discuss the conditions to perform multiplexing. For example:   * If the UCI type is not eligible for multiplexing with different priorities, LP UL channel should be dropped. 🡨 For example, if LP CSI is overlapped with HP HARQ-ACK, LP PUCCH should be dropped. * If the LP UL channel resulting from multiplexing HP PUCCH and LP PUCCH/PUSCH ends later than the last symbol of HP PUCCH, LP UL channel should be dropped. 🡨 this condition is to avoid increased latency of HP UCI. * If the multiplexing timeline is not met, LP UL channel should be dropped. 🡨 this condition is to ensure no additional scheduling restriction for HP channel compared with Rel-16. More details can be found in the discussion below the notes for timeline. * Resolving overlapping PUCCHs and/or PUSCHs with different priorities in the time order.   [Intel] We suggest to add this sub-bullet. We share the same view with HW that performing PUCCH multiplexing between different priorities prior to PUSCH/PUCCH multiplexing suggested by QC, E, LG, and Nokia requires look ahead operation at UE side. To avoid look ahead operation, we prefer to resolve overlapping PUCCHs and/or PUSCHs with different priorities in the tine order. Then, the example in HW’s figure, UE handles overlapping LP PUCCH and HP PUSCH first.  We’d like to point out, if we go with handling PUCCHs first, we need quite a lot effort to modify existing Rel-15 pseudo-code. As we analyzed in our tdoc (section 3, R1-2109607), e.g., :   * How to handle the case, if LP PUCCH is slot-based while HP PUCCH is sub-slot based. 🡨we need to define the time unit for set Q, and we need to define which set Q (which sub-slot) to add LP PUCCH resource in. Currently, we see different solutions are provided by different companies. * How to handle LP PUCCH resource which would be cancelled. 🡨we need to add additional step in the middle of existing Rel- multiplexing 15 pseudo-code. No discussion yet.   Considering very limited time in Rel-17, we’re quite pessimistic that we can finish the work for all the modifications as discussed above for PUCCH multiplexing first mechanism.  Therefore, we prefer the simpler way, i.e., resolve overlapping PUCCHs and/or PUSCHs with different priorities in the time order.   * + [Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.](#_Toc84035002) 🡨 suggest to removed   [Intel] We share similar view with other companies, it is unclear how to directly reuse Rel-15 procedure for inter-priority handling in step 2.   * + [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003) 🡨 suggest to removed   [Intel] This sub-bullet can be removed if we resolve overlapping PUCCHs and/or PUSCHs with different priorities in the time order.   * + [Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004) 🡨 suggest to move to under the newly added sub-bullet of conditions to multiplexing or prioritization, or the newly added sub-bullet for timeline note.   [Intel] We understand the intension here is to allow flexible scheduling for HP as Rel-16, thus we need to hand the case that the timeline is not met. We support the proposal. Maybe we can discuss it under the newly added sub-bullet, i.e., condition to perform multiplexing or prioritization.   * + [When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005) 🡨 suggest to move to under the newly added sub-bullet of conditions to multiplexing or prioritization   [Intel] We understand the intension here is to avoid increased latency for HP UCI, and we agree with the intention. We’re open to further discuss how to achieve this goal. Maybe we can discuss it under the newly added sub-bullet, i.e., condition to perform multiplexing or prioritization.   * + If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.   [Intel] We’re fine with this sub-bullet, we’re also fine to discuss it later.  Note: Avoid recursive pseudo-code to implement this procedure.   * UE does not expect to go back to step 1 after step 2.   [Intel] We suggest adding this sub-bullet to spell out what kind of recursive pseudo-code should be avoided. In our understanding, “avoid recursive pseudo-code” intends to avoid recursive step between step 1 and step 2. We’d like to hear companies’ views.   * To avoid recursive pseudo-code to implement this procedure, * The resultant UL channel in step 2 with one priority should not overlap with another UL channel with same priority, if these two UL channels are not overlapped after step 1.   [Intel] Based on the understanding of not going back to step 1 after step 2, we propose to add this sub-bullet. As shown in the figure below. The figure on the right hand is not allowed. Otherwise, UE needs to go back to step 1 to resolve overlapping new HP PUCCH1 and HP PUCCH2 again. Such recursive step should be avoided.    After step 1 After step 2   * For long LP PUCCH overlapping with multiple short HP PUCCHs in step 2, multiplex LP UCI into the HP PUCCH resource. 🡨 suggest to remove   [Intel] If we resolve overlapping PUCCHs and/or PUSCHs with different priorities in the time order for step 2 as suggested above, this sub-bullet can be removed.   * For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH. 🡨 suggest to move to under the newly added sub-bullet of conditions to multiplexing or prioritization   [Intel] Maybe we can discuss it under the newly added sub-bullet, i.e., condition to perform multiplexing or prioritization   * Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs should be avoided.   [Intel] The relation between this proposal and recursive pseudo-code is unclear to us. Is the intension to avoid handling the same HP channel twice? We think it would be helpful to first clarify the understanding of “Avoid recursive pseudo-code” first, then, discuss how to achieve this goal.  Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable   * Rel-15 intra-UE UCI multiplexing timeline will be applicable for each priority in step 1. * Rel-15 intra-UE UCI multiplexing timeline may be not applicable for different priority in step 2.   + If the timeline is not met, reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH   [Intel] For 1st sub-bullet, if the timeline within each priority is not met, it is error case, as Rel-15. For 2nd sub-bullet, if the timeline is not met between different priorities, it is not treated as error case. Instead, Rel-16 prioritization is performed as long as the cancellation timeline is met. UE does not expect the cancellation timeline is not met as Rel-16.  We think it is important to allow the timeline not met in Step 2. If we restrict that UCI multiplexing timeline is always met for different priorities in step 2, it leads to material performance degradation for HP transmission. Apparently, it does not make sense to improve LP performance at the cost of material degradation for HP. The figures 1-1~1-3 in R1-2109607 provides an example to explain the impact of HP, if we restrict multiplexing timeline is met. |
| Quectel | For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority   Similar views as Nokia that handling overlapping PUCCHs first and then handling resulting PUCCH(s) overlapping with PUSCH.   * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   + [Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.](#_Toc84035002)   Unclear for us.   * + [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003)   More discussions may be needed. For an example, when LP PUCCH overlaps with both of an earlier HP PUSCH and a later HP PUCCH, we think LP PUCCH should be multiplex in HP PUSCH rather than HP PUCCH. And also, we share similar views as QC and Nokia to first focus on slot-based operations.   * + [Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004)   + [When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005)   Similar view as above, we can first focus on slot-based rules.   * + If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.   To avoid recursive pseudo-code to implement this procedure,   * For long LP PUCCH overlapping with multiple short HP PUCCHs in step 2, multiplex LP UCI into the HP PUCCH resource. * For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH. * Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs should be avoided. |
| OPPO | The working assumption was confirmed in GTW as shown in the following.  **Agreement**  The following working assumption is confirmed.  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority   + Reuse existing procedure for low priority PUCCH / PUSCH and high priority PUCCH / PUSCH separately * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   Note: Avoid recursive pseudo-code to implement this procedure  Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable  Regarding to yellow part, companies’ views are not fully aligned, especially for the meaning of existing procedure. In our understanding, R15 multiplexing procedure and intermediate multiplexing procedure in R16 prioritization in spec is different, including:   1. R15 multiplexing is performed for final PUCCH channel only. But intermediate multiplexing procedure in R16 prioritization in spec is performed for intermediate PUCCH channel.   Taking HARQ-ACK overriding as an example, PUCCH 1 is a the first PUCCH for HARQ-ACK and PUCCH 2 is the second PUCCH for HARQ-ACK, which is indicated by later DCI for HARQ-ACK and overrides the first PUCCH for HARQ-ACK. For R15 multiplexing procedure, only PUCCH 2 for HARQ-ACK is considered in multiplexing. For R16 prioritization, PUCCH1 and PUCCH2 will be perform multiplexing separately.   1. The time to multiplex is different. For R15 multiplexing, it depends on UE implementation and one efficient solution is that assuming multiplexing timeline should be satisfied, UE performs multiplexing at T (multiplexing processing time) before the earliest overlapping uplink channel. For R16 prioritization, once overlapping is determined, intermediate multiplexing and prioritization will be performed.   Considering R16 multiplexing’s complexity raise some companies’ concern and the related procedure is still being discussed in R16 maintenance, we prefer to **reuse R15 multiplexing procedure** for low priority PUCCH / PUSCH and high priority PUCCH / PUSCH separately  Regarding details below step 2, We list our views in the following:   * [Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.](#_Toc84035002)   [OPPO]: Generally, we are fine to reuse R15 procedure for eligible UCI and PUSCH, i.e. non-eligible UCI is dropped before pseudo-code for multiplexing is performed. However, we are not sure restriction on slot-based HARQ-ACK codebook is necessary. So we suggest to modify it as:  Updated proposal:  [Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, ~~if only slot-based HARQ~~ ~~codebooks are used~~.](#_Toc84035002)   * [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003)   [OPPO]: Proposal intends to solve the case that LP PUCCH overlaps with multiple PUCCHs, and LP PUCCH will be multiplexed with overlapping HP PUCCH with the earliest staring symbol. But it does not mean that final multiplexed PUCCH should be the original overlapping HP PUCCH. In fact, Final multiplexed PUCCH maybe updated due to payload size changes. So we suggest to change “onto” to “with”,  Updated proposal:  [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI ~~onto~~ with HP UCI in the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003)   * [Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004)   [OPPO] We are fine with proposal assuming at least one of R15 multiplexing timeline and R16 prioritization timeline should be satisfied for all overlapping uplink channels.  Updated proposal:  [Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004)   * It is expected that the LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH meet Rel-16 prioritization timeline. * [When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005)   [OPPO]Firstly, it is not necessary to distinguish sub-slot HARQ codebook and slot-HARQ codebook. Unified solution for any HARQ codebook is preferred. Secondly, Timeline based on PUSCH ending is too restrictive due to UCI can be multiplexed in limited front symbols of PUSCH. So we suggest that  Updated proposal:  [~~When sub-slot HARQ codebooks are used, only~~ ~~m~~Multiplex HP HARQ-ACK onto a LP PUSCH if ~~the LP PUSCH ends in the same sub-slot as the HP PUCCH.~~ The ending symbol used for UCI transmission in a low-priority PUSCH is not later than the ending of high-priority PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005)   * If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.   [OPPO] Deprioritize. We prefer to discuss simultaneous PUCCH and PUSCH transmission firstly, then consider interaction between intra-UE multiplexing and simultaneous transmission. |
| InterDigital | Support the proposal. Ericsson suggestion for the details seems to be a good starting point. |
| Xiaomi | To better understand the frame work, we have a question for the below case,    Which behavior is aligned with the proposed framework?  Bahv 1: UE do multiplexing for HP PUCCH1 and HP SR1 in subslot 0 firstly , then do multiplexing for HP PUCCH2 and HP SR2 in subslot 1, and at last, UE do multiplexing for HP PUCCH1/2 and HP SR1/2 and LP PUCCH 0 in slot 0  Bahv 1: UE do multiplexing for HP PUCCH1 and HP SR1 in subslot 0 firstly , then do multiplexing for HP PUCCH1 and HP SR1 and LP PUCCH 0 in slot 0. HP PUCCH2 and HP SR2 in subslot 1 should be multiplexed but will not be multiplexed to HP PUCCH1 and HP SR1 and LP PUCCH 0.  In short, our question is the mentioned “step 1” and “step 2” is subslot based or slot based? |
| CATT | With the agreement made in previous GTW session, we provide our comments to the remaining bullets as follows.  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   + [Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.](#_Toc84035002)   [CATT] Similar as DCM and Nokia, the bullet is not clear to us. If the intention is to multiplex PUCCHs with different priorities first followed by multiplexing of PUCCH and PUSCH with different priorities, we are fine with the intention. For slot-based vs. non-slot based HARQ-ACK codebook, we would appreciate if FL can clarify the intention for separate discussions.   * + [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003)   + [Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004)   [CATT] For the multiplexing timeline, we share the view from Intel that we should not mandate that timeline should always be satisfied which would severely restrict the scheduling of HP channels. So we agree that the timeline may or may not be met and the UE behavior can be different in different cases. In addition, there is an interaction with other proposals in section 3.3.2 and 4.4.2 on dynamic indication of enabling/disabling the multiplexing.   * + [When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005)   [CATT] What is the intention of the proposal? Is it to avoid multiplexing different HP HARQ-ACK codebooks in different sub-slot into a same PUSCH?   * + If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.   [CATT] After performing step 2 per band, there can be simultaneous PUCCH transmissions in different bands which need to be resolved. In addition, similar handling should be considered in step 1.  To avoid recursive pseudo-code to implement this procedure,   * For long LP PUCCH overlapping with multiple short HP PUCCHs in step 2, multiplex LP UCI into the HP PUCCH resource.   [CATT] The bullet and the relationship with the second sub-bullet above is not clear.   * For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH. * Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs should be avoided. |
| NEC | For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority   [NEC] We share the same view with Nokia/HW/Intel that R15 multiplexing procedure should be adopted for per priority, respectively. For each priority, handle the PUCCH/PUCCH overlapping first, then handle the PUCCH/PUSCH overlapping.   * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   [NEC] We share the same view with Samsung that simultaneous PUCCH and PUSCH transmission is enabled/disabled would be better separately discussed.   * + [Reuse Rel-15 procedure in step 2 for multiplexing eligible UCIs, or multiplexing eligible UCI and PUSCH, of different priorities, if only slot-based HARQ codebooks are used.](#_Toc84035002)   [NEC] It is not clear to us, does it mean that multiplexing eligible UCIs or eligible UCI and PUSCH as they have same priority? It would be further discussed.   * + [When LP PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH and the multiplexing timeline is met, multiplex the LP UCI onto the overlapping HP PUCCH which has the earliest starting symbol.](#_Toc84035003)   [NEC] We share similar view with Nokia that whether dynamic indication for enabling/disabling multiplexing should be taken into account. If dynamic indication for multiplexing of UCIs or UCI and PUSCH with different priorities is supported, LP UCI will be multiplexed on which HP PUCCH can be indicated by gNB.   * + [Reuse Rel-16 prioritization for LP PUCCH/PUSCH overlapping with HP PUCCH/PUSCH that does not meet the Rel-15 multiplexing timeline.](#_Toc84035004)   [NEC]Similar comment as above.   * + [When sub-slot HARQ codebooks are used, only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH. Otherwise deprioritize the LP PUSCH according to Rel-16 rules.](#_Toc84035005)   [NEC]Similar comment as above.   * + If only inter-band simultaneous PUCCH and PUSCH transmission is supported, perform step 2 in the intra-UE multiplexing framework per band. Then transmit PUCCH and PUSCH simultaneously on different bands.   To avoid recursive pseudo-code to implement this procedure,   * For long LP PUCCH overlapping with multiple short HP PUCCHs in step 2, multiplex LP UCI into the HP PUCCH resource. * For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH. * Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs should be avoided. |
|  |  |

**Agreement**

The following working assumption is confirmed.

For handling overlapping PUCCHs/PUSCHs with different priorities in R17

* Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority
  + Reuse existing procedure for low priority PUCCH / PUSCH and high priority PUCCH / PUSCH separately
* Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities

Note: Avoid recursive pseudo-code to implement this procedure

Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable

1st round discussion status:

**Issue 2.1: Whether to consider simultaneous PUCCH/PUSCH transmission in Step 1?**

* Option 1: Simultaneous PUCCH/PUSCH transmission is considered in Step 1, i.e. simultaneous PUCCH and PUSCH in same priority is supported, after UCI multiplexed into PUCCH.
  + Apple
* Option 2: Simultaneous PUCCH/PUSCH transmission is only considered in Step 2, i.e. simultaneous PUCCH and PUSCH is only used to handle overlapping between different priorities. (Note: There is no agreement to support simultaneous PUCCH/PUSCH transmission between different priorities.)
  + Intel, Samsung

**Issue 2.2: Details of the “existing procedure” for Step 1?**

* Focusing on the case where only slot-based HARQ codebooks are used, reuse Rel-15 procedure for Step 1:
  + For each priority, PUCCHs are multiplexed first by following the rule defined in 9.2.5 of 38.213 and then, if the final PUCCH overlaps with PUSCHs, it is piggybacked on one of the PUSCH by following the rule defined in 9 of 38.213.
  + For each priority, the above procedure is performed as the PUCCH or PUSCH with the other priority is ignored.
  + FFS for HP PUCCH with sub-slot based HARQ-ACK.
  + QC, DCM, HW, E///, OPPO, NEC, Nokia/NSB

**Issue 2.3: Details of Step 2?**

* Focusing on the case where only slot-based HARQ codebooks are used, Step 2 consists of the following sub-steps:
  + Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.
    - Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.
  + Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities, e.g., multiplexing or prioritization.
    - If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 is the simultaneous PUCCH and PUSCH transmission in different cells.
    - FFS: Which PUSCH is used for multiplexing.
  + FFS for HP PUCCH with sub-slot based HARQ-ACK.
  + FFS in which sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH.
  + QC, E///, LG, Nokia/NSB
* At least w[hen LP HARQ-ACK PUCCH overlaps with HP sub-slot based HARQ-ACK PUCCH, multiplex the LP UCI onto the overlapping HP PUCCH with the earliest starting symbol satisfying the multiplexing timeline.](#_Toc84035003) FFS other sub-slot based UCI types.
  + DCM,

**Issue 2.4: How to ensure the multiplexing timeline without UE-side checking?**

* For Rel-17 intra-UE UCI multiplexing,
  + UE does not check timeline, but just runs the multiplexing procedure assuming timeline is met.
  + Support dynamic indication for enabling/disabling multiplexing by gNB to ensure the scheduled overlapping channels compliant with the timeline requirement.

**Issue 2.5: Conditions to avoid recursive pseudo-code to implement this procedure?**

* **Principle:** “Avoid recursive pseudo-code” means not going back to step 1 after step 2, i.e. resultant UL channel in step 2 with one priority does not overlap with another UL channel with same priority, if these two UL channels are not overlapped after step 1.
  + Intel
* **Condition 1:** For HP PUCCH overlapping with multiple LP PUCCHs in step 2, multiplex eligible LP UCI(s) into the HP PUCCH resource of the first HP PUCCH. (The condition is at least applicable in case HARQ-ACK. FFS for CSI and SR.)
  + Support: Apple, QC
* **Condition 2:** For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH.
  + Concern: Apple, QC (error case)
* **Condition 3:** Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs should be avoided.
  + Support: QC

**Issue 2.6: Handling prioritization of CG-PUSCH?**

* The prioritization of DG-PUSCH vs CG-PUSCH of different priorities should be handled before the PUCCH/PUSCH multiplexing/cancellation procedure in Rel-17.
  + Support: E///

## 2nd round discussion

Based on the comments from 1st round discussion, the following issues are identified for the 2nd round discussion.

## Whether to consider simultaneous PUCCH/PUSCH transmission in Step 1?

Proposal for 2nd round discussion:

Simultaneous PUCCH/PUSCH transmission is only considered in Step 2, i.e. simultaneous PUCCH and PUSCH is only used to handle overlapping between different priorities.

* Note: There is no agreement to support simultaneous PUCCH/PUSCH transmission between different priorities.

|  |  |
| --- | --- |
| Company | Comments |
| QC | We disagree with the proposal, especially the note.  Please refer to the following agreement in RAN1# 102e. The agreement is a generic agreement covers same and different priority, as it does not say “Support … only for different priority”. The note overturns the existing agreement.  Agreements:  Support simultaneous PUCCH/PUSCH transmissions on different cells at least for inter-band CA.   * FFS how to trigger this function. * FFS for intra-band CA.   From technical point of view, if UE can support simultaneous PUCCH/PUSCH transmission for different priorities, we don’t see any reason to not support it for same priority.  If excluding this feature for same priority, then HP long PUCCH (e.g., with 14 OFDM symbol) on PCC with 30Khz SCS which is meant for high reliability will be multiplexed on a short HP PUSCH (e.g. 1 OFDM symbol) PUSCH on FR2 Scell with 120Khz. This is very problematic for URLLC. |
| Samsung | We share similar view as QC.  Supporting simultaneous PUCCH/PUSCH transmissions regardless of the priority can simplify multiplexing. PUSCHs that support simultaneous PUCCH/PUSCH transmissions can be precluded before multiplexing/prioritization.  Having said that we can compromise with only different priorities to make progress. |
| Intel | We support the proposal. |
| InterDigital | Support |
| DOCOMO | Support the proposal if the note is corrected as follows:   * Note: There is no agreement to support simultaneous PUCCH/PUSCH transmission between same priority ~~different priorities~~.   In our understanding, the following agreement clarifies that simultaneous PUCCH/PUSCH transmission between different priorities is supported in Rel-17. There is no agreement or conclusion on support of simultaneous PUCCH/PUSCH Tx for the same PHY priority.  Agreements:  Per UE with the capability of inter-band CA, simultaneous PUCCH/PUSCH transmission of different PHY priorities over different cells can be RRC configured within the same PUCCH group   * FFS: dynamic indication |
| CATT | We had the following agreement in RAN1#104-e.  Agreements:  Per UE with the capability of inter-band CA, simultaneous PUCCH/PUSCH transmission of different PHY priorities over different cells can be RRC configured within the same PUCCH group   * FFS: dynamic indication   Is it a typo that ‘different’ in the sub-bullet should be ‘same’?  From our perspective, we think it is beneficial to support simultaneous PUCCH/PUSCH transmission of same PHY priority and it does not introduce additional complexity at UE side. Therefore, we prefer to consider simultaneous PUCCH/PUSCH transmission in both step 1 and step 2. However, we can also accept that simultaneous PUCCH/PUSCH transmission is only supported with different priorities. |
| TCL | We support the proposal. |
| Quectel | Some similar views as QC. We can also accept simultaneous PUCCH/PUSCH transmissions with different priories only. |
| NEC | Support the proposal in principle. As pointed out by other companies, the note is not clear for us, the original intention is ‘There is no agreement to support simultaneous PUCCH/PUSCH transmission between same priority ~~different priorities~~’ or ‘There is no agreement to support simultaneous PUCCH/PUSCH transmission between different priorities on a cell’. |
| vivo | We think according to the agreement we made before, simultaneous PUCCH/PUSCH transmissions on different cells at least for inter-band CA is supported regardless of same priority or different priorities. However, for intra-UE multiplexing, both simultaneous transmission of PUCCH/PUSCH of different priorities and multiplexing of UL transmissions with different priorities can be used to reduce the dropping of LP UCI. Whether these two features can be enabled simultaneously should be discuss first. There is no significant benefit but additional complexity is observed from enabling both features comparing with enabling one of them. We prefer to not consider simultaneous PUCCH/PUSCH transmissions in step 1 nor step 2. |
| LG | We support the proposal from FL. |
| Huawei/Hisi R2 | Support DOCOMO’s version.  @QC To the question of HP long PUCCH vs short HP PUSCH, we think the problem can be avoided by gNB scheduling, e.g., the gNB can schedule a longer HP PUSCH on FR2 Scell? |
| Nokia/NSB | Support the proposal, just a small typo in the note would need to be fixed (since we have already agreed to support simultaneous PUCCH/PUSCH transmission of different priorities):  Note: There is no agreement to support simultaneous PUCCH/PUSCH transmission ~~between different~~ of the same priority~~ies~~. |
| OPPO | We’d like to deprioritized simultaneous PUCCH/PUSCH transmission related discussion due to the following reasons:   1. Discussion on simultaneous PUCCH/PUSCH transmission is going on and there are some open issues, e.g. Support simultaneous PUCCH/PUSCH transmission with the same priority or not, support simultaneous PUSCH/PUCCH transmission for intra-band CA or not, support simultaneous PUSCH/PUCCH transmission in the same cell or not, these open issues impact joint operation for simultaneous PUCCH/PUSCH transmission and intra-UE multiplexing directly.   Before we discuss details, we’d better to discuss whether to support joint operation for simultaneous PUCCH/PUSCH transmission and intra-UE multiplexing. In our understanding, these two functions achieve the same goal, i.e. avoid LP UCI information dropping, so these two functions are not necessary to be supported simultaneously, especially taking limited time for R17 into account. |
| ZTE | Support the proposal with DOCOMO’s revision. We can suspend the discussion on simultaneous PUCCH/PUSCH transmission in Step 1 |
| Sony | Share same view as CATT that simultaneous PUCCH/PUSCH transmission should also be supported for same L1 priority. That is the proposal can be supported also for same L1 priority. |
| MediaTek | We agree with QC’s comment. The agreement was generic and didn’t exclude “same priority”.  From UE implementation, there is no difference between supporting simultaneous PUCCH/PUSCH transmission for different priorities and same priorities. The gNB may choose to not configure different priorities but enable simultaneous PUCCH/PUSCH transmission. |
| Sharp | We should not make decision here.  If it is agreed that simultaeouse PUCCH and PUSCH is applicable only for channels with different priorities, then we support the proposal. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Proposed working assumption after 2nd round discussion:

Simultaneous PUCCH/PUSCH transmission is not considered in Step 1, i.e. simultaneous PUCCH and PUSCH is only used to handle overlapping between different priorities if it is used.

* Note: There is no agreement to support simultaneous PUCCH/PUSCH transmission for same priority.
* Support: Intel, IDC, DCM, CATT, TCL, Quectel, NEC, LG, vivo (not for Step 2 either), HW, Nokia, OPPO (not for Step 2 either), ZTE, Ericsson
* Not support: QC, MTK

**Proposal for a Working Assumption** (after Friday GTW session)

Simultaneous PUCCH/PUSCH transmission is not considered in Step 1, i.e. if simultaneous PUCCH/PUSCH transmission is enabled, it is only used to handle overlapping between different priorities.

* Note: There is no agreement to support simultaneous PUCCH/PUSCH transmission for same priority.

## Details of the “existing procedure” for Step 1

Proposal for 2nd round discussion:

Focusing on the case where only slot-based HARQ codebooks are used, reuse Rel-15 procedure for Step 1:

* For each priority, PUCCHs are multiplexed first by following the rule defined in 9.2.5 of 38.213 and then, if the final PUCCH overlaps with PUSCHs, it is piggybacked on one of the PUSCH by following the rule defined in 9 of 38.213.
* For each priority, the above procedure is performed as the PUCCH or PUSCH with the other priority is ignored.
* FFS for HP PUCCH with sub-slot based HARQ-ACK.

|  |  |
| --- | --- |
| Company | Comments |
| QC | We are fine with the principle of this proposal. We suggest some editorial changes as below.  Focusing on the case where only slot-based PUCCH~~HARQ codebooks~~ are used, reuse Rel-15 procedure for Step 1:   * For each priority, PUCCHs are multiplexed first by following the Rel-15 rule defined in subclause 9.2.5 of 38.213 and then, if the final PUCCH overlaps with PUSCHs, it is piggybacked on one of the PUSCH by following the Rel-15 rule defined in subclause 9.3 of 38.213. * For each priority, the above procedure is performed ~~as~~ where the PUCCH or PUSCH with the other priority is ignored. * FFS for HP PUCCH with sub-slot based PUCCH ~~HARQ-ACK~~. |
| Samsung | We don’t understand why we need to focus on slot based in Step 1. There is no interaction between different priorities in Step 1. For Step 2, we may first focus on the PUCCH time unit first including slot based and same sub-slot length for HP and LP PUCCH.  ~~Focusing on the case where only slot-based HARQ codebooks are used, r~~Reuse Rel-15 procedure for Step 1:   * For each priority, PUCCHs are multiplexed first by following the rule defined in 9.2.5 of 38.213 and then, if the final PUCCH overlaps with PUSCHs, it is piggybacked on one of the PUSCH by following the rule defined in 9 of 38.213. * For each priority, the above procedure is performed as the PUCCH or PUSCH with the other priority is ignored. * ~~FFS for HP PUCCH with sub-slot based HARQ-ACK.~~ |
| Intel | We’re fine with the proposal.  Though we think sub-slot based HP PUCCH is very important scenario, we’re fine to discuss slot-based scenario first for both step 1 and step 2. |
| InterDigital | Agree with Samsung |
| DOCOMO | Support the principle of the proposal. Fine with the updates by Qualcomm. |
| CATT | The conclusion in section 2.4.1 may impact the proposal here.  We agree with the comment from Samsung that there is no need to differentiate slot and sub-slot based PUCCH transmission for step 1. |
| Quectel | We are generally fine with this proposal if simultaneous PUCCH/PUSCH transmissions with same priority is NOT supported. Otherwsie, PUCCH may not always be piggybacked on PUSCH depending on whether simultaneous transmission is enabled or reported by UE. |
| NEC | Fine with the proposal. |
| vivo | Agree with Samsung, for step 1, both slot based and sub-slot based can be considered and same procedure is used. |
| LG | We support the update from Samsung. |
| Huawei/Hisi R2 | Support QC’s version. |
| Nokia/NSB | Support the proposal in principle. We are fine with QC’s and Samsung’s edits (to agree the same operation for slot- and sub-slot based HARQ CBs). |
| OPPO | Support. Although we think that unified solution for slot-based HARQ codebook and sub-slot based HARQ codebook should be considered, we could compromise to agree slot-based HARQ codebook case firstly |
| ZTE | Fine with the proposal. We also suggest considering slot based HARQ codebook at first.  Note: different numerology will also cause different slot length, I assume we don’t preclude the different numerology case in this proposal. |
| Sony | Similar to Samsung’s comment, it isn’t clear why there is a need to differentiate between slot and sub-slot for a single L1 priority. Is this for scenario where PUSCH overlaps multiple sub-slot based PUCCHs of the same L1 priority? Isn’t this case already sorted in Rel-16? |
| MediaTek | We have issue with the following part “*if the final PUCCH overlaps with PUSCHs, it is piggybacked on one of the PUSCH by following the rule defined in 9 of 38.213*”. It seems it contradict with the assumption that simultaneous PUCCH/PUSCH transmission can be enabled for same priorities. Is the intention to say “PUCCH overlaps with PUSCHs *on the same cell*”?  A clarification on the “PUCCH overlaps with PUSCHs” is needed. |
| QC2 | We think simultaneous Tx should be included in step 1. But since it is discussed in separate section, we are fine to not discussed same topic in this proposal. However, to make this point clear, It should be clarified that the scope of this proposal is for simultaneous Tx is not enabled.  Proposal for 2nd round discussion:  Focusing on the case where only slot-based PUCCH~~HARQ codebooks~~ are used, reuse Rel-15 procedure for Step 1, if simultaneous PUCCH/PUSCH transmissions is not enabled:   * For each priority, PUCCHs are multiplexed first by following the Rel-15 rule defined in subclause 9.2.5 of 38.213 and then, if the final PUCCH overlaps with PUSCHs, it is piggybacked on one of the PUSCH by following the Rel-15 rule defined in subclause 9.3 of 38.213. * For each priority, the above procedure is performed ~~as~~ where the PUCCH or PUSCH with the other priority is ignored. * FFS for HP PUCCH with sub-slot based PUCCH ~~HARQ-ACK~~. * FFS decide whether/how to include simultaneous PUCCH/PUSCH transmissions in step 1, if simultaneous PUCCH/PUSCH transmissions is enabled.   Before the issue in 2.4.1 is settled, we withdraw our support of FL updated proposal in below. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal after 2nd round discussion:

First focusing on the case where only slot-based PUCCH is used, reuse Rel-15 procedure for Step 1:

* For each priority, PUCCHs are multiplexed first by following the Rel-15 rule defined in subclause 9.2.5 of 38.213 and then, if the final PUCCH overlaps with PUSCHs, it is piggybacked on one of the PUSCH by following the Rel-15 rule defined in subclause 9.3 of 38.213.
* For each priority, the above procedure is performed where the PUCCH or PUSCH with the other priority is ignored.
* FFS for HP PUCCH with sub-slot based PUCCH (pursuing a unified solution for slot and sub-slot cases).
* Support: ~~QC~~, Intel, DCM, Quectel (if proposal 2.4.1 is agreed), NEC, HW, Nokia
* Support (expand the proposal to sub-slot case): Samsung, IDC, CATT, vivo, LG, Ericsson
* Not support:

## Details of Step 2?

Proposal for 2nd round discussion:

Focusing on the case where only slot-based HARQ codebooks are used, Step 2 consists of the following sub-steps:

* Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.
  + Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.
* Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.
  + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 is the simultaneous PUCCH and PUSCH transmission in different cells.
  + FFS: Which PUSCH is used for multiplexing.
* FFS for HP PUCCH with sub-slot based HARQ-ACK.
* FFS in which sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Our understanding of Step 2.1 is to “merge” LP PUCCH(s)’ UCI payloads into HP PUCCH.  Reuse Rel-15 procedure does not work here: if a LP PUCCH starts earlier than HP PUCCH, then the LP PUCCH can be used a reference for “merge”. |
| QC | Support the proposal in general, with the following minor updates:  Focusing on the case where only slot-based PUCCH ~~HARQ codebooks~~ are used, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.   + Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority. * Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 ~~is~~ includes the simultaneous PUCCH and PUSCH transmission in different cells. FFS where/how to performance simultaneous transmission in step 2.2   + FFS: Which PUSCH is used for multiplexing. * FFS for HP PUCCH with sub-slot based PUCCH ~~HARQ-ACK~~. * FFS in which sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH, PUCCH/PUSCH conflict with ULCI, SFI, and semi-static UL/DL configuration. |
| Samsung | As commented above, the sub-slot length should be considered as well.  In Step 2.1 “Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority. ” is not acceptable. For example, we don’t support multiplexing of HP HARQ-ACK and LP CSI. We can leave the details open for now or can separate discuss it.  Focusing on the case where ~~only slot-based HARQ codebooks are used~~ a same PUCCH time unit is configured for HP PUCCH and LP PUCCH, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.   + ~~Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.~~ * Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 ~~is~~ includes the simultaneous PUCCH and PUSCH transmission in different cells. FFS where/how to performance simultaneous transmission in step 2.2   + FFS: Which PUSCH is used for multiplexing. * FFS for HP PUCCH with sub-slot based HARQ-ACK. * FFS in which sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH. |
| Intel | We don’t support this proposal.  As we explained in 1st round,   1. In our view, the outcome of resolving collision between different priorities in step 2 can be either cancellation or multiplexing. The wording in this proposal excludes the case of cancellation.   We want to understand, why cancellation is not considered in step 2. For example, if the resultant UL channel in step 1 is LP PUCCH with only CSI + HP PUCCH with HARQ-ACK, or LP PUCCH with only SR + HP PUSCH, how can we reuse Rel-15 procedure ? For another example, if gNB indicates no multiplexing in DCI or timeline is not met, how can we reuse Rel-15 procedure ?   1. In our view, there is additional complexity at UE side to support PUCCH multiplexing first and then PUCCH and PUSCH. We think the simpler way is to resolve overlapped channel in time order.   As HW and us explained in 1st round, it requires look ahead operation, if PUCCH multiplexing is done first. As show in the figure below, if HP DCI2 comes later than latest time to determine mux of LP PUCCH on HP PUSCH, then, how can UE know there is another HP PUCCH so that LP PUCCH is not multiplexed onto HP PUSCH ? On the contrary, if we resolve overlapped UL channels in time domain, there is no look-ahead issue.    Furthermore, we also explained in 1st round that existing Rel-15 pseudo-code can not be directly reused. Quite a lot modification is needed.  We suggest to modify the proposal as below:  Focusing on the case where only slot-based HARQ codebooks are used, Step 2 consists of the following sub-steps:   * Resolving overlapping PUCCHs and/or PUSCHs with different priorities in the time order. * ~~Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.~~    + ~~Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.~~ * ~~Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.~~    + If simultaneous PUCCH and PUSCH transmission is configured, ~~Step 2.2 is the simultaneous PUCCH and PUSCH transmission in different cells.~~ FFS how to performance simultaneous transmission   + ~~FFS: Which PUSCH is used for multiplexing.~~ * FFS for HP PUCCH with sub-slot based HARQ-ACK. * FFS in which sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH. |
| InterDigital | Agree with previous comments to “Reuse Rel-15 procedure” is not well-defined. |
| DOCOMO | We agree with the two steps in general, but we have the same understanding as Apple that LP PUCCH should not be simply treated as a HP PUCCH into the pseudo code. For example in the following case, if we simply treat HP and LP PUCCH equally with Rel-15 procedure, we need to determine a single PUCCH resource for HP HARQ-ACK, HP SR and LP HARQ-ACK. But actually, multiplexing the LP HARQ-ACK into the HP HARQ-ACK is simpler. So we support the suggested modification proposed by Apple. |
| CATT | For the sub-bullet under step 2.1, Rel-17 procedure instead of Rel-15 should be used.  For the first sub-bullet under step 2.2, we agree with QC’s update. In addition, until now, we have only agreed simultaneous PUCCH/PUSCH transmission on different cells for inter-band CA. So we suggest the following update.  Focusing on the case where only slot-based HARQ codebooks are used, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.   + ~~Reu~~Use Rel-1~~5~~7 procedure ~~by regarding LP PUCCH and HP PUCCH as the same priority~~. * Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 ~~is~~ includes the simultaneous PUCCH and PUSCH transmission in different cells at least for inter-band CA. FFS where/how to performance simultaneous transmission in step 2.2   + FFS: Which PUSCH is used for multiplexing. * FFS for HP PUCCH with sub-slot based HARQ-ACK. * FFS in which sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH. |
| Quectel | For Step 2.1, if LP PUCCH starts earlier than HP PUCCH or if LP PUCCH has longer duration than HP PUCCH meanwhile starting at the same OFDM symbol, HP PUCCH will be multiplexed to LP PUCCH. We can accept Samsung’s updates. |
| NEC | Support the proposal in general.  Focusing on the case where only slot-based HARQ codebooks are used, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.   + Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.   [NEC] We share same view with companies that the Rel-15 procedure cannot be directly reused for multiplexing in step 2.1.   * Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 is the simultaneous PUCCH and PUSCH transmission in different cells.   [NEC]Agree with QC to add the FFS where/how to performance simultaneous transmission in step 2.2   * + FFS: Which PUSCH is used for multiplexing. * FFS for HP PUCCH with sub-slot based HARQ-ACK. * FFS in which ~~sub-~~step to handle the prioritization of DG-PUSCH vs CG-PUSCH.   [NEC] For the last FFS, we think the sub-step can be changed to step. If we handle the prioritization of DG-PUSCH and CG-PUSCH in step 2, LP UCI may be unnecessary dropped in some cases, e.g., a LP PUCCH for eMBB HARQ-ACK is only overlapped with LP CG PUSCH, while the LP CG PUSCH is also overlapped a HP DG PUSCH, after step 1, the LP HARQ-ACK will be multiplexed on LP CG PUSCH, after prioritization of DG-PUSCH and CG-PUSCH in step 2, the LP CG PUSCH with LP HARQ-ACK will be cancelled. The LP HARQ-ACK dropping can be avoided if prioritization of DG-PUSCH and CG-PUSCH is handled before multiplexing of PUCCH and PUSCH. |
| vivo | For step 2.1, agree with Samsung, for PUCCHs with different priorities, not all cases are agreed to support multiplexing |
| LG | We support the update from Samsung, with following slight modification.  ~~Focusing on the case where only slot-based HARQ codebooks are used a same PUCCH time unit is configured for HP PUCCH and LP PUCCH~~, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.   + ~~Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.~~ * Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 ~~is~~ includes the simultaneous PUCCH and PUSCH transmission in different cells. FFS ~~where/~~how to performance simultaneous transmission in step 2.2   + FFS: Which PUSCH is used for multiplexing. * ~~FFS for HP PUCCH with sub-slot based HARQ-ACK.~~ * FFS in which sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH. |
| Huawei/Hisi R2 | **Some clarifications are needed by the proponent companies of this option**. Does the “slot-based HARQ codebooks/PUCCH” mean all the PUCCHs and PUSCHs in the slot are visible to UE before the multiplexing procedure? E.g., the UE does not expect to see the case as shown in the following figure (which is possible in R16), where the UE can only see the LP PUCCH and HP PUSCH when it starts the multiplexing, while receives the DCI scheduling a later PUCCH after multiplexing is finished or even the transmission has started, and has to stop the ongoing transmission in middle.    If R15 timeline is applicable in Step 2, then we can accept the proposal in principle, and a note needs to be added.  In addition, for Step 2.1 we share a similar view with CATT and DOCOM that the PUCCH resources could be on the HP, while HP SR and LP HARQ-ACK is under discussion in other sections. So we recommend to remove the first subbullet.  “  Focusing on the case where only slot-based HARQ codebooks are used, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.   + ~~Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.~~ * Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 is the simultaneous PUCCH and PUSCH transmission in different cells.   + FFS: Which PUSCH is used for multiplexing. * Note: R15 timeline is applied for Step 2. * FFS for HP PUCCH with sub-slot based HARQ-ACK. * FFS in which sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH.   ” |
| Nokia/NSB | Fine with the intention of the proposal. We are also fine with Samsung’s edits. |
| OPPO | In our understanding, step 2.1 and 2.2 are procedures for two different condition. Step 2.1 is applied when only LP PUCCH and HP PUCCH are determined in Step1, Step 2.2 is applied when a PUCCH and a PUSCH are determined in Step1.  In addition, the same reason as feedback of 2.4.1, we’d like to deprioritize joint operation for simultaneous PUCCH/PUSCH transmission and intra-UE multiplexing.  So we suggest to update proposal as:  Update proposal:  Focusing on the case where only slot-based HARQ codebooks are used, Step 2 consists of the following sub-steps:   * If a LP PUCCH and a HP PUCCH are determined by step 1, Resolve collision between LP PUCCH and HP PUCCH.   + Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority. * If a PUCCH and PUSCH(s) are determined by step 1, Resolve collision between PUCCH and PUSCH of different priorities.   + ~~If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 is the simultaneous PUCCH and PUSCH transmission in different cells.~~   + FFS: Which PUSCH is used for multiplexing. * FFS for HP PUCCH with sub-slot based HARQ-ACK. * FFS in which sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH. |
| ZTE | Generally fine with the proposal. But “Reuse Rel-15 procedure” should be carefully treated as Intel mentioned some exceptional cases..  One word is adding to fit the agreement.  If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 is the simultaneous PUCCH and PUSCH transmission in different **inte**r-**band** cells. |
| Sony | It is unclear there is a need to concentrate only on slot-based HARQ-ACK codebook.  Similar to other companies’ comment, Rel-15 may not be directly applied. Also why is there an FFS on “which PUSCH is used for multiplexing” in Step 2.2? Sharing some of Samsung & some of QC’s edits, we suggest the following:  Focusing on the case where ~~only slot-based HARQ codebooks are used~~ a same PUCCH time unit is configured for HP PUCCH and LP PUCCH, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.   + ~~Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.~~ * Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 ~~is~~ includes the simultaneous PUCCH and PUSCH transmission in different cells. FFS where/how to performance simultaneous transmission in step 2.2   + ~~FFS: Which PUSCH is used for multiplexing.~~ * FFS for HP PUCCH with sub-slot based PUCCH ~~HARQ-ACK~~.. * FFS in which sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH. |
| Apple-II | A number of comopanies, such as DOCOMO, Samsung, NEC, HW, CATT, etc expressed their views on Step 2.1. In general, we don’t think Rel-15 procedure can be reused without change for Step 2.1. Please see the illustration provided by DOCOMO. It is clear a new procedure is needed for Step 2.1. If more time is needed to settle on that, we suggest a modified proposal as follows:  Focusing on the case where only slot-based HARQ codebooks are used, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.   + Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.   Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.   + ~~Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.~~ * Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 ~~is~~ includes the simultaneous PUCCH and PUSCH transmission in different cells at least for inter-band CA. FFS where/how to performance simultaneous transmission in step 2.2   + FFS: Which PUSCH is used for multiplexing. * FFS for HP PUCCH with sub-slot based HARQ-ACK. * FFS in which sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH. |
| Ericsson | Do not support.  We are OK with Step 2.1 and 2.2 but not their sub-bullets.   * For sub-bullet of Step 2.1, ‘reuse Rel-15’ is not possible. First, not all HP PUCCH and LP PUCCH are eligible for multiplexing. Second, for the UCIs eligible for multiplexing, the procedures for multiplexing LP PUCCH and HP PUCCH are those agreed in Rel-17. * For sub-bullet of Step 2.2, it’s insufficient to have simultaneous PUCCH/PUSCH transmission in different cells, even if UE has this capability.   For 2nd FFS, we don’t support. In Rel-15/Rel-16 PHY PUCCH/PUSCH multiplexing procedure, the input has at most one actual PUSCH (i.e., with PDU from MAC) for a cell.   * Rel-15: two overlapping DG/CG of same priority are allowed. CG is cancelled by DG (in MAC spec and in 38.214 section 6.1) before PUCCH/PUSCH multiplexing procedure in 38.213. * Rel-16: two overlapping DG/CG of same or different priorities are allowed. MAC ensures that only one grant is given PDU, i.e., resolution between two overlapping PUSCH grants is handled before PUCCH/PUSCH multiplexing procedure in 38.213.   For Rel-17, this principle should be kept, i.e., overlapping PUSCHs are handled before entering PUCCH/PUSCH multiplexing procedure in 38.213.   |  | | --- | | Focusing on the case where only slot-based HARQ codebooks are used, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.   + ~~Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.~~   + Step 2.1(a). Cancel any LP PUCCH that is ineligible for multiplexing with any of the overlapping HP PUCCH(s) in Rel-17. (*Examples of ineligible combinations are: LP CSI vs HP HARQ-ACK, LP SR vs HP HARQ-ACK.)*   + Step 2.1(b). For remaining overlapping and eligible LP PUCCH and HP PUCCH, multiplex the LP PUCCH and HP PUCCH according to Rel-17 procedure. * Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.   + Step 2.2(a). Cancel the LP channel if there is no eligible UCI-PUSCH combination to multiplex the overlapping PUCCH and PUSCH in Rel-17. (*Examples of ineligible combinations are: LP SR vs HP PUSCH, LP CSI vs HP PUSCH, HP SR and LP PUSCH.)*   + Step 2.2(b). For remaining overlapping PUCCH and PUSCH of different priorities, multiplex the PUCCH and PUSCH according to Rel-17 procedure.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2(a) and 2.2(b) are performed across cells in a PUCCH group. Otherwise, Step 2.2(a) and 2.2(b) are performed within the PUCCH cell.   + ~~If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 is the simultaneous PUCCH and PUSCH transmission in different cells.~~   + ~~FFS: Which PUSCH is used for multiplexing.~~ * FFS for HP PUCCH with sub-slot based HARQ-ACK. * ~~FFS in which sub-step to handle~~ the prioritization of DG-PUSCH vs CG-PUSCH is handled before PUCCH/PUSCH multiplexing. | |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal after 2nd round discussion:

First focusing on the case where a same PUCCH time unit is configured for HP PUCCH and LP PUCCH, Step 2 consists of the following sub-steps:

* Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.
  + ~~Reuse Rel-15 procedure by regarding LP PUCCH and HP PUCCH as the same priority.~~
* Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.
  + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 includes the simultaneous PUCCH and PUSCH transmission in different cells at least for inter-band CA. FFS details.
  + FFS: Which PUSCH is used for multiplexing.
* Note: R15 timeline is applied for Step 2.
* FFS for the case where different time units are configured for HP PUCCH and LP PUCCH (pursuing a unified solution).
* FFS in which step/sub-step to handle the prioritization of DG-PUSCH vs CG-PUSCH, e.g. PUCCH/PUSCH conflict with ULCI, SFI, and semi-static UL/DL configuration.

## How to ensure the multiplexing timeline without UE-side checking?

Proposal for 2nd round discussion:

For Rel-17 intra-UE UCI multiplexing,

* UE does not check timeline, but just runs the multiplexing procedure assuming timeline is met.
* Support dynamic indication for enabling/disabling multiplexing by gNB to ensure the scheduled overlapping channels compliant with the timeline requirement.

|  |  |
| --- | --- |
| Company | Comments |
| QC | We don’t support the second sub-bullet “Support dynamic indication for enabling/disabling multiplexing by gNB to ensure the scheduled overlapping channels compliant with the timeline requirement”, due to the following reasons.   * Like we commented in first round, there is no motivation to do dynamic enabling/disabling multiplexing. * Support dynamic enabling/disable multiplexing will complicate the specification and implementation of timeline check at gNB. A simple question here: **if a multiplexing scenario is treated as error case because timeline for multiplexing is NOT met, can gNB can send a later grant to disable multiplexing and turn/revive the error case into a valid overlapping scenario while UE suppose to do Rel-16 dropping**? On UE side, how does UE handle this case revived from error case? In general, dynamic enable/disable will create a lot of timeline related issues. * Second question: **how to deal with missing DCI issue with dynamic indication of enabling/disabling?** |
| Samsung | Support. |
| Intel | We support the proposal with 1st and 2nd sub-bullet. However, if companies cannot agree to support 2nd sub-bullet, we cannot accept 1st sub-bullet alone.  We think a very important design principle for Rel-17 UCI multiplexing is, HP UL performance should not obviously degrade caused by LP and HP multiplexing. If we restrict that the multiplexing timeline between LP and HP is always met, in many cases, HP latency is increased compared with Rel-16 URLLC. For example, if we follow Rel-16 timeline as shown in Figure 1-1, HP DCI for HP PUCCH can come later than LP DCI for LP PUSCH, then, LP PUSCH is cancelled. If we have to obey Rel-15 timeline, as shown in Figure 1-2, HP PUCCH has to be delayed after LP PUSCH, because HP DCI1 comes later than LP DCI which does not meet Rel-15 multiplexing timeline. Apparently, latency of HP PUCCH is increased.    Figure 1-1 Rel-16 timeline for Rel-17 Figure 1-2 Rel-15 timeline for Rel-17  By dynamic enable/disable, gNB can choose to disable the multiplexing, if timeline is not met. For example, in Figure 1-1, gNB disables multiplexing by HP DCI1. In this way, the dynamic disable/enable indication can avoid timeline check by UE side and avoid HP UCI latency.  In that sense, we support the proposal with 1st and 2nd sub-bullet. However, if companies cannot agree to support 2nd sub-bullet, we cannot accept 1st sub-bullet alone. Because without 2nd sub-bullet, HP PUCCH has to be delayed as in Figure 1-2.  Regarding QC’s 1st question, in our understanding, it is possible that a later DCI which does not meet multiplexing timeline can indicate cancellation as shown in Figure 1. HP DCI indicates no multiplexing, then, UE performs cancellation of LP PUSCH. It seems exactly the same as Rel-16. Would you mind further explain the problem at UE side?  Regarding QC’s 2nd question, the miss-detected probability of HP DCI is very low. Even if it is missed, if the default behavior is no multiplexing, then, the miss-detected DCI does not cause timeline issue. |
| InterDigital | Support |
| DOCOMO | Support the proposal. |
| CATT | We support dynamic indication of enabling/disabling multiplexing.  For the 1st bullet, we think it should be conditioned on that multiplexing is enabled, otherwise if multiplexing is not enabled, timeline does not need to be satisified. |
| Quectel | Support |
| NEC | Support the proposal. |
| vivo | Support.  Response to QC’s question:  **if a multiplexing scenario is treated as error case because timeline for multiplexing is NOT met, can gNB can send a later grant to disable multiplexing and turn/revive the error case into a valid overlapping scenario while UE suppose to do Rel-16 dropping**  🡪 we think if a multiplexing scenario where timeline for multiplexing is NOT met, gNB should not indicate “multiplexing” in the corresponding DCI. If Rel-16 timeline for cancellation is met, Rel-16 behavior is used. If Rel-16 timeline for cancellation is not met, it is an error case.  **how to deal with missing DCI issue with dynamic indication of enabling/disabling?**  🡪For the DCI missing issue, it is a common issue, not just for dynamic indication of enabling/disabling. For example, for the indication of PRI, same issue will happen too. Since the DCI for indicating enabling/disabling is the PDSCH scheduling DCI, the missed DCI is not the last DCI, there is no issue. If the missed DCI is the last DCI, similar as PRI. gNB can indicate same state for enabling/disabling in the last DCI and the non-last DCI. In addition, even when multiplexing enabling/disabling is configured by RRC, if DCI is missed, there would be no HP PUCCH/LP PUCCH or the HP PUCCH/LP PUCCH resource is not correct, some issues will happen too. |
| LG | We don’t support the proposal, especially for the 2nd sub-bullet. |
| Huawei/Hisi R2 | We agree with the first bullet and do not agree with the 2nd bullet with the similar reason as QC. The 2nd bullet should be discussed in 3.3.2 and 4.4.2.  “  For Rel-17 intra-UE UCI multiplexing,   * UE does not check timeline, but just runs the multiplexing procedure assuming R15 timeline is met. * ~~Support dynamic indication for enabling/disabling multiplexing by gNB to ensure the scheduled overlapping channels compliant with the timeline requirement.~~   ” |
| Nokia/NSB | Support |
| OPPO | Not support, especially for 2nd subbullet.  For timeline check-based solution, R17 multiplexing and R16 prioritization (fallback mode) procedure are sequential, i.e. R17 multiplexing is done not later than T (T ensures enough processing time to satisfy R15 multiplexing timeline) and R16 prioritization is done after T. For dynamic indication-based solution, it is more complex due to it allows parallel procedure for R17 multiplexing and R16 prioritization.  So from perspective of implementation complexity, dynamic indication-based solution should be avoided. |
| ZTE | If Rel-15 and Rel-16 has time line issue, why not accept Rel-17 timeline?  Or we support dynamic indication of enabling/disabling multiplexing to avoid discussing time line issue? I share the time line analysis from Intel. |
| Sony | Support  If we do not support dynamic enabling/disabling, then we have to define all sorts of rules to govern the multiplexing behaviour which would incur higher specs impact than introducing a single bit in the DCI to switch it on/off.  QC’s concerns are not really the issue of having a dynamic DCI indicator, i.e.:   * **if a multiplexing scenario is treated as error case because timeline for multiplexing is NOT met, can gNB can send a later grant to disable multiplexing and turn/revive the error case into a valid overlapping scenario while UE suppose to do Rel-16 dropping**?   + gNB is responsible to ensure the timeline is met regardless whether mux enabling/disabling is done via RRC or DCI.   + RRC is restricted to rules and would have less scheduling flexibility whilst DCI allows more freedom for the gNB. Hence, it seemed this error scenario that QC is concerned about can be handled easier with dynamic indicator, perhaps the question should be, if enabling/disabling is done by RRC how does the gNB stop multiplexing if the UE is semi-statically configured to do multiplexing? * **how to deal with missing DCI issue with dynamic indication of enabling/disabling?**   + Again this issue is independent of having a dynamic indicator for enabling/disabling multiplexing. Wouldn’t there also be an issue for RRC multiplexing if the UE misses some HP DIC?   It should also be noted that the HP DCI is very unlikely to go missing, and so even if this is an issue solely on using dynamic indication, it does not justify denying the gNB the flexibility in managing multiplexing |
| MediaTek | We don’t support dynamic indication for enabling/disabling multiplexing. |
| QC 2 | The biggest issue on dynamic enabling/disabling of multiplexing is that it is extremely difficult to implement for UE – almost impossible to implement. Please just do a small exercise with a simplified toy example: at T1, UE received DCI-1 indicate multiplex, at T2, UE received DCI-2 indicate not multiplex, at T3, UE received DCI-3 indicate go back to do multiplex, please tell me how should UE implement to support this? When should UE start to act according to the received DCIs? Please note that whenever UE start to perform according to latest DCI, it might need to dump whatever already performed and redo things from zero ground. I hope someone can show a design to prove this is implementable.  Regarding the timeline issue:   * **if a multiplexing scenario is treated as error case because timeline for multiplexing is NOT met, can gNB can send a later grant to disable multiplexing and turn/revive the error case into a valid overlapping scenario while UE suppose to do Rel-16 dropping**?   To sony, VIVO, Intel: if gNB can 100% guarantee multiplexing timeline is met, why gNB need to change the decision from multiplexing to not multiplexing? Isn’t always do multiplexing is better? The performance HP can be guantanteed via using low coding rate anyway.  A side note is that, on UE implement, we always have to deal with error case – Yes, we don’t assume gNB never make scheduling mistakes. So please tell us: **what is UE behavior if an error case (due to not meet mux timeline) is turned into a valid case by DCI**?  Regarding the missing DCI issue:  To Sony, VIVO, Intel: with dynamic enabling/disabling of multiplexing, missing DCI issue has much larger impact to the system, because gNB does not even know UE perform R17 multiplexing or R16 prioritization. There are denifitely more hypothesis for gNB to test, in order to decode the multiple overlapping channels. It is NOT the same issue as missing DCI in Rel-15/16. It is a much larger issue. |
| Intel 2 | Thanks QC for the explanation.  I think maybe there is some misalignment between us about whether gNB can later transmits a DCI to disable multiplexing if the multiplexing timeline is not met.  I agree with you that if gNB knows the multiplexing timeline is met, no strong motivation for gNB to change the decision from multiplexing to not multiplexing (except gNB finds the resource may be insufficient to carry all HARQ-ACKs, but let’s ignore such case).  But, if gNB knows the multiplexing timeline can not be met when HP traffic arrives, e.g. in Figure 1-1, HP DCI comes after LP DCI for LP PUSCH, what will gNB do ? In my understanding, gNB can indicates no multiplexing of HP UCI onto LP PUSCH, because gNB knows the multiplexing timeline is not met. And for LP DCI, of course, gNB does not indicate multiplexing, because at that time, gNB does not know there will be a HP DCI coming later. Do you agree that it is workable?  If we do not support dynamic enable/disable, one way to support timely HP PUCCH transmission is, UE checks the timeline and determines to drop LP PUSCH as Rel-16. Still taking figure 1-1 as an example, UE knows the latest time to determine mul on LP PUSCH, let’s say t0. If HP DCI comes later than t0, UE knows the timeline is not met. Then, UE drops LP PUSCH. I’m not sure how much complexity would be for UE implementation.  If we do not support dynamic enable/disable, and we do not support timeline check at UE side, it implies that gNB has HP PUCCH and LP PUSCH can not be overlapped, otherwise it is error case if timeline is not met. Then, gNB has to delay the transmission of HP PUCCH as shown in Figure 1-2, which causes much latency for HP compared with Rel-16.  If I miss-understand your intention, please correct me.    Figure 1-1 Rel-16 timeline for Rel-17 Figure 1-2 Rel-15 timeline for Rel-17 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal after 2nd round discussion:

For Rel-17 intra-UE UCI multiplexing,

* UE does not check timeline, but just runs the multiplexing procedure assuming timeline is met.
* Support dynamic indication for enabling/disabling multiplexing by gNB to ensure the scheduled overlapping channels compliant with the timeline requirement.
* Support: Samsung, Intel, IDC, DCM, CATT, Quectel, NEC, vivo, Nokia, Sony, Ericsson
* Not support: QC, LG, HW, OPPO, MTK

## Conditions to avoid recursive pseudo-code to implement this procedure?

* **Principle:** “Avoid recursive pseudo-code” means not going back to step 1 after step 2, i.e. resultant UL channel in step 2 with one priority does not overlap with another UL channel with same priority, if these two UL channels are not overlapped after step 1.
* **Condition 1:** For HP PUCCH overlapping with multiple LP PUCCHs in step 2, multiplex eligible LP UCI(s) into the HP PUCCH resource of the first HP PUCCH. (The condition is at least applicable in case HARQ-ACK. FFS for CSI and SR.)
* **Condition 2:** For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH.
* **Condition 3:** Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs should be avoided.

|  |  |
| --- | --- |
| Company | Comments |
| QC | We are fine with the principle.  For condition 1: We don’t support it for now. First, are there typos in condition 1? It should be “For ~~HP~~ LP PUCCH overlapping with multiple ~~LP~~ HP PUCCHs in step 2”? Anyway, for this case, it needs more discussion. The decision to put LP on the first HP PUCCH is very ad hoc. Of course, this might be a secondary point. But why not put it on the last HP PUCCH so the processing time for UE is more relaxed?  For Condition 2: it looks OK to us. But we like to clarify that the timeline for this overlapping case is still Rel-15 timeline, although the behavior is Rel-16 dropping.   * **Condition 2:** For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH, with the assumption that Rel-15 UCI multiplexing timeline requirements are still met.   For Condition 3: we support it. |
| Samsung | Condition 1 needs further discussion. What if the first overlapping HP channel is HP SR? The solution for overlapping HP SR and LP HARQ-ACK is not clear yet. If the first HP channel has HARQ-ACK, the symbols can change after multiplexing. Restriction on not changing the symbols will limit the scheduling flexibility. The simplest way is reuse the R15 pseudo code.  Condition 2 needs further discussion. If there are multiple overlapping PUSCHs, we only need to restrict that no more than one HARQ-ACK will be multiplexed in a same LP PUSCH similar as in Rel-15.  Condition 3 needs further discussion. It is not clear about LP PUCCH. For example, a HP HARQ-ACK overlaps with both a LP HARQ-ACK and a LP SR. Is the intention is to drop LP HARQ-ACK even if the LP HARQ-ACK can be multiplexed in the HP HARQ-ACK PUCCH? |
| Intel | We support the principle as proponent company.  For 3 conditions, we think they are irrelevant to the principle. Condition 1-3 seems to avoid multiplexing among 3 channels in step 2 ?  For condition 1, we also think there is typo as explained by QC, i.e., we are discussing the case of one LP overlapped two HP PUCCH here. Based on this understanding, if we only consider slot-based PUCCH for both step 1 and step 2 as suggested in section 2.4.2, what is the scenario for a LP PUCCH overlapped with two HP HARQ-ACK PUCCH? In our understanding, it only happens with sub-slot based HP PUCCH. Therefore, we suggest to hold the discussion on condition 1.  For condition 2, we support the proposal. But we don’t support the modification provided by QC. As we explained in section 2.4.4, Rel-15 timeline adds too much restriction on HP.  For condition 3, we support it. We are also fine to drop the later LP PUCCH, if companies think condition 3 is too restricted. |
| DOCOMO | For condition 1: We also think there is typo, and it should be “For ~~HP~~ LP PUCCH overlapping with multiple ~~LP~~ HP PUCCHs in step 2”? With the typo corrected, we supported the principle of condition 1. But as commented in the 1st round, we still think UCI type can be considered to determine the HP PUCCH for multiplexing the LP PUCCH. The behavior for multiplexing of HP HARQ-ACK and LP HARQ-ACK is much clearer and simpler than multiplexing of HP SR and LP HARQ-ACK. We are also fine to multiple the LP PUCCH into the last overlapping HP PUCCH. Therefore, we suggest the condition 1 to be modified as:   * **Condition 1:** For LP PUCCH overlapping with multiple HP PUCCHs in step 2, multiplex eligible LP UCI(s) into the HP PUCCH resource of only one HP PUCCH. (The condition is at least applicable in case HARQ-ACK. FFS for CSI and SR.)   + FFS the HP PUCCH for multiplexing LP UCI(s), e.g. first/last HP PUCCH, and/or HP HARQ-ACK/SR PUCCH.   For condition 2: we support it.  For condition 3: It is not our first preference for the case of one long LP PUCCH overlapping with multiple HP PUCCHs. But we can compromise to accept it if it is difficult to converge companies’ views on handling the case. |
| CATT | There are typos in condition 1 as pointed out by Qualcomm. We also think it is simpler to follow Rel-15 principle.  We are fine with condition 2 and we do not think multiplexing timeline needs to be satisfied since multiplexing is not performed.  For condition 3, we suggest to restrict to LP PUCCH with HARQ-ACK  Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs with HARQ-ACK should be avoided. |
| NEC | For condition 1, as pointed out by other companies, there is typo. The handling rule that multiplexing eligible LP UCI(s) into the HP PUCCH resource of the first HP PUCCH is not clear for us, does it mean the resource of the first HP PUCCH is enough to carry the multiplexed LP and HP UCI, otherwise the LP UCIs will be dropped? we think it can be discussed further.  For condition 1, fine with the simple handling rule.  For condition, fine with the restriction if needed.  In addition, other cases, such as collision between a LP PUCCH and non-overlapped HP PUCCH and HP PUSCH needed to be considered? |
| vivo | For condition 1, for HARQ-ACK multiplexing, new PUCCH resource need to be determined based on the multiplexed LP UCI and HP UCI. It is not correct to say “multiplex eligible LP UCI(s) into the HP PUCCH resource of the first HP PUCCH”. We can say “UE does not expect the resultant PUCCH resource for multiplexing overlaps with another PUCCH resource with the same priority”. Btw, what’s the priority of the PUCCH for multiplexing UCI with different priorities? |
| LG | For Condition 1: We support the update from DOCOMO, and prefer multiplexing of LP UCI into the first HP PUCCH with HP HARQ-ACK.  For Condition 2: We are OK with the proposal.  For Condition 3: We think it needs further discussions including to consider the case where HP PUSCH (PUCCH) has smaller SCS than LP PUCCH (PUSCH). |
| Huawei/Hisi R2 | We agree with the 1st conclusion, 2nd conclusion (with QC’s version) and the 3rd conclusion.  As we mentioned in 2.4.3, if the R15 timeline is applied for the R17 multiplexing, the gNB will ensure all the overlapping channels in per slot/subslot is visible to the UE before the multiplexing, so there is no worry that the timeline for multiplexing LP PUCCH on the 1st HP PUCCH will not be satisfied. |
| Nokia/NSB | We share other companies’ views that the three conditions (especially Condition 1) need some further clarification and discussion, while noting that we could be fine with the intention of Conditions 2 and 3. |
| OPPO | In principle, we are fine with 3 conditions.  For condition 1, LP PUCCH will be multiplexed with overlapping HP PUCCH with the earliest staring symbol. But it does not mean that final multiplexed PUCCH should be the original overlapping HP PUCCH. In fact, Final multiplexed PUCCH maybe updated due to payload size changes. So we suggest to modify it as  **Condition 1:** For HP PUCCH overlapping with multiple LP PUCCHs in step 2, multiplex eligible LP UCI(s) ~~into the HP PUCCH resource of~~ with HP UCI in the first HP PUCCH. (The condition is at least applicable in case HARQ-ACK. FFS for CSI and SR.) |
| ZTE | Fine with condition 2.  Can live with condition 3. But drop some LP PUCCHs is also an alternative.  For condition 1, the time line requirement should be considered. Or by dynamic indication to enable/disable multiplexing to avoid time line issue. |
| Sony | Condition 1: Apart from the typo pointed out by QC, I think the type of UCI on the 1st HP PUCCH needs to be considered as described by DOCOMO.  Condition 2: What is the issue in multiplexing the HP UCI into this LP PUSCH? What does this have to do with recursive pseudo-code?  Condition 3: This scenario shows again the benefit of dynamic enabling/disabling of multiplexing. Here the gNB can easily avoid this scenario by indicating in the HP DCI to disable multiplexing. |
| Apple-II | We think the original condition-1 makes sense. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal after 2nd round discussion:

“Avoid recursive pseudo-code” means not going back to step 1 after step 2, i.e. resultant UL channel in step 2 with one priority does not overlap with another UL channel with same priority, if these two UL channels are not overlapped after step 1.

* Support: QC, Apple, Intel
* Not support:

Proposal after 2nd round discussion:

Conditions to avoid recursive pseudo-code for handling overlapping PUCCHs/PUSCHs with different priorities include:

* Condition 1: For LP PUCCH overlapping with multiple HP PUCCHs in step 2, multiplex eligible LP UCI(s) with HP UCI in one HP PUCCH. (The condition is at least applicable in case HARQ-ACK. FFS for CSI and SR.)
  + FFS the HP PUCCH for multiplexing LP UCI(s), e.g. first/last HP PUCCH, and/or HP HARQ-ACK/SR PUCCH.
  + Support: ~~Intel,~~ DCM, LG, HW, OPPO, Sony
  + FFS: QC, Samsung, Nokia, Intel
* Condition 2: For long LP PUSCH overlapping with multiple short HP PUCCHs in step 2, drop the LP PUSCH, with the assumption that Rel-15 UCI multiplexing timeline requirements are still met.
  + Support: QC, ~~Intel,~~ DCM, CATT, NEC. LG, HW, OPPO
  + FFS: Samsung, Nokia, ZTE, Intel
* Condition 3: Long HP PUCCH/PUSCH overlapping with multiple short LP PUCCHs with HARQ-ACK should be avoided.
  + Support: QC, Intel, DCM, CATT, NEC, HW, OPPO, ZTE
  + FFS: Samsung, LG, Nokia
* FFS other conditions.

## Handling prioritization of CG-PUSCH?

* The prioritization of DG-PUSCH vs CG-PUSCH of different priorities should be handled before the PUCCH/PUSCH multiplexing/cancellation procedure in Rel-17.

|  |  |
| --- | --- |
| Company | Comments |
| QC | In our understanding, even in Rel-16, where to handle DG vs CG in Rel-16 prioritization framework is still under discussion. We suggest to hold on the discussion on this topic until Rel-16 baseline is clear. |
| Samsung | We think HP DG/CG PUSCH and LP DG/CG PUSCH collision should be handled before multiplexing with HP HARQ-ACK to avoid HP HARQ-ACK dropping.    We are fine with postponing the discussion until we are clear about DG CG collsion issue. |
| Intel | We share same view with QC to hold the discussion for this issue. |
| DOCOMO | We share similar view as QC that it’s better to discuss the issue after there is conclusion for Rel-16 behavior. |
| NEC | Fine with the proposal. |
| vivo | Agree with Samsung, HP DG/CG PUSCH and LP DG/CG PUSCH collision should be handled before multiplexing with HP HARQ-ACK to avoid HP HARQ-ACK dropping. |
| LG | We share same view with QC. |
| Huawei/Hisi R2 | Not support. We should allow separate the UE capabilities for that supporting R16 prioritization and not supporting R16 prioritization. To be clear, the R16 prioritization here means stopping an ongoing transmitted (LP) channel in middle and transmit a new (HP) channel instead. Mixed R16 prioritization and R17 multiplexing would be challenging for UE implementation.  E.g., for the UE that does not support R16 prioritization, the spec should avoid forcing the UE to stop an ongoing channel during the R17 multiplexing procedure, such as the case of HP DG PUSCH cancels the ongoing LP CG PUSCH in middle. |
| Nokia/NSB | We agree with Samsung, that DG/CG PUSCH collision would need to be done first, to prevent HP HARQ-ACK dropping. |
| OPPO | Not support  We prefer to follow legacy design logic, i.e. multiplexing is before prioritization. Moreover, it also contradicts with step1 and 2 in agreement. |
| ZTE | Deprioritize this discussion. |
| Sony | Fine with the proposal. |
| MediaTek | Postpone the discussion until R16 behavior is clear. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 3rd round discussion

## Whether to consider simultaneous PUCCH/PUSCH transmission in Step 1?

**Proposal for a Working Assumption** (from Friday GTW session)

Simultaneous PUCCH/PUSCH transmission is not considered in Step 1, i.e. if simultaneous PUCCH/PUSCH transmission is enabled, it is only used to handle overlapping between different priorities.

* Note: There is no agreement to support simultaneous PUCCH/PUSCH transmission for same priority.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support |
| Intel | We support the WA. |
| LG | We support the WA. |
| Sony | Support |
| Huawei/Hisi R3 | Support |
| Ericsson | Support |
| QC | Like we explained in Friday GTW, this proposal reverts a previous agreement. So we object the proposal. |
| Samsung | Fine in principle. |
| Sharp | Support |
| ZTE | Support |
| Quectel | Support |
| vivo | Regarding whether simultaneous PUCCH/PUSCH transmission can be used to handle overlapping between same priority, we think it can according to our previous agreements. The highlight part and the note are conflict with the previous agreements.  If companies can’t achieve concensus regarding this issue. We support Samsung’s suggestion on the GTW that we can deprioritized simultaneous PUCCH/PUSCH transmission when we discuss about multiplexing UCI of different priorities. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Details of the “existing procedure” for Step 1

**Agreement**

For both the subslot-based PUCCH and slot-based PUCCH, if simultaneous PUCCH/PUSCH transmission is not enabled, reuse Rel-16 procedure for Step 1

With the above agreement, the 3rd round discussion for this issue is skipped.

## Details of Step 2

**Possible Agreement** (from Friday GTW session)

First focusing on the case where a same PUCCH time unit is configured for HP PUCCH and LP PUCCH, Step 2 consists of the following sub-steps:

* Step 2.1: Resolve collision between LP PUCCH and HP PUCCH.
* Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.
  + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 includes the simultaneous PUCCH and PUSCH transmission in different cells at least for inter-band CA. FFS details.
  + FFS: Which PUSCH is used for multiplexing.
* Note: R15 timeline is applied for Step 2.
* FFS for the case where different time units are configured for HP PUCCH and LP PUCCH (pursuing a unified solution).

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support |
| Intel | Although we really think a single step to resolve collision between UL channes in time order is simpler and without much scheduling restriction as proposed step 2.1 + step 2.2, we can compromise to support the proposed step 2.1+ step 2.2 with the condition that Alt.1 in section 2.5.4 (timeline) is agreed or both Alt.1 and Alt.2 can be supported as UE capability. Otherwise, we can not support proposed step 2.1+step 2.2.  The reason we can not support proposed step 2.1+step 2.2 with Alt.2 for timeline is, it leads to large scheduling flexibility (Fig. 2) or larger latency (Fig.3) for HP transmission, since all DCIs for all overlapped UL channels in the same slot should come before the earliest time point for potential multiplexing for the earliest UL channel (i.e. no later than t0).   |  |  |  | | --- | --- | --- | |  |  |  | | Fig.1: Not allowed, because HP DCI2 comes later than t0 | Fig.2: HP DCI2 has to come no later than t0 | Fig.3: HP PUCCH has to start after end of LP PUCCH, because HP DCI2 comes later than t0 |   If we support Alt.1 for timeline, then, if HP DCI2 comes later than t0, gNB can indicate multiplexing of LP PUCCH onto HP PUSCH in HP DCI1, and disable multiplexing of LP PUCCH onto HP PUCCH in HP DCI2. If HP DCI2 comes earlier, then, gNB can disable multiplexing of LP PUCCH onto HP PUSCH in HP DCI1 and enables multiplexing of LP PUCCH onto HP PUCCH in HP DCI2. The outcome of step 2.1 and step 2.2 depends on DCI indication.  Furthermore, we’d like to clarify that rel-15 timeline is applied for multiplexing, while rel-16 priortization timeline is applied for cancellaiton of LP UL transmission, e.g., if UCI type is not eligible for multiplexing, or gNB disables multiplexing.  Based on the analysis above, we suggest to modify the proposal as below (modified part is high-lighted in green)  First focusing on the case where a same PUCCH time unit is configured for HP PUCCH and LP PUCCH, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH. * Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 includes the simultaneous PUCCH and PUSCH transmission in different cells at least for inter-band CA. FFS details.   + ~~FFS: Which PUSCH is used for multiplexing.~~ * Note: R15 timeline is applied for multiplexing in Step 2. R16 prioritization timeline is applied for cancellation of LP transmission in step 2. * Note: the outcome of step 2.1 and step 2.2 depends on dynamic indciaiton for enabling/disabling multiplexing by gNB, if the dynamic indication is configured. * FFS for the case where different time units are configured for HP PUCCH and LP PUCCH (pursuing a unified solution). |
| Sony | Thanks Intel for the clarification. We agree with the argument and support Intel’s modified proposal. However, we think it should be a NOTE in the formulation but rather Step 2.1 and Step 2.2 is as per instructed by dynamic indication. That is:  First focusing on the case where a same PUCCH time unit is configured for HP PUCCH and LP PUCCH, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCH and HP PUCCH as instructed by dynamic indication for enabling/disabling multiplexing, if configured. * Step 2.2: Resolve collision between PUCCH and PUSCH of different priorities as instructed by dynamic indication for enabling/disabling multiplexing, if configured.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 includes the simultaneous PUCCH and PUSCH transmission in different cells at least for inter-band CA. FFS details.   + ~~FFS: Which PUSCH is used for multiplexing.~~ * Note: R15 timeline is applied for multiplexing in Step 2. R16 prioritization timeline is applied for cancellation of LP transmission in step 2. * FFS for the case where different time units are configured for HP PUCCH and LP PUCCH (pursuing a unified solution). |
| Apple | Support FL’s proposal |
| Huawei/Hisi R3 | Support the proposal by Moderator.  @Intel @Samsung It should be noted that in the WA which has been agreed at this meeting, there is a note that **R15 timeline should be satisfied**. That means the procedure we shall discuss should at least by taking R15 timeline as a basis. R16 timeline, even if needs to be discussed, should be deprioritized after the procedure based on R15 timeline is finished.   |  | | --- | | Working Assumption  *For handling overlapping PUCCHs/PUSCHs with different priorities in R17*   * *Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority* * *Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities*   *Note: Avoid recursive pseudo-code to implement this procedure*  *Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable* |   For the timeline issue, we need to clarify that the UE capabilities for R15+R17 and R16+R17 should be decoupled, where the R15+R17 UE has a basic capability by taking R15 rule for multiplexing, while R16+R17 UE has a higher capability which also supports the R16 cancellation of an ongoing channel. As a difference shown below, the R15+R17 UE always assumes the R15 timeline will be satisfied during the multiplexing procedure, which is simple; while the R16+R17 UE has to support both inter-priority cancelling and inter-priority multiplexing, which is much more complex.  In the design of Step 2, we should avoid bundling the procedure with the R16 timeline by assuming R16 capability will definitely be supported by a R17 UE; e.g., as assumed by @Intel, that R16 prioritization is always supported, or gNB can use DCI to dynamically indicate multiplexing or R16 prioritization. If the UE does not support R16 prioritization, it makes no sense for the gNB to indicate such prioritization behavior.   |  |  | | --- | --- | | R15+R17 timeline | R16+R17 timeline | |
| QC | We support FL proposal. We don’t support Intel’s proposal.  To Intel: the issue your conerned can be at least partially solved by simultaneous transmission – just schedule the HP PUSCH on a different CC. For HP PUCCH, if the UE support PUCCH carrier switch, again, just schedule it on a difference CC and apply simultaneous transmission.  We also agree with Huawei’s comment – Reuse Rel-15 timeline for Rel-17 intra-UE multiplexing is already agreed. Let’s not revert existing agreement. |
| Samsung | Fine in principle.  In our understanding, the most essential issue in Step 2 is avoiding HP HARQ-ACK dropping, solutions should take it into consideration.  In addition, R15 timeline should apply to multiplexing in Step 2.  We suggest the following update,  Updated proposal  First focusing on the case where a same PUCCH time unit is configured for HP PUCCH and LP PUCCH, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision between LP PUCCHs and HP PUCCHs. * Step 2.2: Resolve collision between PUCCHs and PUSCHs of different priorities.   + If simultaneous PUCCH and PUSCH transmission is configured, Step 2.2 includes the simultaneous PUCCH and PUSCH transmission in different cells at least for inter-band CA. FFS details.   + FFS: Which PUSCH is used for multiplexing. * Note: R15 timeline is applied for multiplexing in Step 2. * FFS for the case where different time units are configured for HP PUCCH and LP PUCCH (pursuing a unified solution). * FFS: How to avoid HP HARQ-ACK dropping |
| ZTE | Agree one of Intel and Sony’s comments: ‘Note: R15 timeline is applied for multiplexing in Step 2. R16 prioritization timeline is applied for cancellation of LP transmission in step 2.’  Not all UCI types and all scenarios are allowed to be multiplexed in Rel-17 stage according to this WID discussion scope. If some UCI should be cancelled, Rel-16 time line is needed. Also agree with the sub-steps should be instructed by dynamic indication for enabling/disabling multiplexing |
| Quectel | Support FL’s proposal. |
| Intel2 | To HW and QC: We don’t think what we proposed reverts the agreement. In our understanding, the agreed note means, Rel-15 timeline is only applied for multiplexing. If two overlapped channels are not multiplexing, e.g., cancellation, Rel-15 timeline is not applied. In other words, if gNB indicates UE to perform multiplexing, UE does not expect Rel-15 timline is not met. But if gNB indicates UE not to multiplex, or UE performs cancellation due to pre-defined rule (as ZTE pointed out, not all UCI types and scenarios are allowed to be multiplexed according to WID scope), then, it is irrelevant to Rel-15 timeline.  To QC: simultenous PUCCH/PUSCH transmission and intra-UE multiplexing/prioritization are two independent UE features. We can’t always rely on one feature to resolve the problem of another feature.  To HW: We’re open to discuss UE behaviour without Rel-16 capabiblity. But we also want to point out, the cancellation we consider in Rel-17 is not only due to the timeline, but there’re also still several other reasons which lead to cancellation, e.g., due to UCI type, or some scenarios (e.g., some conditions we discussed).  To Samsung: we agree with your intention of your FFS to avoid HP HARQ-ACK dropping in step 2, but we think if gNB dynamic enable/disable indication is configured, such undesirable dropping can be easily avoided. Dynamic enable/disable indication can not only avoid timeline check, but also avoid many undesirable corner cases. |
| vivo | Thanks Intel for the clarification. We agree with the argument and support Intel’s modified proposal except the first sub bullet for simultaneous PUCCH and PUSCH transmission. As our comment in 2.5.1, we think simultaneous PUCCH and PUSCH transmission can be deprioritized. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## How to ensure the multiplexing timeline without UE-side checking?

Proposal for 3rd round discussion:

For Rel-17 intra-UE UCI multiplexing, down-select from the following two alternatives:

* Alt.1: Agree on both the two bullets below:
* UE does not check timeline, but just runs the multiplexing procedure assuming timeline is met.
* Support dynamic indication for enabling/disabling multiplexing by gNB to ensure the scheduled overlapping channels compliant with the timeline requirement.
* Alt.2: There is no restriction that UE does not check timeline.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support Alt. 1.  With dynamic indication for enabling/disabling multiplexing by gNB, it is gNB’s responsibility to ensure that the multiplexing timeline is met, and the overall specification efforts can be minimized. |
| Intel | We’re not sure the meaning of Alt.2 Does it mean, UE does not check the timeline, and UE always assumes Rel-15 timeline is met for overlapped UL channels with different priority?  We support Alt.1. As we explained, the motivation to support Alt 1 is to ensure HP latency is not materially increased compared with Rel-16 URLLC. And we share the same view with Nokia/NSB that dynamic indication minimized standard effort.  For the sake of progress, we can compromise to support both alternatives as UE capability, but we can not accept to Alt.2 alone. |
| LG | We are not supportive to Alt.1.  And also, some clarification is needed for Alt.2. |
| Sony | We support Alt 1. For the sake of 1 bit dynamic indicator, we avoid having to introduce complexity in ensuring timeline, avoid having fancy DL grant misdetection mechansims and avoid having to define all sorts of multiplexing conditions. In addition, we provide maximum flexibility for the gNB scheduler.  It isn’t clear what Alt 2 supposed to mean. |
| Apple | Timeline issue and disabling/enabling multiplexing issue should be separated. The current formulation does not give us any good choice. Note the wording “enabling/disabling multiplexing” is not so clear, there can be two readings:   * + - 1. Prioritization as in Rel-16 and inter-L1 priority multiplexing can be dynamically indicated;       2. Inter L1-priority multiplexing can be effectively disabled for dynamic PUCCH resource (for DG PUCCH) through beta=0 with a DL DCI. |
| Huawei/Hisi R3 | Support Alt. 2 (with the clarification something like “**UE does not check timeline by expecting R15 timeline is satisfied**”). As analyzed in 2.5.3:   1. We have agreed that R15 timeline should be applicable. 2. The design of R17 multiplexing procedure should not be bundled with R16 timeline by assuming the R17 UE will definitely support R16 prioritization capability. |
| Ericsson | Support Alt 1. Suggest to change the first sentence of the proposal to “For Rel-17 intra-UE ~~UCI~~ multiplexing of overlapping PUCCHs or overlapping PUCCH(s) and PUSCH(s), …” Otherwise, “UCI multiplexing” may be interpreted to cover PUCCH-PUCCH multiplexing only.  For Alt 2: it seems to mean that UE may or may or check timeline. This is not acceptable, since the outcome of multiplexing is uncertain. We can support Alt 2 if it is changed to: “It’s UE responsibility to check timeline when performing intra-UE multiplexing/cancellation.” |
| QC | We do not support this proposal.  We echo Apple’s comment. Timeline issue and disabling/enabling multiplexing issue should be separated. The current formulation does not give us any good choice.  To us, the timeline issue is already settle by previous agreement to reuse Rel-15 timeline. RAN1 should not reopen the discussion on timeline.  The question we really need to address is: **should RAN1 support dynamic enable/disabling of multiplexing?**  But the above question is already discussed in Section 3.3/4.4. Honest, we don’t think the FL proposal is needed.  Regarding whether UE check timeline or not check timeline, this is UE implementation choice. I don’t think spec should mandate UE to either check or not check. Spec just need to mandate gNB follow the R-15 timeline requirement, which is already in the spec anyway. So, again, we don’t think the proposal is needed. |
| Samsung | Support. Alt 1 is preferred.  Dynamic indication can avoid predefined rules for whether the multiplexing condition is satisfied and thus avoid corner cases due to dynamic scheduling decisions, and reduce specification impact and implementation complexity. |
| Sharp | We do not support the proposal.  Timeline and dynamic indication are separate problems. They should not be combined in a package in Alt 1. Alt 2 is also unclear.  If UE does not need to check the timeline, it can be a gNB implementation issue, i.e. the gNB should ensure the multiplexing timeline condition can be met for overlapping channels. On the other hand, the timeline condition already exist in Rel-16 channel dropping rules for HP PUCCH and HP DG PUSCH, the multiplexing timeline can be extended from the dropping timeline. |
| ZTE | Support Alt.1 with Ericsson’s revision. I think the first sub-bullet in Alt.1 should be a supplementary method if dynamic indication is not configured. |
| Quectel | We support Alt 1. |
| vivo | We support Alt 1. Alt 2 is not clear to us. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Conditions to avoid recursive pseudo-code to implement this procedure?

Proposal for 3rd round discussion:

“Avoid recursive pseudo-code” means not going back to step 1 after step 2, i.e. resultant UL channel in step 2 with one priority does not overlap with another UL channel with same priority, if these two UL channels are not overlapped after step 1.

Proposal for 3rd round discussion:

Down-select from the two alternatives:

* Alt. 1: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, aggregate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits and apply the procedures described in Sec. 6.3.2.5 of R15 TS 38.211 to the aggregated coded HARQ-ACK bit sequence.
* Alt.2: Do not support multiplexing of HP HARQ-ACK and LP HARQ-ACK in PUCCH format 2 in Rel-17. Drop LP HARQ-ACK if the resulting PUCCH resource is with PUCCH format 2.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | * 1st proposal: support * 2nd proposal: support Alt. 1.   Aggregate the coded HP HARQ-ACK ACK bits and the coded LP HARQ-ACK bits and reusing existing procedures should be quite simple and straightforward way to avoid dropping LP HARQ-ACK. |
| Intel | For 1st proposal: we are supportive.  For 2nd proposal: we support Alt 2. |
| LG | For 1st proposal: we are fine with the proposal.  For 2nd proposal: we are not supportive to the proposal.  We suggest (and prefer) the following Alt.3.  Alt.3: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, support mapping encoded HP HARQ-ACK bits first with a distributed RE mapping in frequency domain, followed by mapping encoded LP HARQ-ACK bits onto remaining REs. |
| Sony | 1st proposal: Agree  2nd proposal: Support Alt. 1 (this proposal seems to be repeated in Section 3.2.4) |
| Apple | Support both proposals from FL |
| Huawei/Hisi R3 | 1st proposal: support  2nd proposal: support the proposal with the preference of Alt.1. There is already two coding chains supported by PF3/4, and it is little effort to extend it to PF2. |
| Ericsson | 1st proposal: support  2nd proposal: Alt 1  Agree with Sony this proposal is repeated in Section 3.2.4 |
| QC | 1st proposal: support  2nd proposal: We support Alt. 3 proposed by LG. We suggest RAN1 do down-selection between Alt 1 (proposed by FL) and Alt. 3 (proposed by LG). We don’t support Alt 2, which impose quite restriction to the system. For URLLC, using PF2 is quite common. |
| Samsung | Not support the first proposal.  It will introduce scheduler restrictions which are not generally possible. Further, the proposal only precludes the resulting PUCCH from overlapping with an UL channel of same priority and does not address the case of different priorities. For example, a HP HARQ-ACK overlaps with a LP HARQ-ACK and the HP HARQ-ACK does not overlap with a LP CSI. After multiplexing, the resulting PUCCH overlaps with LP CSI.  For the 2nd proposal, we support Alt2. We can accept it to make progress.  The 2nd proposal is same as the first one under 3.2.4. |
| Sharp | 1st proposal: support  2nd proposal: support the proposal with the preference of Alt.1. |
| LG2 | Regarding the 2nd proposal, first of all, we agree with QC that Alt 2 is quite undesirable way (thus needs to be precluded) from the system perspective and in terms of supporting Rel-17 inter-priority multiplexing on PUCCH for URLLC operation.  In addition, we would like to point out major concern on Alt 1 reusing current RE mapping rule as it is after aggregating HP AN bits and LP AN bits.  Even in case where frequency hopping is enabled, if current RE mapping is applied as it is, HP AN REs (with relatively small payload size compared to LP AN) could be mapped only on the first frequency hop in the PUCCH as shown in the figure below. In this case, HP AN performance would be degraded compared to Rel-16 HP AN.    Moreover, distributed RE mapping rule (e.g., the mapping proposed in QC’s contribution) is not new mapping but existing mapping rule being used for UCI multiplexing on PUSCH. Thus, the expected impact to spec/UE is to be small. |
| ZTE | 1st proposal: support  2nd proposal: support Alt. 1. |
| Quectel | 1st Proposal: support  2nd Proposal: Support Alt. 3 proposed by LG. Since it is aimed to do down-selection, it is fair to put all the proposals on the table. |
| vivo | For the first proposal, fine in principle.  For the second proposal, we support alt 1. We think it is important to support PUCCH format 2 for multiplexing HP HARQ-ACK and LP HARQ-ACK considering its low latency. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# Multiplexing UCIs of different priorities in a PUCCH

## Agreements in previous meetings

Agreements:

*Support multiplexing for following scenarios in R17:*

* *Multiplexing a high-priority HARQ-ACK and a low-priority HARQ-ACK into a PUCCH in R17.*
* *Multiplexing a low-priority HARQ-ACK and a high-priority SR into a PUCCH for some HARQ-ACK/SR PF combinations (FFS applicable combinations).*
* *Multiplexing a low-priority HARQ-ACK, a high-priority HARQ-ACK and a high-priority SR into a PUCCH.*

*For the above multiplexing scenarios,*

* *FFS conditions, if needed, for the multiplexing, e.g*
  + *Whether to support multiplexing between different resources not confined within a sub-slot.*
  + *Whether to support multiplexing in case a PUCCH overlaps with more than one PUCCH.*
  + *Timeline requirements.*
* *FFS: details, if needed, of the multiplexing scheme, e.g.*
  + *How to minimize impact on the latency for high-priority HARQ-ACK.*
  + *How to determine the PUCCH resource used for multiplexing (e.g. HP or LP PUCCH resource, or a dedicated PUCCH resource for the multiplexing).*
  + *How to multiplex the HARQ-ACK bits (e.g. multiplexing, bundling).*
  + *How to encode the UCIs with different priorities (e.g. separate coding vs. joint coding)*
  + *How to guarantee the target code rate (e.g. payload control, multiplexing priority, LP HARQ-ACK compression/compaction).*
  + *Explicit indication for enabling multiplexing.*

*Multiplexing rule and order (e.g. HP/LP multiplexing is after resolving collision within the same priority).*

Agreements:

*For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits are more than 2 bits, down-select from the following options in RAN1#104-e:*

* *Option 1: Support joint coding.*
* *Option 2: Support separate coding.*
* *Option 3: Combination of Option1 and 2.*
* *FFS the details*

*For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is 2 bits, provide design details for decision for the following cases in RAN1#104-e:*

* *Multiplexing on a PUCCH format 0*
* *Multiplexing on a PUCCH format 1*

Agreements:

*For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, support a mechanism for gNB to enable/disable the multiplexing.*

* *FFS the type of the mechanism, e.g. DCI indication and/or RRC configuration*
* *FFS: Interaction between the enable/disable mechanism and other multiplexing conditions*
* *FFS for other types of UCI.*

Agreements:

*For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,*

* *Use a PUCCH resource in the second PUCCH-Config (the PUCCH-config containing the PUCCH resource of the HP HARQ-ACK) at least in case the total number of LP and HP HARQ-ACK bits is more than 2.*
* *FFS: The PUCCH resource is configured dedicated for multiplexing of HP HARQ-ACK and LP HARQ-ACK.*
* *FFS in case the total number of LP and HP HARQ-ACK bits is 2.*
* *FFS details*

Working assumption:

*Reuse Rel-15 intra-UE PUCCH/PUSCH multiplexing timeline requirements for Rel-17 intra-UE PUCCH/PUSCH multiplexing with different priorities*

* *FFS whether or not to specify a different behavior than Rel-15 when the timeline requirements are not met*

Agreements:

*When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, further study the following options (proponents are encouraged to provide more details and analysis):*

* *Opt.1: The positive SR and HARQ-ACK are multiplexed and transmitted on the SR resource.*
  + *Opt.1a: The UE does not transmit negative SR.*
  + *Opt.1b: For negative SR, the UE transmit only HARQ-ACK on the HARQ-ACK resource.*
  + *Opt.1c: For negative SR, the UE transmits SR and HARQ-ACK on the SR resource*
  + *FFS: whether with power boost to transmit multiplexed payload or not.*
* *Opt.2: The SR and HARQ-ACK are multiplexed and transmitted on the HARQ-ACK resource.*
  + *Opt.2a: If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the HARQ-ACK PUCCH resource.*
  + *Opt.2b: Using 4 CS values as for SR+1-bit HARQ-ACK in Rel-15/16. For the case of 2-bit HARQ-ACK, the HARQ-ACK is reduced/compressed to 1-bit.*
  + *Opt.2c: If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.*
* *Opt.3: No enhancement over Rel-16.*
* *Other options not excluded.*
* *FFS: Whether/How to differentiate HP SR and LP SR when multiplexed with LP HARQ-ACK?*

Agreements:

*When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, further study the following options (proponents are encouraged to provide more details and analysis):*

* *Opt.1: The positive SR and HARQ-ACK are multiplexed and transmitted on the SR resource.*
  + *Opt.1a: The UE does not transmit negative SR.*
  + *Opt.1b: For negative SR, the UE transmit only HARQ-ACK on the HARQ-ACK resource.*
  + *Opt.1c: For negative SR, the UE transmits SR and HARQ-ACK on the SR resource*
  + *FFS: whether with power boost to transmit multiplexed payload or not.*
* *Opt.2: The SR and HARQ-ACK are multiplexed and transmitted on the HARQ-ACK resource.*
  + *Opt.2a: If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the HARQ-ACK PUCCH resource.*
  + *Opt.2b: Applying QPSK for SR+1-bit HARQ-ACK. For the case of 2-bit HARQ-ACK, the HARQ-ACK is reduced/compressed to 1-bit.*
  + *FFS on conditions of multiplexing.*
* *Opt.3: For positive SR, transmit HARQ-ACK on the SR resource. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.*
* *Opt.4: For positive SR, transmit SR on the SR resource and drop HARQ-ACK. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.*
* *Opt.5: No enhancement over Rel-16.*
* *Other options not excluded.*
* *FFS: Whether/How to differentiate HP SR and LP SR when multiplexed with LP HARQ-ACK?*

Agreements:

*When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, further study the following options (proponents are encouraged to provide more details and analysis):*

* *Opt.1: The SR and HARQ-ACK are multiplexed and transmitted on the SR resource.*
  + *Opt.1a: For positive SR, the UE transmits the PUCCH in the resource using PUCCH format 1 for SR. The value of cyclic shift of sequence, i.e., , of this PUCCH format 1 is determined by HARQ-ACK, and the bit, i.e., b(0), of this PUCCH format 1 is determined by SR. For negative SR, the UE transmits only a PUCCH with HARQ-ACK information and drops the PUCCH with negative SR.*
  + *Opt.1b: SR and HARQ-ACK are multiplexed and modulated to be transmitted on the SR resource*
* *Opt.2: The SR and HARQ-ACK are multiplexed and transmitted on the HARQ-ACK resource.*
  + *Opt.2a: If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the HARQ-ACK PUCCH resource.*
  + *Opt.2b: Using 4 CS values as for SR+1-bit HARQ-ACK in Rel-15/16. For the case of 2-bit HARQ-ACK, the HARQ-ACK is reduced/compressed to 1-bit.*
  + *Opt.2c: If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.*
  + *Opt.2d: HP SR and LP HARQ-ACK are multiplexed by the Rel-15 cyclic shift only if latency requirement for HP SR is met. Otherwise, drop the LP HARQ-ACK and only transmit the HP SR on its resource.*
* *Opt.3: For positive SR, transmit HARQ-ACK on the SR resource. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.*
* *Opt.4: No enhancement over Rel-16.*
* *Other options not excluded.*
* *FFS: Whether/How to differentiate HP SR and LP SR when multiplexed with LP HARQ-ACK?*

Agreements:

*For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is more than 2, support separate coding for the two HARQ-ACKs.*

* *FFS for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s).*
* *(working assumption) Drop CSI (including part 1 and part2, if exist) if CSI would multiplex on a PUCCH which has HP A/N.*
  + *FFS Strive to let HP A/N reuse the encoder, rate matching equation, and RE mapping rules in Rel-15 for A/N+CSI-1.*
  + *FFS Strive to let LP A/N reuse the encoder, rate matching equation, and mapping rules in Rel-15 for CSI-2.*

Agreement:

*For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is more than 2,*

* *For HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding. Down-select from the two options:*
  + *Option 1: Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.*
  + *Option 2: Reuse R15 TS 38.212 Clause 5.3.3.3, i.e., padding to 3 bits and using RM coding.*
* *For HP HARQ-ACK or LP HARQ-ACK >2 bit(s), HP HARQ-ACK and LP HARQ-ACK are separately encoded according to R15 TS 38.212 Clause 5.3.3.3 or Clause 5.3.1.*
* *FFS rate matching equation and RE mapping rules for PF2/3/4. Rel-15 is baseline if available.*

Agreement:

*For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is 2, treat the two bits as HARQ-ACK bits with High priority.*

* *Rel-15 design (for PF0 and PF1) is baseline.*
* *Note: Qualcomm has strong concern on above scheme. The scheme cannot provide unequal error protection between the HP bit and LP bit hence could suffer from performance degradation for the HP bit. Qualcomm accepts the scheme for the sake of progress in RAN 1 with the concern on the performance reserved.*

Agreement

*For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,*

* *HP A/N reuses rate matching equation, and RE mapping rules in Rel-15 for A/N+CSI-1.*
* *LP A/N reuses rate matching equation, and RE mapping rules in Rel-15 for CSI-2.*

*Above applies at least for PUCCH format 3 and 4.*

Agreement

*For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, an additional maxCodeRate for LP HARQ-ACK can be configured in the second PUCCH-Config per PUCCH format.*

Agreement

*For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,*

* *PUCCH resource set determination is based on: UCI payload size = the number of HP UCI bits + the number of LP UCI bits.*
* *FFS PRB number determination for HP A/N and LP A/N, e.g. based on their coding rates.*
* *FFS the impact to the number of LP UCI bits due to missed DCI and potential solutions*
* *Note: the number of LP UCI bits in the above agreement does may not necessarily mean the actual number of LP UCI bits until the second FFS is resolved*

## Coding, rate matching, RE mapping and power control

## Inputs from Tdocs

**Details of separate coding when the total number of LP and HP HARQ-ACK bits > 2:**

* **Encoder for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s):**
  + Option 1: Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.
    - HW, ZTE, Nokia, QC, Quectel, Intel, vivo, OPPO, DCM, Pana
  + Option 2: Reuse R15 TS 38.212 Clause 5.3.3.3, i.e., padding to 3 bits and using RM coding.
    - E///, CATT, Samsung, LGE, Spreadtrum
* **Coding rate configuration**
  + QC: Configure multiple coding rates for HARQ-ACK based on the payload size for a given priority.
* **RE mapping** for PUCCH format 2
  + Option 1: Aggregate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits and apply the procedures described in Sec. 6.3.2.5 of R15 TS 38.211 to the aggregated coded HARQ-ACK bit sequence.
    - ZTE, Nokia, CATT, vivo
  + Option 2: Distributed RE mapping for HP UCI and LP UCI in frequency domain.



* + - HW, QC, LGE, Quectel
  + Option 3: Do not support multiplexing of HP HARQ-ACK and LP HARQ-ACK in PUCCH format 2 in Rel-17. Drop LP HARQ-ACK if the resulting PUCCH resource is with PUCCH format 2.
    - Samsung, Intel
* **CSI dropping or not:**
  + Option 1: Confirm WA: Drop CSI (including part 1 and part2, if exist) if CSI would multiplex on a PUCCH which has HP A/N.
    - ZTE, Nokia, QC, Quectel,, vivo, Apple (for LP CSI)
  + Option 2: Drop CSI part 2 if CSI would multiplex on a PUCCH which has HP A/N.
    - LGE, DCM
* **Power control:**
  + QC: Two open-loop power control P0 values are configured for multiplexing LP and HP UCI
  + E///, Samsung, IDC: the parameters configured for HP HARQ-ACK should be used to determine 

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 2: For PUCCH format 2, support 2 encoding chains for the case of HP HARQ-ACK and LP HARQ-ACK multiplexing. And separate code rates can be configured for HP HARQ-ACK and LP HARQ-ACK for PUCCH format 2.***  ***Proposal 3: For the encoders* *of LP and HP HARQ-ACK bits with more than 2 bits total payload***, ***and HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support option 2, i.e., padding and RM encoding.***  ***Observation 1: It is feasible to consider an enhanced RE mapping rule in Rel-17.***  ***Proposal 4: For multiplexing of HP HARQ-ACK and LP HARQ-ACK, the distributed mapping between HARQ-ACK and LP HARQ-ACK could be considered for PUCCH format 2.***  ***Proposal 5: The BPRE calculation can be further studied for the transmission power of multiplexed HP HARQ-ACK and LP HARQ-ACK.*** |
| E/// | [Proposal 9For separate coding of HP or LP HARQ-ACK of 1-2 bits when multiplexed into a PUCCH, reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.](#_Toc79181289)  [Proposal 8 If the total number of high priority UCI bits is 11 or lower, let , otherwise let .](#_Toc84035008) |
| ZTE | ***Proposal 1:*** *For HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding and reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit, reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.*   * Reuse R15 scrambling for PUSCH as baseline, if scrambling is needed.   ***Proposal 2:*** *When the two UCIs with different priorities will be multiplexed on a PUCCH format 2/3/4 by separate coding, for a certain priority UCI,*   * If the payload size is more than 2 but less than 12, RM code is performed. * If the payload is more than 11 bits, Polar coding is performed.   ***Proposal 3:*** *Modify the agreement in RAN1#106-e to:*  *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17* ***in case of the total number of LP and HP HARQ-ACK bits >2****,*   * *HP A/N reuses rate matching equation, and RE mapping rules in Rel-15 for A/N+CSI-1.* * *LP A/N reuses rate matching equation, and RE mapping rules in Rel-15 for CSI-2.*   *Above applies at least for PUCCH format 3 and 4.*  ***Proposal 4:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is more than 2,*   * *Coded bits of HP HARQ-ACK and LP HARQ-ACK are continuously mapped in the time-frequency resources for PF2.* |
| Nokia | **Proposal 3.4: For the scenario where a PUCCH carrying high-priority HARQ-ACK overlaps with another PUCCH carrying low-priority HARQ-ACK and the total payload size is two bits, the order of the multiplexed two bits could be [high-priority HARQ-ACK bit, low-priority HARQ-ACK bit].**  **Proposal 3.6: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK where the high-priority or low-priority HARQ-ACK is 1-2 bits and the total payload size is greater than 2,**   * **Adopt Option 1 as follows: In case HARQ-ACK is 1 bit, use the existing Rel-15 1-bit information encoding scheme in TS 38.212 Sec. 5.3.3.1 to encode this HARQ-ACK; in case HARQ-ACK is 2 bits, use the existing Rel-15 2-bit information encoding scheme in TS 38.212 Sec. 5.3.3.2 to encode this HARQ-ACK.**   + **In case HARQ-ACK is 1 bit, the scrambling design for PUSCH could be reused to account for the placeholder bits.**   **Proposal 3.7: Confirm the RAN1#104bis-e meeting’s Working Assumption to not support multiplexing of CSI (including part 1 and part 2, if any) and high-priority HARQ-ACK on PUCCH and thus to drop the CSI and prioritize the high-priority HARQ-ACK.**  **Proposal 3.8: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, adopt the following approach for mapping the separately coded bits to PUCCH:**   * **Aggregate the coded high-priority HARQ-ACK bits and the coded low-priority HARQ-ACK bits and apply the procedures described in Sec. 6.3.2.5 of TS 38.211 to this aggregated coded HARQ-ACK bit sequence.** |
| CATT | ***Proposal 5: For multiplexing of HP HARQ-ACK and LP HARQ-ACK on PUCCH when total number of bits is more than 2, padding to 3 bits and using RM coding for HP HARQ-ACK or LP HARQ-ACK of 1 or 2 bits.***  ***Proposal 6: For separate coding of HP HARQ-ACK and LP HARQ-ACK when multiplexing on a PUCCH resource with PUCCH format 2, the encoded HP HARQ-ACK and LP HARQ-ACK are cascaded and mapping to PUCCH REs in increasing order of frequency domain followed by time domain.*** |
| QC | ***Proposal 4*: Confirm the working assumption made in RAN1 #104bis-e**  **For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,**   * **Drop CSI (including part 1 and part2, if exist) if CSI would multiplex on a PUCCH which has HP A/N.**   ***Proposal 5*: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into PUCCH format 3 or format 4, when the total number of LP and HP HARQ-ACK bits is more than 2, and when the number of HP or LP HARQ-ACK has less than or equal to 2 bits**   * **The HP or LP HARQ-ACK uses repetition encoding if the payload size is 1 bit, and uses the simplex encoding if the payload size is 2 bits**   ***Proposal 6*: In NR Rel-17, for multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into PUCCH, when the total number of low priority (LP) and high priority (HP) HARQ-ACK bits is more than 2**   * **For a given priority, support gNB to configure multiple coding rates for HARQ-ACK based on the payload size.**   ***Proposal 8*: For HP UCI and LP UCI multiplexing on PUCCH format 2, support mapping encoded HP UCI bits first with a distributed RE mapping in frequency domain, followed by mapping encoded LP UCI bits onto remaining REs.**  ***Proposal 9*: the distance d for HP UCI distributed RE mapping is determined as , where**   * **is the payload size for HP UCI, is the coding rate for HP UCI.** * **S is number of OFDM symbols in the PUCCH resource.** * **L is the total number of RBs determined for multiplexed HP UCI and LP UCI transmission**   ***Proposal 10*: For HP UCI and LP UCI multiplexing on PUCCH format 2/3/4, support the following**   * **Two open-loop power control P0 values are configured for multiplexing LP and HP UCI** * **Two separate powers are computed for LP UCI and HP UCI (following TS 38.213 Section 7.2.1) based on the corresponding and BPRE for LP and HP UCI respectively, and based on the total number of RBs used to HP and LP UCI** * **The final PUCCH power is determined based on the max power of the HP and LP powers** |
| Samsung | **Proposal 3: Zeros are appended to the LP/HP HARQ-ACK information bits if the payload of LP/HP HARQ-ACK is 1 or 2 bits when multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH.**  **Proposal 4: Do not support multiplexing of HP HARQ-ACK and LP HARQ-ACK in PUCCH format 2 in Rel-17.**   * **Drop LP HARQ-ACK if the resulting PUCCH resource is with PUCCH format 2.**   **Proposal 5: RRC configures presence of a T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.**  **Proposal 6: RRC separately configures enabling multiplexing of HP HARQ-ACK and LP HARQ-ACK for HP HARQ-ACK with and without a PDCCH.**  **Proposal 11：For determining the transmitting power for a PUCCH with HP HARQ-ACK and LP HARQ-ACK, the parameters configured for HP HARQ-ACK should be used to determine .**   * **FFS: Whether/How to drop LP HARQ-ACK if the calculated power based on is larger than the configured maximum output power .** |
| LGE | **Proposal #1: Consider to apply RM coding with bit-padding for HP/LP HARQ-ACK of up to 2 bits (in case when the total number of LP and HP HARQ-ACK bits is more than 2), in order to minimize impacts to the specification as well as UE implementation.**  **Proposal #2: Consider the following UE behaviour for the multiplexing of CSI at least on PUCCH format 3/4.**   * **In case with HP HARQ-ACK and CSI (without LP HARQ-ACK), the HP HARQ-ACK and CSI part 1 can be separately encoded where CSI part 2 is dropped.** * **In case with HP HARQ-ACK, LP HARQ-ACK and CSI, the LP HARQ-ACK and CSI part 1 can be jointly encoded and the HP HARQ-ACK can be solely encoded where CSI part 2 is dropped.**   **Proposal #3: Consider to support separate encoding for HP HARQ-ACK and LP HARQ-ACK on PUCCH format 2.**   * **HP (coded) UCI is firstly mapped over distributed REs on the PUCCH resource (to guarantee the reliable HP UCI performance by achieving frequency diversity), then LP UCI is mapped to the remaining REs not occupied by the HP UCI.**   **Proposal #4: Consider the following aspects for the multiplexing of HP HARQ-ACK and LP HARQ-ACK on PUCCH format 0/1 with the total UCI payload size of 2 bits.**   * **HP UCI bit and LP UCI bit are mapped to MSB and LSB, respectively.** * **HP PUCCH format 0/1 resource is selected for the UCI multiplexing.** |
| IDC | ***Proposal 9: Support additional maxCodeRate2 parameter for HP HARQ-ACK. In case the same number of RBs is sufficient to accommodate resources for both HP and LP coded bits when HP bits use either maxCodeRate or maxCodeRate2, the HP maxCodeRate for rate matching is the minimum between maxCodeRate and maxCodeRate2.***  ***Proposal 10: For a PUCCH format 3 or format 4 when HP HARQ-ACK is multiplexed with LP HARQ-ACK, the BPRE term in PUCCH transmission power adjustment component TF,b,f,c is set to BPRE= maxCodeRateQm where maxCodeRate is the configured maximum coding rate for HP bits and Qm is the modulation order.*** |
| Quectel | **Proposal 2**: Confirm the working assumption that CSI (including part 1 and part2, if exist) is dropped if CSI would multiplex on a PUCCH which has HP A/N.  **Proposal 3**: Option 1 is supported, i.e., R15 TS 38.212 Clause 5.3.3.1 is reused for 1-bit and R15 TS 38.212 Clause 5.3.3.2 is reused for 2-bit.  **Proposal 9**: Interleaved multiplexing/RE mapping of HP HARQ-ACK and LP HARQ-ACK is supported when HP HARQ-ACK and LP HARQ-ACK are multiplexed in PUCCH with PF2. |
| Intel | **Proposal 6: For HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding by reusing R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.**  **Proposal 7: LP and HP HARQ-ACK multiplexing is not supported for PUCCH format 2.** |
| Apple | **Proposal 9-1: leverage the Rel-15 design, LP HARQ-ACK is mapped to UCI Part II in separate encoding, adopt the UCI mapping in Figures 9-6a/9-6b.**  **Proposal 9-2:**  **Consider for PUCCH format 2 to support multiplexing of HP UCI(s) and LP UCI(s):**  **generating two encoded sequences for HP-ACK (with r1) and LP-ACK (with r2) separately and then concatenating those two encoded sequences into one encoded sequence, UCI mapping is not changed for PUCCH Format 2.**  **Proposal 13: For PUCCH formats 2/3/4, the delta factor is determined from UCI part 1:**   * **The number of resource elements for UCI part 1 where is the number of coded bits for UCI part 1** * **If is smaller or equal to 11,**   + **If a HARQ-ACK codebook with bits is included in UCI part 1,  is used instead of for the HARQ-ACK codebook:**   + **If more than one HARQ-ACK codebooks are included in UCI part 1 (e.g. one due to SPS HARQ deferral, another for HARQ feedback for dynamic grant PDSCH(s)), then replacement of the number of HARQ-ACK codebook size by the associated can be applied to each HARQ-ACK codebook.** * **otherwise**   + **where**      - **and** * **And = is applied to both UCI parts.** |
| vivo | ***Proposal 2: When the total number of LP and HP HARQ-ACK bits is more than 2 and for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), option 1 is preferred.***   * ***Option 1: Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.***   ***Proposal 3: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH format 2, the encoded HP HARQ-ACK and LP HARQ-ACK are concatenated and mapping to PUCCH REs in increasing order of frequency domain followed by time domain.*** |
| OPPO | ***Proposal 1: When the total LP HARQ-ACK and HP HARQ-ACK bits is more than 2 and one of HP HARQ-ACK and LP HARQ-ACK is not more than 2, option 1 is supported.***  ***Proposal 2: PUCCH format 2 can be used for multiplexing of HP HARQ-ACK and LP HARQ-ACK.*** |
| DCM | **Proposal 1:**   * *CSI part 2 is dropped if CSI would multiplex on a PUCCH which has HARQ-ACK information in case the total number of LP and HP HARQ-ACK bits is more than 2.*   **Proposal 2:**   * *Option 1 is slightly preferable considering the potential overhead of padding for the separate coding method of 1-2 HARQ-ACK bit(s).*   + *Option 1: Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.* |
| Pana | **Proposal 1: For the encoder for HP or LP HARQ-ACK of 1-2 bit(s) when the total number of LP and HP HARQ-ACK bits is more than 2**   * **Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit.** * **Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit** |
| Spreadtrum | 1. ***For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH, if HP HARQ-ACK or LP HARQ-ACK is of 1-2 bit(s), reuse R15 TS 38.212 Clause 5.3.3.3, i.e., padding to 3 bits and using RM coding.*** |
| NEC | ***Proposal 1:***  *Support multiplexing of two Type-1 HARQ-ACK codebooks of different priorities on a PUCCH in Rel-17 as follows:*   * *Firstly, UE constructs the high-priority Type-1 HARQ-ACK codebook based on K1 set of high-priority HARQ-ACK as Rel-16, and constructs low-priority Type-1 HARQ-ACK codebook based on K1’ set obtained by removing values in the intersection of the two separate HARQ-ACK timing K1 sets of two Type-1 CBs from the K1 set of low-priority HARQ-ACK.* * *Then, UE pastes the two HARQ-ACK codebooks together as a multiplexed HARQ-ACK codebook.* |
| ETRI | **Proposal 5: The LP DCI determines the final PUCCH resource in at least for the HP SPS case.** |
| Sharp | **Proposal 2: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH with total payload greater than 2 bits,**   * **The coding method can be configured between separate coding and joint coding.**   **Proposal 3: LP HARQ-ACK payload reduction can be configured by higher layer signaling, and be applied if the total payload exceeds the PUCCH capacity**   * **FFS the supported payload reduction methods.** |
| WILUS | * ***Proposal 1:*** *Further discuss whether/how to multiplex HP HARQ-ACK and LP HARQ-ACK in a PUCCH resource if the second PUCCH-Config contains only the first PUCCH resource (for 1- or 2-bit HARQ-ACK information).* * ***Proposal 2:*** *For PUCCH format 3/4,*    + *To maximize reliability of HP HARQ-ACK, the mapping rule of PUCCH format 3/4 in Rel-15 can be reused., i.e., the HP HARQ-ACK is mapped to adjacent symbols to DMRS symbols.*   + *To minimize latency of HP HARQ-ACK, the HP HARQ-ACK can be mapped to earlier symbols.* * ***Proposal 3:*** *For PUCCH format 2,*   + *Support PUCCH format 2 to multiplex LP HARQ-ACK and HP HARQ-ACK*   + *To maximize a reliability of HP HARQ-ACK, the HP HARQ-ACK is distributed to REs across RBs as much as possible.* * ***Proposal 5:*** *To multiplex HP-SR with PF0 and LP HARQ-ACK with PF0, we propose*   + *If HP-SR is negative, then transmit LP HARQ-ACK on HARQ-ACK resource.*     - *In case of 1-bit LP HARQ-ACK, use 2 CSs, i.e., {0, 6} CS index*     - *In case of 2-bit LP HARQ-ACK, use 4 CSs, i.e., {0, 3, 6, 9} CS index*   + *If HP-SR is positive, then transmit LP HARQ-ACK and HP-SR on HARQ-ACK resource*     - *In case of 1-bit LP HARQ-ACK, use 2 CSs, i.e., {3, 9} CS index*     - *In case of 2-bit LP HARQ-ACK, use 4 CSs, i.e., {1, 4, 7, 11} CS index*        * *To enhance HP-SR reliability, 2-bit LP HARQ-ACK can be bundled to 1-bit and then the 1-bit bundled LP HARQ-ACK is treated as 1-bit LP HARQ-ACK, i.e., use 2 CSs, {3, 9} CS index .* |

## 1st round discussion

Proposal for 1st round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is more than 2, for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding, and

* Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.
  + Reuse R15 scrambling for PUSCH as baseline. FFS details.

Proposal for 1st round discussion:

For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, support mapping encoded HP HARQ-ACK bits first with a distributed RE mapping in frequency domain, followed by mapping encoded LP HARQ-ACK bits onto remaining REs.

Proposal for 1st round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,

* If the total number of high priority UCI bits is 11 or lower, let , otherwise let .

|  |  |
| --- | --- |
| Company | Comments |
| Sony | 1st Proposal: Agree  2nd Proposal: Not agree. Shouldn’t we put the HP UCI first followed by LP UCI in time so that the HP UCI reaches the gNB earlier? |
| Apple | 2nd proposal: not agree.  3rd proposal: not agree on the delta formula. As analyzed in our contribution, there is a huge discrepancy in Delta value w.r.t. spectral efficiency. |
| Lenovo/Motorola Mobility | 1st proposal: Support  2nd proposal: We think HP UCI channel bits should be mapped to available REs of PUCCH, starting from the earliest PUCCH symbol in a frequency-first manner (i.e. in increasing order of first the subcarrier index over the assigned physical resource blocks and then the PUCCH symbol index).  3rd proposal: In Rel-15, for payload size no larger than 11 bits, CRC bits are not attached. Thus, the following modification is suggested:  If the total number of high priority UCI bits is 11 or lower, let , otherwise let . |
| InterDigital | 1st Proposal: Agree  3rd Proposal: Don’t agree.  The resulting power adjustment would be much too high in a typical scenario where the number of LP bits is larger than the number of HP bits (Example: 10 LP bits and 2 HP bits). It seems better to adjust based on the BPRE of HP bits only, i.e. number of HP bits divided by RE’s available for HP bits. |
| Intel | We support 1st proposal.  We do not support 2nd proposal. It is undesirable to increase the number of coding chains for PUCCH format 2, which complicates UE/gNB implementation. We support drop LP UCI for PUCCH format 2.  We do not see the need of 3rd proposal. It is unclear how much gain can be provided by changing the existing power control equation, and why the existing mechanism can not work. It is noted that separate coding is also supported in Rel-15/16, but takes all UCI bits into account rather than using one UCI type. |
| QC | We support the 1st proposal. Regarding the scrambling issue mentioned by a few companies, we don’t see it has an issue because PUCCH is only QPSK based and the scrambling is automatically avoided – scrambling only take effect with UCI mux on PUSCH with 16QAM and above.  We support the 2nd proposal.  To Sony: if I understand FL proposal correct, the ordering of mapping is FL proposal is the logic ordering of mapping HP or LP UCI to available REs first. Of course, when mapping HP UCI first, the location of the HP UCI REs should be on earlier OFDM symbol available. To clarify this point, maybe we can modify the proposal as below:  “For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, support mapping encoded HP HARQ-ACK bits first with a distributed RE mapping in frequency domain, starting from the earliest OFDM symbol available in the determined PF 2 PUCCH resource, followed by mapping encoded LP HARQ-ACK bits onto remaining REs.”  We don’t support proposal 3 for now, as we don’t follow the logic of it. We’d like to ask FL a few questions for clarification. Question 1: the n\_HARQ-ACK in first equation is HP HARQ-ACK, or LP HARQ-ACK or both? Question 2: the BPRE in the second equation is calculated based HP HARQ-ACK, or LP HARQ-ACK or both? |
| Ericsson | 1st proposal: do not support.  Even though it is possible to make it work to reuse PUSCH scrambling for PUCCH (e.g., considering that PUCCH uses QPSK only, as commented by QC), it requires much spec change to implement this for PUCCH format 1 and 3/4. For example, in 38.211, both section 6.3.2.5 and 6.3.2.6 need to add the pseudo code currently defined for PUSCH scrambling. We do not see the need to cause significant spec change and implementation change, without significant performance benefit. It’s much simpler to go with Option 2 (zero padding to 3 bits and reuse RM code).  2nd proposal: do not support. The procedure can become complicated quickly considering the various scenarios, e.g., number of bits for HP HARQ-ACK is more than that of LP, or less than that of LP. If frequency diversity is desired, frequency hopping can be applied. Thus, it’s better to simply concatenate and reuse existing procedure.  3rd proposal: support. |
| DOCOMO | 1st proposal: Agree  2nd proposal: Not agree. Although it would improve HP reliability by frequency diversity, we think it is an optimization. In case of sequential mapping of HP HARQ-ACK (1st) -> LP HARQ-ACK (2nd), the HP HARQ-ACK is mapped to frequency domain first and then time domain, which would also have some frequency diversity gain. Besides, the proposal leads to standardization efforts on how to determine the distance of the distribution mapping. On the other hand, the sequential mapping is simpler and gNB could decode the HP HARQ-ACK faster. For example, if the HP HARQ-ACK is mapped to only 1st symbol in the sequential mapping, while it is mapped to 2 symbols in the distributed mapping, gNB doesn’t need to wait for the 2nd symbol by the sequential mapping for decoding of the HP HARQ-ACK.  3rd proposal: Share the similar view with Intel. |
| MediaTek | 1st proposal: do not support. Unjustified significant spec and implementation changes.  2nd proposal: do not support. |
| Panasonic | We support the 1st proposal.  On 2nd proposal, we have similar view with Lenovo that HP UCI bits should be mapped to available REs of PUCCH, starting from the earliest PUCCH symbol in a frequency-first manner.  On 3rd proposal, we share the Intel’s view. We are not sure to change the existing power control equation. |
| LG | 1st proposal: Not agree.  RM coding with (or without) bit-padding is more preferable from the perspective of specification impact and UE implementation.  2nd proposal: Agree.  Otherwise (if current frequency-first mapping on PF2 is used as it is), HP HARQ-ACK performance would be degraded compared to Rel-16 HP HARQ-ACK, especially, in case where HP HARQ-ACK REs are mapped only on the first frequency hop in the PUCCH.  3rd proposal: We are open to discuss further on this issue including other ways. |
| vivo | 1st Proposal: Agree  2nd Proposal: not support. we support to map encoded HP HARQ-ACK bits first in frequency-first manner, followed by mapping encoded LP HARQ-ACK bits onto remaining Res  3rd Proposal: same question as QC |
| Nokia/NSB | We support the 1st Proposal – while noting that we would also be fine with padding to 3 bits and reusing RM code.  We do not support the 2nd Proposal, and we share similar views as Ericsson, i.e. aggregate the coded high-priority HARQ-ACK bits and the coded low-priority HARQ-ACK bits and apply the procedures described in Sec. 6.3.2.5 of TS 38.211 to this aggregated coded HARQ-ACK bit sequence (as also proposed in our Tdoc).  Do not support the 3rd proposal for now, and we share similar view as Intel. Also, we have similar questions as QC. |
| ITRI | 1st proposal: Support.  2nd proposal: do not support. We support to map HP HARQ-ACK first, starting from the earliest PUCCH symbol in a frequency-first manner, followed by the LP HARQ-ACK. |
| ZTE | Support the first proposal as the performance gain could be observed compared with option of padding to 3 bits. Reuse R15 scrambling for PUSCH doesn’t need much specification effort.  Not support the second proposal, because the distributed RE mapping in frequency domain doesn’t show performance gain in the narrow band PUCCH transmission. And localized RE mapping is straightforward and easy to be implemented.  Not support the third proposal, as the power needed for LP HARQ-ACK may be more than that for HP HARQ-ACK. So select the maximum needed power for LP HARQ-ACK or HP HARQ-ACK should be considered. |
| Sharp | Support the 1st Proposal.  2nd Proposal: Not agree. Continuous mapping HP HARQ-ACK + LP HARQ-ACK is enough. |
| Huawei/Hisi | 1st proposal: We slightly prefer RM coding, but we can live with it.  2nd proposal: Support. It should be noted that the time length is too short to improve the reliability from the time domain, so the frequency diversity is valuable for PUCCH format 2. In addition, similar distributed mapping rule has also been applied to UCI on PUSCH.  3rd proposal: Do not support. Simply using the total HP and LP HARQ-ACK to calculate BPRE will derive an averaged equivalent UCI code rate which is lower than LP code rate, thus the power allocated for LP will be harmed. We recommend to use the LP UCI payload and LP RE number to calculate the BPRE to avoid the power loss for LP.  If the number of UCI bits is smaller than or equal to 11, ;  if the number of UCI bits is larger than 11, , where . |
| Samsung | NOT support the 1st proposal. It complicates both specification and implementation. The proposal is clearly an optimization which should be avoided considering only two meetings left. It is straightforward to pad to 3 bits and use RM coding which have been supported in Rel-15. It can avoid introducing new scrambling. If the proposal is agreed, both options will be implemented for PUCCH for both UE and gNB, the implementation complexity is not acceptable.  NOT support the 2nd proposal. The proposal is an optimization which complicates the spec and implementation. The principle of UCI multiplexing of different priorities is to avoid coding chain. Clearly, the proposal is against the principle.  OK with the 3rd proposal. |
| Quectel | 1st Proposal: support; In our view, the performance is important especially for HP HARQ-ACK, otherwise the usefulness of HP HARQ-ACK and LP HARQ-ACK multiplexing may be quite limited, especially considering that HP HARQ-ACK may be at a high risk of performance degradation due to multiplexing. In addition, the lowest coding rate supported by existing PUCCH-config is 0.08 whereas the coding rate of mother code for padding based RM would be 1/32 and 1/16 respectively for 1 and 2 bit HARQ-ACK. It is unclear for us what impact of RM shortening or truncation is and what specification change is needed. We think Option 1 is a much safer choice at this stage.  2nd Proposal: support in principle. We think this is low-hanging fruit with almost zero specification effort. Similar distributed mapping rules for UCI in PUSCH in 38.212 Section 6.2.7 can be fully reused, i.e., a type of UCI bit sequence (e.g, HARQ-ACK) is firstly mapped to the earliest available OFDM symbols then the orphan bits (if exist) are mapped in a distributed way on the last occupied OFDM symbol.  3rd Proposal: we fail to understand FL’s proposal unfortunately. Are both HP and HP counted by or ? Why are CRC bits counted for less than 11 bit case? Why is only the number of HP bits used for determining the formulation? |
| OPPO | 1st proposal, agree  3rd proposal, Not agree  Power control enhancement for PUCCH is valid due to separate coding is introduced. Different code rate leads different power control value, so it is necessary to clarify which code rate is applied for power control determination. If parameter for UCI with higher code rate, e.g. low priority UCI, is applied, the reliability for all UCI can be satisfied.  For the proposal, we cannot follow the logic. In our understanding, unified parameter, low priority UCI or high priority for UCI, for all steps should be applied. It is simpler and it can bring more benefit, more reliable or more efficient.  To ensure reliability of all UCI, we suggest that  Updated proposal  For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH format 2 or 3 or 4 in R17,   * If the total number of ~~high~~ low priority UCI bits is 11 or lower, let , otherwise let * Note that, is determined by low priority UCI. |
| InterDigital 2 | Some comments on the 3rd proposal (power offset):  @Intel, DOCOMO, Panasonic: There is already separate coding between HARQ-ACK+CSI1 and CSI2 in R15 but both use a common maxCodeRate parameter which results in approximately same coding rate after rate matching. In the case of HP HARQ-ACK vs LP HARQ-ACK, each is configured with different maxCodeRate parameters, and therefore the coding rates and BPRE could be quite different.  @Huawei: Using the LP UCI payload or BPRE does not guarantee that the HP UCI reliability target is met. Also, the PUCCH resource is taken from the second PUCCH config and power control parameters of that config are set to meet the HP UCI requirement (since HP UCI can be transmitted without LP UCI). It is better to set power based on HP UCI payload/BPRE. By configuring maxCodeRate of LP UCI appropriately compared to the maxCodeRate of HP UCI, the network can avoid the case where LP UCI would require more power compared to HP UCI. |
| Xiaomi | 1st Proposal: support |
| CATT | We do not agree with the 1st proposal since it introduced additional specification impact on scrambling. Even though only QPSK is applied for PUCCH as commented by QC, the placeholder is still used for 1-bit payload size.  We do not agree with the 2nd proposal which complicate the design by supporting distributed RE mapping.  We do not agree with the 3rd proposal and share the same view as InterDigital. |
| NEC | Support the 1st proposal.  For the 2nd proposal, whether such complex design is needed can be further studied. |
| FGI/APT | 1st proposal: Support.  2nd proposal: Not support. The proposal is an optimization that is not justified. Simpler method with less specification impact for mapping HP HARQ-ACK and LP HARQ-ACK should be adopted.  3rd proposal: Not support. The reliability of HP HARQ-ACK can be ensured by separate coding. We don’t see the need for changing the power control method. |
| Huawei/Hisi2 | For the 1st proposal, to QC: I understand the major issue for simplex/repetition code is the complexity of borrowing PUSCH coding/rate matching/scrambling procedure to PUCCH; as a comparison, the padding and RM coding is already there for R15 PUCCH, so the complexity is much smaller. Though we do not object considering the method with more gains, we need to note that the gain only occurs for LP/HP payload = 2 bits case; whether the benefit under such a specific case is worth the additional complexity is also concerned by companies.  For the 3rd proposal, **to InterDigital and CATT**: according to the power control formula in 38.213 Clause 7.2.1, PUCCH Tx power is positively correlated with BPRE, i.e., UCI code rate. That means a larger CR leads to a larger Tx power. **Using LP CR (generally > HP CR) as BPRE will result in a larger total power than using HP CR**, which can both ensure the performance of HP and LP. Note that other power control parameters (such as P0) will be taken from the HP PUCCH-config.   |  | | --- | | …the UE determines the PUCCH transmission power  in PUCCH transmission occasion  as  [dBm]  …  For a PUCCH transmission using PUCCH format 2 or PUCCH format 3 or PUCCH format 4 and for a number of UCI bits larger than 11, , where  -  -  … | |

Proposal after 1st round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is more than 2, for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding, and

* Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.
  + Reuse R15 scrambling for PUSCH as baseline. FFS details.
* Support: Sony, Lenovo, IDC, Intel, QC, Pana, vivo, Nokia (also support Opt.2), ITRI, Sharp, HW (2nd preference), Quectel, OPPO, Xiaomi, NEC, FGI/APT
  + PUCCH is only QPSK based and the scrambling is automatically avoided.
* Not support (support Opt.2: Reuse R15 TS 38.212 Clause 5.3.3.3, i.e., padding to 3 bits and using RM coding.): E///, MTK, LG, Samsung, CATT
  + Option 1 requires much spec change for PUCCH format 1 and 3/4. For example, in 38.211, both section 6.3.2.5 and 6.3.2.6 need to add the pseudo code currently defined for PUSCH scrambling.

Proposal after 1st round discussion:

For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, support mapping encoded HP HARQ-ACK bits first with a distributed RE mapping in frequency domain, starting from the earliest OFDM symbol available in the determined PF 2 PUCCH resource, followed by mapping encoded LP HARQ-ACK bits onto remaining REs.

* Support: QC, LG, HW, Quectel
  + Time length is too short to improve the reliability from the time domain for PUCCH format 2.
  + If current frequency-first mapping on PF2 is used as it is, HP HARQ-ACK performance would be degraded compared to Rel-16 HP HARQ-ACK, especially, in case where HP HARQ-ACK REs are mapped only on the first frequency hop in the PUCCH.
  + Similar distributed mapping rule has also been applied to UCI on PUSCH.
* Not support (support Opt.1: Aggregate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits and apply the procedures described in Sec. 6.3.2.5 of R15 TS 38.211 to the aggregated coded HARQ-ACK bit sequence.): Sony, Apple, Lenovo, E///, DCM, MTK, Pana, vivo, Nokia, ITRI, Sharp, Samsung, CATT, FGI/APT
  + Option 2 makes the specs complicated, e.g. how to determine the distance of the distribution mapping, and procedure considering the various scenarios, e.g., number of bits for HP HARQ-ACK is more than that of LP, or less than that of LP.
  + If frequency diversity is desired, frequency hopping can be applied.
* Not support (support Opt.3: drop LP UCI for PUCCH format 2.): Intel

Proposal after 1st round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,

* If the total number of high priority UCI bits is 11 or lower, let , otherwise let .
* Option 1: Use the HP UCI bit number and HP RE number for calculation
  + E///, Lenovo (delete *OCRC*), Samsung
* Option 2: Use the LP UCI bit number and LP RE number for calculation
  + HW, OPPO
* Option 3: Not need for enhancement support: Apple, IDC, Intel, DCM, Pana, vivo, Nokia, FGI/APT
  + Unclear how much gain can be provided by changing the existing power control equation, and why the existing mechanism cannot work.
  + There is a huge discrepancy in Delta value w.r.t. spectral efficiency
  + Separate coding is also supported in Rel-15/16, but takes all UCI bits into account rather than using one UCI type.

## 2nd round discussion

The first and second proposals have been discussed for meetings, and pros and cons are clarified. It seems the two proposals are workable, although some companies think the other option is better for optimization. To make progress and save the precious GTW time, it is suggested to agree on them by email approval. It is suggested you show the objection only if you cannot live with the proposal.

The third proposal deserves the 2nd round discussion.

Proposal for 2nd round discussion (for email approval):

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is more than 2, for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding, and

* Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.
  + Reuse R15 scrambling for PUSCH as baseline. FFS details.

|  |  |
| --- | --- |
| Supporting companies: | QC, Intel, DOCOMO, Quectel, NEC, vivo, Nokia/NSB, OPPO, ZTE, Panasonic, ITRI, Sony, Sharp, Lenovo/Motorola Mobility |
| Objecting companies: | Samsung, LG, MediaTek |
| Company | Reason for objection |
| Samsung | We have strong concern on this proposal.  The proposal is clearly an optimization, it will not offer any real benefit, while it complicates both specifications and gNB/UE implementation. Padding to 3 bits and using RM coding is Rel-15 operation and does not require introducing new scrambling. It cannot be possibly acceptable to introduce another UE/gNB implementation for no reason. |
| LG | We share same view with Samsung.  Just padding to 3-bit is all UE (and the spec) has to do.  On the other hand, with the proposal in above, both UE and gNB (as well as the spec) has to largely change current behavior/implementation/structure. |
| Huawei/Hisi R2 | Not object, but we want to see how many companies have strongly concerns on adopting the padding and RM coding solution which leads to more complexity than simplex/repetition code while takes benefit only on the payload = 2 bits case. |
| MediaTek | Agree with Samsung and LG views. |
| QC2 | we support this proposal. We just want to ask companies objecting this proposal: what is the “huge” spec impact, given this scrambling is in Rel-15 spec already? Furthermore, as PUCCH only support BPSK and QPSK, the scrambling is effectively bypassed. For 2 bit payload with, there is obvious no scrambling needed, as only the highlighted two entries are needed.  Table 5.3.3.2-1: Encoding of 2-bit information   |  |  | | --- | --- | |  | Encoded bits | | 1 |  | | 2 |  | | 4 |  | | 6 |  | | 8 |  |   For 1 bit, the only entry **MAY** need scrambling is with QPSK modulation. However, in this case, we can just simply set y=C0 to bypass the scrambling. Since 1 bit is simply with repetition encoding, set y=C0 simply means more repetition of the single bit with effectively halved code rate. So spec impact is realy trivial, just set y=C0. Implementationwise, it is also trivial, just repetition of 1 bit.  Table 5.3.3.1-1: Encoding of 1-bit information   |  |  | | --- | --- | |  | Encoded bits | | 1 |  | | 2 |  | | 4 |  | | 6 |  | | 8 |  | |
| Ericsson | For reason for Option 1 is not correct: “PUCCH is only QPSK based and the scrambling is automatically avoided.” See [c0, y] below of 38.212 Table 5.3.3.1-1. ‘y’ is problematic and need the pseudo-code in 38.211 PUSCH section, even though conceptually it’s simply repetition.  **Table 5.3.3.1-1: Encoding of 1-bit information**   |  |  | | --- | --- | |  | **Encoded bits** | | **1** |  | | 2 |  |   We would be ok to compromise to encoding of 1-bit and 2-bit without padding, if the following is added in 38.212 Clause 5.3.3.1. With Table 5.3.3.1-1A, then 1-bit and 2-bit encoding of TS 38.212 Clause 5.3.3.1 and 5.3.3.2 works for PUCCH, together with PUCCH scrambling. That is, no need of the pseudo code for Rel-15 PUSCH scrambling.  **Table 5.3.3.1-1A: Encoding of 1-bit information**   |  |  | | --- | --- | |  | **Encoded bits** | | **1** |  | | 2 |  |   In summary, we suggest the following:  Revised Proposal:  For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is more than 2, for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding, and   * Introduce Table 5.3.3.1-1A in TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit. * Apply the Rel-15 scrambling for PUCCH.   + ~~Reuse R15 scrambling for PUSCH as baseline. FFS details.~~ |

Proposal for 2nd round discussion (for email approval):

For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, aggregate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits and apply the procedures described in Sec. 6.3.2.5 of R15 TS 38.211 to the aggregated coded HARQ-ACK bit sequence.

|  |  |
| --- | --- |
| Supporting companies: | DOCOMO, CATT, vivo, Nokia/Nsb, OPPO, ZTE, Panasonic, ITRI, Sony, Sharp |
| Objecting companies: | Samsung, LG (object for RE mapping), MediaTek, Intel |
| Company | Reason for objection |
| Samsung | We have strong concern on this proposal.  The proposal is an optimization without practical benefit and complicates specifications and UE/gNB implementation. The principle of UCI multiplexing of different priorities is to avoid coding chain. Clearly, the proposal is against the principle. |
| LG | Firstly, we support HP+LP multiplexing on PF2 since it is short-duration PUCCH which would mainly be used for low latency.  Secondly, we object to apply the current RE mapping since it would cause performance loss of HP UCI in case where HP UCI REs are mapped on only one frequency hop (in case configured with frequency hopping for PF2).  For this RE mapping, we support the proposal from QC. |
| MediaTek | Added complexity. |
| Intel | It increases complexity with addtoinal coding chain for PF 2. |
|  |  |

Proposal after 2nd round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, down-select from the options:

* Option 1: Use the HP UCI bit number and HP RE number for calculation
* Option 2: Use the LP UCI bit number and LP RE number for calculation
* Option 3: No enhancement.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | For Rel-17, multiplexing LP UCIs over HP PUCCH should not be supported at the cost of the reliability of HP UCIs.  Really hope in October 2021, companies won’t have difference on such fundamental point. Note the power control formula will be used even if both HP UCI and LP UCI are for SPS HARQ-ACK. We don’t see how the requirement for HP UCI can suddenly be relaxed just because the HP PUCCH with the HP UCI collides with a LP PUCCH with LP UCI.  Option 1 is the option making sense. Please see further discussion below:  We first observe:  A key discussion on Rel-17 URLLC power control is about how the spectral efficiency is calculated.  Let the payload including potential CRC bits for HP be , let the REs taken by HP UCI be , let be the modulation order for PUCCH, then roughly , where is the coding rate for HP UCI(s), and Let the payload including potential CRC bits for LP be , let the REs taken by LP UCI be , then roughly , where is the coding rate for LP UCI(s).  We can consider several alternatives:   * Alt. 1: * Alt. 2: * Alt. 3: , where .   When LP UCIs are multiplexed over a HP PUCCH, the reliability of HP UCIs should not be compromised. Hence it is very reasonable to take Alt. 1. Now we can check whether Alt. 3 can approximately achieve Alt. 1 under most conditions. From our examination, the answer is no.  We exhaustively checked all the maxcoderate combinations for HP UCI and LP UCIs,  {zeroDot08, zeroDot15, zeroDot25, zeroDot35, zeroDot45, zeroDot60, zeroDot80}  And by assume a difference for from 1 to 30 (i.e. equal payload size for HP and LP and 30 times payload size for HP over LP), the checked results for Reed-Muller and Polar are attached for you to review.      It is amply clear the difference between Alt. 1 and Alt. 3 is large. Since the discussion at hand is about URLLC, the past discussion on DCI size compaction and UCI size overhead are all relevant: the difference for many cases probably is about 0.1 or 0.2 dB or even less. If here the large difference can be discounted, then it is truly mystifying what design principle we have been following? Or maybe from now on if a design cannot exhibit a difference at least 7 dB, then we just discount that?  Now we also want to comment on the implementation complexity aspect:  the HP UCI bit number and HP RE number are determined/used in the rate-matching step. We don’t see implementation/specification complexity issue here.  **We support FL’s Alt. 1** |
| QC | We see the discussion of the power control is going into a wrong direction. We should discuss the power control equation as a whole, rather than only looking at a single term such as . Making decision single term by single term might lead to wrong decision, because there are inter connections between different terms in power control equation and they supposed to be considered together.  We think the discussion on power control should look at the total transmission power, at least we should look at the priority dependent terms together. In power control equation, P0 and are the two priority dependent terms. We think the way to determine the power control should be 1) calculate the power for HP UCI assuming HP P0 + calculated based on HP code rate/BPRE, 2) calculate the power for LP UCI assuming LP P0 + calculated based on LP code rate/BPRE, 3) take the max power of the power calculated from 1) and 2) |
| Samsung | Support Option 1. Option 3 is not clear to us. |
| InterDigital | Support Option 1.  Option 2 does not work because PC parameters (P0) are that of the second PUCCH config and is set to meet HP reliability requirements (also when there is no LP bit multiplexed).  Option 3 is clearly not right as explained by Apple in the above.  The solution outlined by QC would result in a correct power setting but require additional PC parameters in the second PUCCH config. It is sufficient to ensure reliability of HP bits and rely on maxCodeRate setting of LP bits to ensure their reliability. |
| DOCOMO | Fine with the proposal to move forward. |
| CATT | We support option 1. |
| Quectel | We prefer Option 1. In our view, we do not need to over-optimize the performance. Option 1 can ensure the performance of HP HARQ-ACK, which is sufficient. |
| NEC | Fine with the proposal. |
| vivo | Support option 1. |
| LG | We are open to this issue. |
| Huawei/Hisi R2 | Not support.  The equation for calculating BPRE in R15 is based on the BPRE (equivalently the CR) of the UCI. In R15 the CR for all UCIs are the same, but in R17 different CRs are assigned for different priorities.  The problem for Alt.3 is that BPRE is derived by the fraction where a mixed (HP payload + LP payload) divided by a mixed (HP RE\_ Num + LP RE\_Num). It is a hybrid fraction and cannot represent the CR of the UCI.  Therefore, we need to adopt either HP CR (Option 1) or LP CR (Option 2) to calculate the BPRE, instead of using a hybrid fraction. Whether it is based on HP CR or LP CR can be FFS. |
| Nokia/NSB | Option 1 & 2 would need further clarifications: how to define the number of REs for HP and LP separately is unclear to us.  Option 3 of no enhancement is not clear to us: Would this mean that we consider the total HARQ payload size as *nHARQ-ACK*(i.e. *nHARQ-ACK* = HP HARQ bit number + LP HARQ bit number) and using the existing method to determine the number of REs of the PUCCH resource |
| OPPO | Support. Option 2 is preferred to ensure reliability for all UCI.  We are open to option 1 |
| ZTE | Share the view with QC. Select the maximum power between the calculation result from option 1 and option 2. |
| InterDigital2 | @Nokia/NSB: In my understanding, the number of REs for HP and LP would be inferred from Table 6.3.1.4.1-1 of 38.212 which we agreed to use at last meeting. |
| Sharp | Support Option 1. |
| Lenovo/Motorola Mobility | Support Option 1. Since power control parameters in the high priority PUCCH configuration are used, power adjustment based on HP UCI spectral efficiency is more appropriate. |
| Ericsson | For the term, we suggest Option 4 as a compromise:  Option 4: The formula for is based on HP UCI size. No enhancement to the parameters in the formula. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal after 2nd round discussion:

Down-select from the two alternatives:

* Alt. 1: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, aggregate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits and apply the procedures described in Sec. 6.3.2.5 of R15 TS 38.211 to the aggregated coded HARQ-ACK bit sequence.
* Alt.2: Do not support multiplexing of HP HARQ-ACK and LP HARQ-ACK in PUCCH format 2 in Rel-17. Drop LP HARQ-ACK if the resulting PUCCH resource is with PUCCH format 2.

Proposal after 2nd round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, down-select from the options:

* Option 1: Use the HP UCI bit number and HP RE number for calculation
  + Apple, Samsung, IDC, CATT, Quectel, vivo, Sharp, Lenovo/Motorola Mobility
* Option 2: Use the LP UCI bit number and LP RE number for calculation
  + OPPO
* Option 3: No enhancement.
* Option 4: The formula for is based on HP UCI size. No enhancement to the parameters in the formula.
  + Ericsson

## 3rd round discussion

Proposal for 3rd round discussion:

Down-select from the two alternatives:

* Alt. 1: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, aggregate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits and apply the procedures described in Sec. 6.3.2.5 of R15 TS 38.211 to the aggregated coded HARQ-ACK bit sequence.
* Alt.2: Do not support multiplexing of HP HARQ-ACK and LP HARQ-ACK in PUCCH format 2 in Rel-17. Drop LP HARQ-ACK if the resulting PUCCH resource is with PUCCH format 2.

Proposal for 3rd round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,

* Use the HP UCI bit number and HP RE number for calculation

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | * 1st proposal: support Alt. 1.   Agrgregate the coded HP HARQ-ACK ACK bits and the coded LP HARQ-ACK bits and reusing existing procedures should be quite simple and straightforward way to avoid dropping LP HARQ-ACK.  -2nd proposal: Support |
| Intel | 1st proposal is same as the 2nd proposal in section 2.5.5 ? We support Alt.2.  For 2nd proposal, we’d like to deprortize the discussion in this meeting. |
| InterDigital | Support both proposals |
| LG | For 1st proposal: we are not supportive to the proposal.  We suggest (and prefer) the following Alt.3.  Alt.3: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, support mapping encoded HP HARQ-ACK bits first with a distributed RE mapping in frequency domain, followed by mapping encoded LP HARQ-ACK bits onto remaining REs.  For 2nd proposal: we are open to the proposal. |
| Sony | 1st proposal: This is a repeat of the proposal in Section 2.5.5. However, we support Alt 1. |
| Apple | We support both proposals from FL |
| Huawei/Hisi R3 | Support both proposals. For the 1st proposal, support Alt.1. |
| Ericsson | 1st proposal: Alt 1 (Agree with Sony this proposal is repeated in Section 2.5.5)  2nd proposal: Do not support   * For PUCCH format 0 or 1: there should be no change to the calculation. That is, no need to involve HP UCI bit number and HP RE number. * For PUCCH format 2/3/4: we prefer “Option 4: The formula for is based on HP UCI size. No enhancement to the parameters in the formula.” It is simple and adequate. Reasons:   + First, it is unnecessarily complicated to get to the number of HP REs. It cannot use the existing calculation of NRE associated with (see below). The only way is to calculate E\_tot, then from E\_tot to get the number of coded bits for HP part, then converted back to the number of REs for HP.   + Second, Option 1 is not accurate anyways. To be accurate, one should calculate power for HP and LP separately, and then select the maximum between these two.   + Thirdly, there are numerous other factors in PUCCH power control formula, for example, P0, ΔF\_PUCCH, ΔUCI, gb,f,c (power control command). These can all be adjusted to take into account of HP/LP multiplexing.   Existing calculation of NRE associated with , which cannot be easily modified to get to the number of HP REs: |
| QC | 1st proposal: We support Alt. 3 proposed by LG. We suggest RAN1 do down-selection between Alt 1 (proposed by FL) and Alt. 3 (proposed by LG). We don’t support Alt 2, which impose quite restriction to the system. For URLLC, using PF2 is quite common.  2nd proposal: We prefer use max(power for HP, power for LP). But for RAN1 progress, we are OK with the proposal. |
| Samsung | For the 1st proposal, we support Alt2. The scenario is an atypical case for which using Rel-16 is enough.  Support the 2nd proposal. |
| Sharp | Support both proposals. |
| LG2 | Regarding the 1st proposal, first of all, we agree with QC that Alt 2 is quite undesirable way (thus needs to be precluded) from the system perspective and in terms of supporting Rel-17 inter-priority multiplexing on PUCCH for URLLC operation.  In addition, we would like to point out major concern on Alt 1 reusing current RE mapping rule as it is after aggregating HP AN bits and LP AN bits.  Even in case where frequency hopping is enabled, if current RE mapping is applied as it is, HP AN REs (with relatively small payload size compared to LP AN) could be mapped only on the first frequency hop in the PUCCH as shown in the figure below. In this case, HP AN performance would be degraded compared to Rel-16 HP AN.    Moreover, distributed RE mapping rule (e.g., the mapping proposed in QC’s contribution) is not new mapping but existing mapping rule being used for UCI multiplexing on PUSCH. Thus, the expected impact to spec/UE is to be small. |
| ZTE | 1st proposal: support Alt. 1.  2nd proposal not supported. We suggest considering the alternative to select the max power for between HP and LP. But for sake of progress, we can compromise to FL’s proposal. |
| Quectel | 1st Proposal: Support Alt. 3 proposed by LG. Since it is aimed to do down-selection, it is fair to put all the proposals on the table.  2nd Proposal: Support. We can use a similar calculation as the one for rate matching output sequence length  to get the number of HP REs. The specification impact is quite minimal. |
| vivo | For the first proposal, we support alt 1. We think it is important to support PUCCH format 2 for multiplexing HP HARQ-ACK and LP HARQ-ACK considering its low latency.  For the second proposal, fine. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Multiplexing enable/disable mechanism

## Inputs from Tdocs

* Option 1: RRC configuration + DCI indication
  + E///, ZTE, Nokia (Mux is not supported for SPS HARQ-ACK), Samsung, IDC, Intel, Quectel, vivo, Pana, Sony, ETRI
* Option 2: Only RRC configuration
  + HW, CATT, Samsung, QC, LGE, IDC (for SPS), MTK, DCM, Spreadtrum, TCL, Xiaomi

|  |  |  |  |
| --- | --- | --- | --- |
|  | | Arguments | Counter arguments |
| Advantages | Flexibility | Even if the multiplexing timelines are met, the latency and reliability of high priority transmission should not be affected.  Straightforward method to select from Rel-16 and Rel-17 behaviors  URLLC traffic usually has a sporadic or periodic pattern, overlapping cases occur either occasionally or predictably.  Semi-static indication for periodic or predictable URLLC transmissions. Dynamic indication based on multiplexing conditions, e.g. latency requirement, channel condition, number of UCI bits. |  |
| Problems of DCI-based indication | Not a unified solution | Not applicable in some cases, e.g. the case of HARQ-ACK for PDSCH(s) scheduling by fallback DCI or SPS HARQ-ACKs.  HW[4]: Not applicable for the case of multiplexing LP HARQ-ACK and HP SR also, since it is impossible for gNB to predict the state of SR. | [vivo]: Unified solution for DG PUCCH and configured PUCCH is never needed. For DG PUCCH, it can naturally get the benefits from dynamic indication. For the configured PUCCH, whether multiplexing between different priorities is supported can be RRC configured. For example, in NR Rel-16, similar mechanism is used for priority index indication. |
| extra DCI overhead |  |  |
| UE complexity | [MTK] Very complex to handle at the UE side and requires a lot of implementation effort as the UE needs to accommodate two scenarios for each case which will complicate the implementation. | [vivo]: For UE supports multiplexing, UE anyway needs to handle the case of multiplexing, there is no additional complexity for prioritization. In addition, even RRC configuration method is used, some additional conditions may be needed, such as reliability requirement, latency requirement, etc. UE implementation may be more complex in that case. |

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 1: Adopt RRC configuration to enable/disable the multiplexing of HP HARQ-ACK and LP HARQ-ACK on PUCCH, and the multiplexing of HARQ-ACK on PUSCH with different priorities.***   * ***Additional conditions shall be specified to further guarantee the latency/reliability of the HP HARQ-ACK for the overlapping case.*** |
| E/// | [Proposal 9 Support dynamic enabling/disabling of multiplexing of different priorities both for PUCCH and PUSCH.](#_Toc84035009) |
| ZTE | ***Proposal 5****: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, support DCI+RRC configuration for gNB to enable/disable the multiplexing when DCI is applied.*   * *For SPS HARQ-ACK, the enable/disable scheme falls back to RRC configuration.*   ***Proposal 6****: The indicator of intra-UE multiplexing UCI with different priorities should be carried on the scheduling DCI or RRC parameter for the high priority transmission.* |
| Nokia | **Proposal 3.1: The gNB dynamically indicates, via an explicit field in the last DCI scheduling HARQ-ACK, whether multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK (or more generally low-priority multiplexed UCIs) is enabled or disabled.**  **Proposal 3.5: For the scenario where a PUCCH carrying high-priority HARQ-ACK overlaps with another PUCCH carrying low-priority HARQ-ACK: If the low- and high-priority HARQ-ACK does not have a corresponding PDCCH (i.e. low- and high priority ‘SPS’ HARQ only), the multiplexing is not supported.** |
| CATT | ***Proposal 12: Semi-static RRC configuration to enable/disable the multiplexing between channels with different priorities is supported.*** |
| Samsung | **Proposal 1: Support multiplexing UCI of different priorities subject to timeline conditions and RRC configuration and/or dynamic indication from gNB.**  **Proposal 2: The UCI types with first priority that can be multiplexed in a PUCCH/PUSCH of a second priority are configurable by the network.**  **Proposal 14: If a UE is configured by RRC for HP/LP multiplexing, the UE can be configured a 1-bit field in DCI format 0\_1/0\_2 to indicate whether or not HP/LP multiplexing is enabled.** |
| IDC | ***Proposal 2: DCI indicating HP HARQ-ACK also indicates if UE multiplexes HP HARQ-ACK with LP HARQ-ACK.***  ***Proposal 3: RRC configuration of SPS with HP HARQ-ACK includes an indication of whether the UE can multiplex HP HARQ-ACK with LP HARQ-ACK.***  ***Proposal 4: RRC configuration of a HP SR resource includes an indication of whether the UE can multiplex HP SR with LP HARQ-ACK.*** |
| Intel | **Proposal 11: DCI triggering HARQ-ACK may include an indication for enabling or disabling multiplexing.**  **Proposal 12: Further discuss whether support to LP and HP PUCCH multiplexing into a HP PUCCH resource without DCI.** |
| MTK | 1. Dynamic indication of the multiplexing activation/de-activation is not supported. 2. Guard gap timeline of the new multiplexed PUCCH is of the earliest PUCCH. |
| vivo | ***Proposal 14: Dynamic indication of intra-UE multiplexing and prioritization manner can be supported in Rel-17.***  ***Proposal 15: For dynamic indication, multiplexing or prioritization indication field can be included in DCI for HP or LP or both HP and LP service.*** |
| DOCOMO | **Proposal 5:**   * *RRC configuration should be baseline for enabling/disabling multiplexing of LP and HP PUCCH* |
| Pana | **Proposal 4:**   * **For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH in Rel.17, the multiplexing is RRC configured.**   + **Dynamic indication for enabling should also be supported.** |
| Sony | **Proposal 1: The gNB dynamically enables/disables multiplexing in an HP PUCCH by using a new Multiplexing Indicator in the DL Grant scheduling the HP PUCCH.** |
| Spreadtrum | 1. ***Support RRC configuration method for multiplexing enable/disable mechanism for UCI on PUCCH.*** |
| TCL | **Proposal 3: Support explicit indication to enable multiplexing procedure between HP UCI and LP UCI via RRC configuration.** |
| Xiaomi | ***Proposal 5: For enabling/disabling multiplexing of channels of different priorities, semi-static configuration is preferred.*** |
| ETRI | **Proposal 4: The scheduling DL-DCI has an additional field whether or not to allow multiplex HP UCI and LP UCI, or otherwise by the RRC signalling.** |
|  |  |
|  |  |

## 1st round discussion

Proposal for 1st round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, at least support RRC configuration for gNB to enable/disable the multiplexing.

* FFS whether or not to additionally introduce DCI indication to enable/disable the multiplexing.
* FFS: Interaction between the enable/disable mechanism and other multiplexing conditions
* FFS for other types of UCI.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | We prefer to use DCI for enabling/disabling multiplexing. It is only a single bit but offer significant flexibility to the gNB scheduler. It isn’t clear why there is an obsession on unifying solution, since DG-PDSCH and SPS These are different way of scheduling targeting different traffic and naturally there are different mechanism and behaviour. |
| Lenovo/Motorola Mobility | Fine with the proposal. |
| InterDigital | Don’t support. Agree with Sony about unifying solution. The feature may not be used in practice if the network does not have a fail-safe mechanism to indicate that multiplexing is not allowed for a specific transmission for dynamic PDSCH or PUSCH. We should decide now and not leave FFS.  One possible compromise could be that the DCI indication can be configured to be not present? |
| Intel | It seems no company object RRC configuration. We think the key point is whether to allow additional DCI indication on top of RRC configuration, i.e., resolve FFS point.  In our view, it is beneficial to support dynamic indication, to better control the impact of LP on HP UL transmission.  Regarding the interaction between enable/disable mechanism and other multiplexing conditions (e.g. timeline, UCI type which can be multiplexed), we think, it is reasonable and simpler to assume the indication would not conflict with the pre-defined multiplexing condition. |
| QC | We support this proposal.  For DCI based enabling/disabling multiplexing, we can further discuss. But we have the following concerns 1) it complicates UE implementation without justified benefit. As UE procedure allowed UE to automatically move to a larger HP PUCCH resource to transmit HP+LP UCI, we don’t see the need to dynamically disable/enable multiplexing. 2) How to solve the missing DCI issue, which will create misaligned behavior between UE and gNB? 3) large spec impact as indicated in the second FFS. |
| Ericsson | Do not support.  We also think it’s important to have DCI indication. |
| DOCOMO | Support the proposal. |
| MediaTek | We don’t see a need for DCI indication. RRC should be the only option. |
| Panasonic | Although the proposal is OK, as mentioned by other companies, resolve FFS on DCI indication would be necessary for the progress. In our view, dynamic enabling/disabling UCI multiplexing on PUCCH and PUSCH should considered as a unified principle. |
| LG | Support RRC only. |
| vivo | Do not support. We agree with Sony. DCI indication can significantly reduce the multiplexing rule discussed in session 2. For example, for the following cases: 1) more than one HP PUCCH overlap with one LP PUCCH/PUSCH, 2) one HP PUCCH overlaps with more than one LP PUCCH/PUSCH. 3) Long LP PUCCH overlapping with multiple short HP PUCCHs in step 2.  We don’t need to specify which HP PUCCH is multiplexed with which LP PUCCH/LP PUSCH in these cases, it can be indicated by gNB in the corresponding DCI. We don’t need to limit that only multiplex HP HARQ-ACK onto a LP PUSCH if the LP PUSCH ends in the same sub-slot as the HP PUCCH, we don’t need to discuss whether/how to support LP UCI compression, either. Whether UCI is multiplexed or not is totally controlled by gNB, and UE’s behavior is very simple, i.e., just follows the indication from gNB. |
| Nokia/NSB | Do not support.  We agree on the RRC aspect (as it would be anyhow needed) but not without the DCI indication. In the following, we reiterate our view on the importance of introducing DCI indication for dynamically enabling/disabling multiplexing.  Without such dynamic support, the reliability and latency requirements cannot be guaranteed. Otherwise, we would need to define a set of complicated rules/conditions for the UE to decide whether mux is OK or not in such a way that the latency and reliability requirements are not impacted. In addition to the complexity that this would bring, this will require a large specification effort and thus should be really avoided (as we don’t have the luxury of time). |
| ITRI | Do not support. Prefer to use DCI for enabling/disabling multiplexing. |
| TCL | Support the proposal. |
| ZTE | We support RRC+DCI indication to enable/disable the multiplexing. |
| Sharp | Support the proposal. |
| Huawei/Hisi | Support. |
| Samsung | RRC configuration needs to be agreed, so the proposal is OK in that sense. However, that is not much progress. The real question is whether to have indication by DCI. We request companies to be constructive on that issue as it can be a useful enabler for LP/HP multiplexing by giving control to the NW based on scheduling decisions/requirements. Adding 1 bit in the DCI is trivial from every aspect and there is no impact other than a ‘yes’/’no’ for multiplexing LP UCI. |
| Quectel | We support DCI based disabling on top of RRC. We don’t think any specification change is needed for 38.212 DCI part. The DCI based disabling could be realized implicitly by PRI indicating to a PUCCH resource that cannot accommodate both HP UCI and LP UCI. |
| OPPO | Support |
| Xiaomi | Support the proposal |
| CATT | We are fine with the proposal but also agree that the main discussion point should be whether DCI indication is supported or not. |
| NEC | Fine with the proposal. But we prefer to support DCI indication to enable/disable the multiplexing, it is simple and flexible. |
| FGI/APT | Do not support. Prefer to also support DCI indication. |

## PUCCH resource determination and mapping for multiplexing between HARQ-ACKs with different priorities

## Inputs from Tdocs

**In case the total number of LP and HP HARQ-ACK bits is 2:**

* Option 1: Use a PUCCH resource in the second *PUCCH-Config* (the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK).
  + ZTE, Nokia, IDC, Quectel, Intel, vivo, Leno/Moto, Xiaomi

|  |  |  |  |
| --- | --- | --- | --- |
|  | | Arguments | Counter arguments |
| Option 1 | Advantages | It can be guaranteed that the selected PUCCH resource uses the same power control as well as spatial processing as the PUCCH resource carrying the HP HARQ-ACK, and hence ensures the reliability of the HP transmission.  Unified solution with HARQ-ACK bits >2. |  |

**PRB number determination**

* The number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format 2 and 3 is determined as following:
  + *If , the number of RBs is determined as ;*
  + *Otherwise, the number of RBs is determined as the minimum number of , satisfying .*
  + CATT, HW, Nokia, IDC, Intel, vivo, Pana
* Based on maxCodeRate configured for HP UCI in high priority PUCCH and nominal UCI payload size, where nominal UCI payload size = the number of HP UCI bits + the number of LP UCI bits\* Coderate HP/ Coderate LP.
  + Xiaomi
* The UE determines the number of PRBs for HP HARQ-ACK first, followed by the LP HARQ-ACK.
  + Sharp

**The problem of ambiguity on LP HARQ-ACK existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection and the candidate options:**

* Option 1: Configure a dedicated PUCCH resource for HP+LP in the second *PUCCH-Config*
  + HW, Quectel
* Option 2: PRI+x in the HP DCI is used to implicitly determine an extended PUCCH resource
  + ZTE
* Option 3a: The LP type 2 codebook size is quantized/rounded up to a nearest reference size. FFS reference size granularity.
  + QC
* Option 3b: Configuration of semi-static size reservation for LP HARQ-ACK payload is provided by RRC. LP HARQ-ACK semi-static size reservation is used instead of determined LP HARQ-ACK codebook size when selecting the PUCCH resource set.
  + Nokia (1st preference), CATT (FFS whether it is semi-static), LGE, Quectel, DCM, Pana
* Option 4: Additional DCI field in DCI corresponding HP HARQ-ACK or HP PUSCH for determining the number of LP HARQ-ACK bits multiplexed on PUCCH/PUSCH.
  + Nokia (2nd preference), CATT, LGE, NEC
* Option 5: Provide indication on at least the number of RBs and/or PUCCH resource set index to be used in the PUCCH transmission, where the indication is included in the high-priority DL assignment.
  + Nokia (2nd preference)
* Option 6: Introduce a 1-bit “last DL Grant” indicator in the DL Grant to indicate whether a DL Grant is the last DL Grant associated with a LP PUCCH.
  + Sony

|  |  |  |  |
| --- | --- | --- | --- |
| Resource determination for multiplexing between HARQ-ACKs with different priorities | | | |
|  | | Arguments | Counter arguments |
| Option 1 | Advantages | Avoid the decoding error of HP HARQ-ACK due to the ambiguity of the LP HARQ-ACK number. The gNB can configure different PUCCH resources (RB/CS/OCC) for HP only and hybrid HP+LP, respectively, and simply perform the blind detection of PUCCH DMRS on the two hypotheses for easy verification of the LP DCI missing. | The ambiguity due to the uncertainty of LP HARQ-ACK multiplexing with HP HARQ-ACK can be solved by gNB implementation, i.e. blind decoding the PUCCH based on the hypothesis of different payload size under the condition that whether the LP HARQ-ACK is multiplexed with HP HARQ-ACK or not. |
| Problems | Considering that maximum 16 resources can be configured in each PUCCH-resource-set, and the reliability of scheduling DCI for HP HARQ-ACK is generally high enough to avoid miss detection, we do not see much necessity to configure dedicated PUCCH resources for multiplexing. |  |

**Resource determination:**

LGE:

* In case when at least one HP DL DCI is received by the UE, the PUCCH resource corresponding to the PRI indicated in the last HP DCI is selected.
* In case when LP DL DCI is only received by the UE, the PUCCH resource corresponding to the PRI indicated in the last LP DCI is selected.

**Resource determination when HP HARQ-ACK is SPS HARQ-ACK**

* Option 1: The LP DCI determines the final PUCCH resource.
  + ETRI
* Option 2: Multiplexing is not allowed in this case
  + Nokia, OPPO

**If no enough resource for both HP and LP HARQ-ACK:**

* Option 1: LP HARQ-ACK is compressed/bundled/compaction.
  + QC, OPPO, Apple, MTK, TCL, WILUS
* Option 2: LP HARQ-ACK is (partially) dropped.
  + HW, Quectel
  + *[Sony]: What’s the difference between Option 2 and Option 3? We support fully dropping the LP HARQ-ACK.*
* Option 3: LP HARQ-ACK is partially dropped.
  + Intel, TCL
* Option 4: Transmit LP HARQ-ACK with higher code rate than configured.
  + HW
* Option 5: Further check possible multiplexing in the next sub-slot.
  + Leno/Moto

**DCI indicating HP HARQ-ACK includes an indication of the DAI of LP HARQ-ACK.**

* + ZTE, Samsung, CATT, IDC, Intel

|  |  |  |
| --- | --- | --- |
| Company | Proposals/observations from Tdocs | |
| Huawei | ***Proposal 6: For HP HARQ-ACK and LP HARQ-ACK multiplexing on PUCCH format 2/3, the minimum PRB numbers for HP and LP are separately determined based on their coding rates, respectively.***   * ***In case the remaining rate matching resources cannot guarantee the LP configured code rate, drop all LP HARQ-ACKs or transmit LP HARQ-ACK with higher code rate than configured.***   ***Observation 2: Ambiguity on the existence of LP HARQ-ACK should be the target case that needs to be resolved by specification***.  ***Proposal 7: Support a group of dedicated PUCCH sets in the second PUCCH-Config to carry the multiplexed HP HARQ-ACK and LP HARQ-ACK.*** | |
| ZTE | ***Observation 1:*** *The ambiguity problem due to LP HARQ-ACK non-existence, in case the total number of LP and HP HARQ-ACK bits is no more than 2 bits, is very severe and need to be solved.*  ***Observation 2:*** *The ambiguity problem on LP HARQ-ACK type-2 codebook size due to DCI miss-detection, is not severe and could be solved by gNB implementation.*  ***Observation 3:*** *The option 3/4/5 aiming to solve issue of ambiguity on LP HARQ-ACK type-2 codebook size due to DCI miss-detection, have kinds of shortcomings, such as DCI overhead increase and less efficient to over-optimize a low probability event.*  ***Proposal 7****: For the case that the total number of bits is no more than 2 bits, the PRI+x in the HP DCI is used to implicitly determine an extended PUCCH resource from the same PUCCH set in the PUCCH-config with high priority for the multiplexed UCI.*  *x is predefined, e.g., x=1.*  ***Proposal 8****: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, use a PUCCH resource in the second PUCCH-Config (the PUCCH-config containing the PUCCH resource of the HP HARQ-ACK) in case the total number of LP and HP HARQ-ACK bits is 2.*  ***Proposal 15:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH, a new T-DAI field for LP HARQ-ACK is added in HP DCI.* | |
| Nokia | **Proposal 3.2: For the scenario where a PUCCH carrying 1-bit high-priority HARQ-ACK overlaps with another PUCCH carrying 1-bit low-priority HARQ-ACK, the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK is done on the high-priority PUCCH resource.**  **Proposal 3.3: Dedicated PUCCH resource configuration for multiplexing of high- and low-priority HARQ-ACK is not supported.**  **Proposal 3.9: For the selected PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs, the number of PRBs is determined as the minimum number of PRBs that allows the separately encoded high-priority and low-priority HARQ-ACK bits, including the corresponding maxCodeRates, to fit in the PUCCH resource.**   * **If the configured max number of PRBs corresponding to the PUCCH resource doesn’t allow the high-priority and low-priority HARQ-ACK bits to fit in the PUCCH resource, the low-priority HARQ-ACK bits are dropped.**   ***Observation 3.1: Errors in low-priority HARQ-ACK codebook size determination e.g. due to missed DCI may cause selection of different PUCCH resource set or use of smaller number of PRBs for the multiplexed high-priority and low-priority HARQ-ACKs feedback than what gNB would expect.***  **Proposal 3.10: To avoid discrepancy between the UE and the gNB on the determination of PUCCH resource set and number of PRBs for UCI containing multiplexed high-priority and low-priority HARQ-ACKs, support Option 3b:**   * **Option 3b: Configuration of semi-static size reservation for low-priority HARQ-ACK payload is provided by RRC.**   **Otherwise, as a second preference, support either Option 4 or Option 5:**   * **Option 4: The indication and determination are defined by combining dynamic indication for enabling/disabling low-priority HARQ-ACK multiplexing and for low-priority HARQ-ACK codebook size, using a new DCI field in the high-priority DL DCI.** * **Option 5: The indication and determination are defining the number of RBs and/or PUCCH resource set index to be used in the PUCCH transmission, where the indication is carried in a new DCI field in the high-priority DL DCI.**   ***Observation 3.2: In principle, multiplexing could be supported for all four possible combinations of high-priority HARQ-ACK overlapping with low-priority HARQ-ACK considering Type-1 and Type-2 codebooks. If there would be a need to prioritize some cases for the discussions, the cases involving same HARQ-ACK codebook type (Type-1/Type-2) could be discussed first. The case corresponding to multiplexing high-priority Type-1 HARQ-ACK and low-priority Type-2 HARQ-ACK could also be of interest.*** | |
| CATT | ***Proposal 7: The number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format 2 and 3 is determined as following:***   * ***If , the number of RBs is determined as ;*** * ***Otherwise, the number of RBs is determined as the minimum number of , satisfying .***   ***Proposal 11: The following two options can be considered to avoid the impact on HP HARQ-ACK(s) due to missing DCIs corresponding to LP HARQ-ACK codebook.***   * ***Option 1: Define a reference number of bits for LP HARQ-ACK codebook*** * ***Option 2: Indicate information for determine the number of LP HARQ-ACK bits by DCI corresponding to HP HARQ-ACK***   ***Proposal 14: An additional UL DAI bit field can be considered to be added in the UL DCI for multiplexing PUCCH and PUSCH with different priorities.*** | |
| QC | ***Proposal 7*: For HP UCI and LP HARQ-ACK (in type 2 codebook) multiplexing on a PUCCH, round up LP HARQ-ACK size to a nearest reference size, in the calculation of total number of RBs for HP and LP UCI and in the PUCCH resource set determination.**  ***Proposal 18:* In Rel-17 UCI multiplexing, support low priority HARQ-ACK compression.**   * **FFS conditions to trigger low priority HARQ-ACK compression** * **FFS details of compression scheme.** | |
| Samsung | **Proposal 5: RRC configures presence of a T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.**  **Proposal 7: A UE determines a PUCCH resource set for multiplexing LP/HP HARQ-ACK in a PUCCH as in Rel-16 based on the total number of LP/HP HARQ-ACK bits (Option 1).**  **Proposal 12: For multiplexing a LP Type-2 HARQ-ACK codebook in a HP PUSCH**   * **RRC configures an additional T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.** * **A number of REs is reserved for LP HARQ-ACK in a HP CG-PUSCH.** | |
| LGE | **Proposal #7: Consider the following LP HARQ-ACK handling for the case of exceeding the maximum UCI coding rate on PUCCH.**   * **HARQ-ACK bundling for LP HARQ-ACK in spatial domain and/or CBG domain.** * **Partial dropping for LP HARQ-ACK according to HARQ-ACK codebook type.**   **Proposal #8: Consider the following to determine a PUCCH resource in the HP PUCCH resource set selected based on total UCI payload size.**   * **In case when at least one HP DL DCI is received by the UE, the PUCCH resource corresponding to the PRI indicated in the last HP DCI is selected.** * **In case when LP DL DCI is only received by the UE, the PUCCH resource corresponding to the PRI indicated in the last LP DCI is selected.**   **Proposal #14: Consider the following aspect by taking potential missing of the DCI corresponding to HP HARQ-ACK by the UE into account.**   * **The reserved REs corresponding to 2-bit HARQ-ACK on PUSCH are to be generated based on the beta offset configured for HP HARQ-ACK and to be mapped even on LP PUSCH as well as HP PUSCH, even in case when there is no HP HARQ-ACK from UE perspective.** | |
| IDC | ***Proposal 5: DCI indicating HP HARQ-ACK also indicates the PUCCH resource for multiplexing HP HARQ-ACK and LP HARQ-ACK.***  ***Proposal 6: The PUCCH resource for multiplexing HP HARQ-ACK and LP HARQ-ACK is from the PUCCH configuration for HP HARQ-ACK (for any total number of LP and HP bits).***  ***Proposal 7: When multiplexing OHP HP HARQ-ACK and OLP LP HARQ-ACK in PUCCH format 3 or 4 with MRBPUCCH PRBs, the UE transmits all HP and LP HARQ-ACK bits if the following condition is satisfied, otherwise the UE transmits all HP HARQ-ACK bits and drop all LP HARQ-ACK bits:***  ***OHP / RHP + OLP / RLP  MRBPUCCHNsc,ctrlRBNsymb-UCIPUCCHQm***  ***where RHP and RLP are maxCodeRate configured for HP and LP HARQ-ACK bits, respectively, and Nsc,ctrlRB, Nsymb-UCIPUCCH and Qm have same meaning as in 38.213 section 9.2.5.2.***    ***Proposal 8: When multiplexing OHP HP HARQ-ACK and OLP LP HARQ-ACK in PUCCH format 3, the UE selects the minimum number MRB,minPUCCH of PRBs satisfying the following condition:***  ***OHP / RHP + OLP / RLP  MRB,minPUCCHNsc,ctrlRBNsymb-UCIPUCCHQm***  ***where RHP and RLP are maxCodeRate configured for HP and LP HARQ-ACK bits, respectively, and Nsc,ctrlRB, Nsymb-UCIPUCCH and Qm have same meaning as in 38.213 section 9.2.5.2.***  ***Proposal 11: DCI indicating HP HARQ-ACK includes an indication of the DAI of LP HARQ-ACK.***  ***Proposal 21: DCI scheduling PUSCH includes a single DAI value. In case both LP and HP HARQ-ACK are multiplexed in PUSCH, the DAI corresponds to HP HARQ-ACK only.*** | |
| Quectel | **Proposal 5**: A PUCCH resource in the second *PUCCH-Config* (i.e., the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK) is used for multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK in case the total number of LP and HP HARQ-ACK bits is 2.  **Proposal 6**: Dedicated PUCCH resource(s) could be optionally configured for HP HARQ-ACK and LP HARQ-ACK multiplexing in case the total number of LP and HP HARQ-ACK bits is 2.  **Proposal 7**: PUCCH PRB number determination for HP A/N and LP A/N is based on: UCI payload size = the number of HP UCI bits + the number of LP UCI bits.  **Proposal 8**: A reference LP type 2 HARQ-ACK codebook size is used for PUCCH resource set determination and/or PUCCH PRB number determination. The configuration of the reference size is FFS.  **Proposal 9**: Interleaved multiplexing/RE mapping of HP HARQ-ACK and LP HARQ-ACK is supported when HP HARQ-ACK and LP HARQ-ACK are multiplexed in PUCCH with PF2.  **Proposal 10**: HP HARQ-ACK and LP HARQ-ACK multiplexing in PUCCH is disabled if the PRI in DCI indicates a PUCCH resource that cannot accommodate both HP HARQ-ACK and LP HARQ-ACK. | |
| Intel | **Proposal 8: When sufficient resource is not available for accommodating LP HARQ-ACK on HP PUCCH, LP HARQ-ACK payload bits can be partially dropped.**  **Proposal 9: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, support the following for determining the UCI payload size for PUCCH resource determination:**   * **For PUCCH resource set determination, UCI payload size = the number of HP UCI bits + the number of LP UCI bits** * **For the number of PRBs of a PUCCH resource, minimum number of PRBs from PRBs is chosen based on their code rates, i.e.**   **Proposal 10: For multiplexing a HP HARQ-ACK and LP HARQ-ACK into a PUCCH in R17, additional T-DAI for LP HARQ-ACK can be indicated by the DCI triggering HP HARQ-ACK.** | |
| vivo | ***Proposal 8：For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH in R17, option 1 are preferred***   * ***Option 1:*** ***Configure a dedicated PUCCH resource for HP and LP HARQ-ACK in the second PUCCH-Config***   ***Proposal 9: PRB determination is based on the sum of HP HARQ-ACK bits and a converted LP HARQ-ACK bit* accordingto *code rate.*** | |
| OPPO | ***Proposal 3: The number of PRBs used to transmit HP HARQ-ACK and LP HARQ-ACK should result to:***  , and  ***Proposal 4: If , the UE transmits the PUCCH over  PRBs. LP HARQ-ACK should be compressed into bits that satisfy:***  , and  ***Proposal 6: If a PUCCH carrying HP SPS HARQ-ACK overlaps with a PUCCH carrying LP HARQ-ACK, multiplexing of HP SPS HARQ-ACK and LP HARQ-ACK is not supported.***  ***Proposal 13: When the total number of HP HARQ-ACK/SR and LP HARQ-ACK exceeds the capacity of the multiplexing PUCCH,***   * ***If CBG-based HARQ-ACK, HARQ-ACK bundling across multiple CBGs of one TB is firstly used for LP HARQ-ACK;*** * ***For TB-based HARQ-ACK, HARQ-ACK bundling across multiple PDSCHs on one serving cell can be used for LP HARQ-ACK.*** * ***If after time-domain TB-based HARQ-ACK bundling, the number of bundled bits is still more than , LP HARQ-ACK can be dropped.*** | |
| Apple | | **Proposal 5-1: considering coding rates of UCI parts in the PRB number adjustment/interlace number adjustment.**  **Proposal 5-2: The condition to trigger PRB number adjustment is given by**    **And the stop condition for PRB number adjustment is as follows:**    **Proposal 6-1: Consider different coding rates for UCI parts in UCI omission rule.**  **Proposal 6-2: With two UCI parts, the omission rule is as follows:**  **The following conditions are used for UCI omission:**    **If all UCI part II is dropped, then the the following is examined to determine remaining UCIs in UCI part I:**  **.**  **Proposal 7-1:**  **when HP CSI is present, only the following UCIs are carried in UCI part I and part II:**  **HP HARQ-ACK > HP SR > (HP CSI) > LP HARQ-ACK > (LP SR)**  **When HP CSI is absent, only the following UCIs are carried UCI part I and part II**  **HP HARQ-ACK > HP SR > LP HARQ-ACK > (LP SR) > LP CSI**  **Proposal 8-1: consider joint PUCCH resource set selection and PUCCH resource selection.**  **Proposal 8-2: if joint PUCCH resource set selection and PUCCH resource selection is supported, and are configured per PUCCH format or per PUCCH resource.**  **Proposal 10-1: consider PRB # adjustment and CSI omission/HARQ compaction for the PUCCH resource under multi-CSI-PUCCH-ResourceList and pucch-CSI-ResourceList.** |
| MTK | 1. Group-bundling is supported when multiplexing and when the resulted UCI payload is large. | |
| Pana | **Proposal 2: Determination of the number of PRBs is as follows.**   * **If**    + **The number of PRBs is determined as minimum number of , satisfying and** * **Otherwise,**   + **The number of PRBs is determined as**   **Proposal 3: Configuration of semi-static size reservation for LP HARQ-ACK payload is provided by RRC. LP HARQ-ACK semi-static size reservation is used instead of determined LP HARQ-ACK codebook size when selecting the PUCCH resource set and PRB number determination.** | |
| Sony | **Proposal 2: Since misalignment on the number of LP HARQ-ACK *NLP* for Type 2 HARQ-ACK Codebook is caused by the UE missing the last DL Grant associated with the LP PUCCH, any proposed solution should address this issue directly with no overhead to either the PUCCH or DCI.**  **Proposal 3: Introduce a 1-bit “last DL Grant” indicator in the DL Grant to indicate whether a DL Grant is the last DL Grant associated with a LP PUCCH.**  **Proposal 4: The last DL Grant indicator can reuse the Multiplexing Indicator field, such that;**   * **If *Priority Indicator* = “1”, then the Multiplexing Indicator indicates whether UCI multiplexing of different L1 priority in a PUCCH is enabled or disabled** * **If *Priority Indicator* = “0”, then the Multiplexing Indicator indicates whether or not the DL Grant is the last DL Grant associated with a LP PUCCH .**   **Proposal 5: The UE performs UCI multiplexing if it detects a positive Multiplexing Indicator in one (i.e. the last) of the LP DL Grants and a positive multiplexing Indicator in at least one of the HP DL Grants, otherwise the UE drops the LP PUCCH.** | |
| Spreadtrum | 1. ***For the PRB number determination, the minimum PRB number is calculated separately based on its own maximum coding rate for HP and LP UCI.*** 2. ***Actual number of LP UCI bits is used for PUCCH resource set selection.*** 3. ***No additional method is supported for the ambiguity on LP HARQ-ACK.*** | |
| Leno/Moto | * **Proposal 1:** A PUCCH resource for multiplexing UCI of mixed priorities including HARQ-ACK is selected from a PUCCH resource set configured by the second PUCCH-Config, based on:   + a last DCI format indicating a higher priority index, or   + a last DCI format if no DCI format indicating a higher priority index is detected, or   + a PUCCH resource configured for UCI of mixed priorities for a given UCI size range, when there is no corresponding DCI format. * **Proposal 3:** UE determines whether to multiplex LP HARQ-ACK with HP UCI in a PUCCH resource of PUCCH format 2, 3, or 4 of higher priority index, based on the total UCI payload size and configured max. code rate/max PRB parameters. | |
| NEC | ***Proposal 2:***  *For multiplexing of a low priority Type-2 HARQ-ACK codebook and a high priority Type-1/Type-2 HARQ-ACK codebook on a PUCCH in Rel-17,*   * *Support introducing an additional DCI field in DCI associated with high priority HARQ-ACK or high priority PUSCH for determining the total number of LP HARQ-ACK bits.* | |
| TCL | **Proposal 4: If the total UCI bits exceed the payload of the multiplexed PUCCH resource, partially dropping low priority UCI and/or compressed/bundled low-priority HARQ-ACK should be supported.** | |
| Xiaomi | ***Proposal 1:*** ***For scenario that multiplexing a HP HARQ-ACK and LP HARQ-ACK into a PUCCH,*** ***PRB number determination is based on maxCodeRate configured for HP UCI in high priority PUCCH and nominal UCI payload size, where nominal UCI payload size = the number of HP UCI bits + the number of LP UCI bits\* Coderate HP/ Coderate LP.***  ***Proposal 3: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH, when the total number of LP and HP HARQ-ACK bits is 2 bits, the PUCCH resource/ format of the HP HARQ-ACK should be the selected as the PUCCH resource for the multiplexed 2 bits.*** | |
| ETRI | **Proposal 5: The LP DCI determines the final PUCCH resource in at least for the HP SPS case.** | |
| Sharp | **Proposal 4: The UE determines the number of PRBs for HP HARQ-ACK first, followed by the LP HARQ-ACK.**   * **The coded HP HARQ-ACK bits and coded LP HARQ-ACK bits are multiplexed to the corresponding PRBs of the PUCCH resource sequentially.** * **The PRB determination and multiplexing methods are applied for PUCCH format 2/3/4.** | |
| WILUS | * ***Proposal 4:*** *If the required # of RBs for low-priority HARQ-ACK information exceeds the limit of PUCCH formats, then bundle the low-priority HARQ-ACK information. Detail bundling rules should be further discussed in Rel-17 URLLC/IIoT WI.* | |
|  |  | |

## 1st round discussion

Proposal for 1st round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, in case the total number of LP and HP HARQ-ACK bits is 2:

* Use a PUCCH resource in the second *PUCCH-Config* (the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK).

Proposal for 1st round discussion:

For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs,

* The number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format 2 and 3 is determined as following:
  + - If , the number of RBs is determined as ;
    - Otherwise, the number of RBs is determined as the minimum number of , satisfying .

Proposal for 1st round discussion:

For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs,

* Configuration of semi-static size reservation for LP HARQ-ACK payload is provided by RRC. LP HARQ-ACK semi-static size reservation is used instead of determined LP HARQ-ACK codebook size when selecting the PUCCH resource set.

Proposal for 1st round discussion:

In Rel-17 intra-UE UCI multiplexing between different priorities, support low priority HARQ-ACK compression.

* FFS conditions to trigger low priority HARQ-ACK compression
* FFS details of compression scheme.

Proposal for 1st round discussion:

For multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH format 3/4,

* RRC configures presence of a T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.

For multiplexing a LP Type-2 HARQ-ACK codebook in a HP PUSCH,

* RRC configures an additional T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | 1st Proposal: Agree  2nd Proposal: Agree  3rd Proposal: Not agree.   * This is basically inventing a new semi-static CB which has an impact on the PUCCH reliability since it increases its size and introduces higher complexity. We already have Type 1 CB, so it isn’t clear why we need yet another one to deal with something that has very low probability of happening. What is the point of using Type 2 CB and defeats the purpose of a dynamic CB, if LP HARQ-ACK must follow some semi-static size? If gNB is so concern about this, why not just use Type 1 CB? * We already have DAI mechanism to mitigate against misdetection of DL Grant, so this issue is unlikely to occur. * For rare event where DAI cannot handle misdetection of DL Grant which some missing HARQ-ACK (most likely just one missing HARQ-ACK), the gNB can detect the DMRS to work out the PUCCH resource as described in Huawei’s T-doc [2]. * It is much more efficient to address the root of the problem i.e. missing DL Grant rather than try to patch it up with a highly inefficient method such as inventing a new CB.   4th Proposal: Not agree.   * This issue is for the case where there are not sufficient resource (e.g. maxed out PRB) to carry the LP HARQ-ACK and it is easier to just drop the LP HARQ-ACKs.   5th Proposal: Further consider   * This will solve the misdetection of DL Grant issue of missing the last DL Grant associated with a LP PUCCH. However, this would add 2 more bits to the HP DCI for the DAI field. |
| Apple | Proposal 2: It is important to have the ceil function so at any RE, it has coded bits for a single UCI part. But proposal 2 is okay.  Proposal 3: not essential to consider.  Proposal 4: okay to consider. |
| Lenovo/Motorola Mobility | 1st proposal: Support  2nd proposal: Since separately coded HP and LP HARQ-ACK bits are mapped to separate REs, we think the equations should be updated as follows:   * + If , the number of RBs is determined as ;   + Otherwise, the number of RBs is determined as the minimum number of , satisfying .   3rd proposal: In our understanding, the 3rd proposal tries to address a corner case, where a large number of DCI formats indicating LP HARQ-ACK are missed. We don’t think special treatment for the corner case is necessary.  4th proposal: Do not support. If a PUCCH resource does not have enough REs to accommodate configured max code rates, LP HARQ-ACK should not be multiplexed in the PUCCH resource. |
| InterDigital | 1st Proposal: Agree  2nd Proposal: Don’t agree.  The first condition needs to consider that there may be insufficient resources even with MRB resource blocks. In such case, after dropping the LP bits there may be no need to utilize MRB resource blocks.  The proposal does not state what the rates r\_hp\_uci and r\_lp\_uci correspond to. In our view, r\_hp\_uci is one of the values of maxCodeRate configured for HP bits and r\_lp\_uci is a value of maxCodeRate configured for LP bits. It should be possible to configure more than one maxCodeRate value for HP bits for a UE and select the smallest one that allows accommodating both HP and LP bits when 1 RB is sufficient, to avoid over-allocating resources to a few LP bits.  3rd Proposal: Don’t agree  This would seem to result in systematic waste of resource. If this is only for PUCCH resource set selection, the agreement made at last meeting is sufficient?  4th Proposal: Don’t agree  It is simpler and sufficient to drop the LP HARQ-ACK in this case.  5th Proposal: Agree  This is needed to avoid that reliability of HP traffic is driven by reliability of DL DCI for LP traffic. |
| Intel | For 1st proposal, we’re supportive.  For 2nd proposal, it is ok if it is only for PF 3, because we don’t support separate coding for PF2 yet.  For 3rd and 5th proposal, it seems both proposals are trying to address the impact of miss-detected LP DCI. We’d like to understand why whether using reserved payload or using T-DAI depends on PUCCH format? We support additional T-DAI for LP in DCI scheduling HP PUCCH/PUSCH.  For 4th proposal, it seems companies have different mechanisms for compression, it would be very difficult to converge within 2 meetings. And we don’t think bundling between multiple PDSCHs in time domain can work properly, e.g. in case of missed PDCCH. We think, it is simpler to drop some LP HARQ-ACK rather than compression. |
| QC | For the 1st proposal, we are fine with it.  For the 2nd proposal, support it with the modification to use celling operation on each term on the left side of the inequalities.  For the 3rd proposal, partially agree. We agree with the principle of the proposal. But always using a single fixed reservation size may not be a good idea (like Sony commented, it is like a type 1 codebook). We think the number of reservation sizes can be multiple or single, and how many reservation sizes are up to gNB configuration. On UE side, UE just quantize the type 2 codebook size up to the nearest reservation size.  To Sony: we don’t think proposal 3 introduced a new codebook. It is still type 2 codebook with a mini step at the end of codebook construction to pad a few dummy bits. The argument of missing DCI is rare event so it does not need to be treated is not justified, because we are considering URLLC application with reliability of 10^-5. The probability of missing LP DCI is around 10^-2 which apparently exceeds 10^-5. So this is not rare event from URLLC perspective.  For the 4th proposal, we support it.  For proposal 5 & 6, further discussion is needed. There are other alternatives such as: don’t increase DAI size by introducing additional DAI as suggested in proposal 5&6, still use a single DAI but double-interpret the T-DAI in UL DCI, i.e., the same T-DAI is interpreted twice. One interpretation for HP HARQ-ACK just follow legacy interpretation. The second interpretation is for LP HARQ-ACK. If the T-DAI value X in the UL DCI is smaller than the T-DAI in the DL LP DCI, X is interpreted as X+4 (which is legacy behavior anyway due to the mod 4 operation with DAI).  The same idea of double interpreting T-DAI can be applied to DAI in HP DL DCI as well, i.e., it can be considered as another alternative for proposal 5. |
| Ericsson | 1st Proposal: support.  2nd proposal: support Lenovo/Motorola Mobility version of the formula, i.e., Qm should be divided before taking ceil(.).  3rd proposal: do not support.  4th proposal: do not support.  5th proposal: Further study |
| DOCOMO | 1st proposal: agree  2nd proposal: basically fine but ceil function should be added as follows. Besides, the definition of and should be clarified.   * + - If , the number of RBs is determined as ;     - Otherwise, the number of RBs is determined as the minimum number of , satisfying .   3rd proposal: agree  4th proposal: not supportive. If there is no sufficient resource for LP HARQ-ACK, the LP HARQ-ACK is dropped.  5th proposal: it seems the target issue is same as 3rd proposal, i.e. ambiguity of LP HARQ-ACK CB. We are wondering why two solution are needed for the same issue.. |
| MediaTek | 1st Proposal: Support.  2nd proposal: Do not support. We agree with the view from InterDigital.  3rd proposal: Do not support.  4th proposal: Do not support.  5th proposal: FFS. |
| Panasonic | We are fine with the 1st proposal.  We are fine with the 2nd proposal. The modification to use celling operation is also OK.  We are support the 3rd proposal.  For the 4th proposal, although we are open to consider it, it would not be essential function. |
| LG | 1st proposal: Agree.  2nd proposal: Not agree.  As commented in 1st GTW session, the ceiling function need to be applied as for the multiplexing of HARQ-ACK and CSI part 1/2 in Rel-15.  3rd proposal: Not agree.  Not to reflect actual PDSCH scheduling and codebook type of LP HARQ-ACK at all, is not to be reasonable way to support multiplexing of HP and LP HARQ-ACKs. Moreover, even with the proposal, the presence of LP HARQ-ACK would be misaligned between UE and gNB.  4th proposal: Agree.  5th proposal: It seems to need more consideration including potential HP DCI overhead in case where the CBG-based PDSCH is configured for LP HARQ-ACK which requires separate DAI from the TB-based PDSCH. |
| vivo | 1st Proposal: Agree  2nd Proposal: Agree  3rd Proposal: Not agree. LP HARQ-ACK bits can be various in different slots. It is hard to configure the semi-static size reservation for LP HARQ-ACK. In addition, padding bits would be introduced due to the payload size alignment around up to a semi-static configured size.  4th proposal: we share similar view with Intel.  5th proposal: not agree. The motivation to configure presence of a T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK seems similar with that in 3rd proposal. That is to avoid the ambiguity on number of LP HARQ-ACK bits. For this issue, we support option 1, i.e., configure a dedicated PUCCH resource for HP and LP HARQ-ACK in the second PUCCH-Config. Introducing additional T-DAI in DL DCI format will have negative impact on PDCCH performance. |
| Nokia/NSB | - Support the 1st proposal.  - Fine with the 2nd proposal in principle, and agree with other companies that the ceiling function is needed for each term before the inequality. Another possibility for the case where the configured max number of PRBs corresponding to the PUCCH resource doesn’t allow the high-priority and low-priority HARQ-ACK bits to fit in the PUCCH resource, is to drop the low-priority HARQ-ACK bits.  - Support the 3rd proposal if it covers both PUCCH resource set determination as well as PRB number determination. As a second preference, we are fine with any of the following options:   * Option 4: The indication and determination are defined by combining dynamic indication for enabling/disabling low-priority HARQ-ACK multiplexing and for low-priority HARQ-ACK codebook size, using a new DCI field in the high-priority DL DCI. * Option 5: The indication and determination are defining the number of RBs and/or PUCCH resource set index to be used in the PUCCH transmission, where the indication is carried in a new DCI field in the high-priority DL DCI.   - Do not support the 4th proposal as we don’t see it as essential optimization. Simply dropping the LP HARQ-ACK bits should be enough.  - Fine with the intention of the 5th proposal (which is related to the 3rd proposal), as it provides another option (i.e. other than the one under the 3rd proposal) to solve the DCI misdetection issue. |
| ITRI | 1st Proposal: support.  2nd proposal: support Lenovo/Motorola Mobility’s version  3rd proposal: do not support.  4th proposal: Support.  5th proposal: FFS |
| ZTE | Support the first and sixth proposals.  Principally support the second, fourth, and fifth proposals. For second proposal, we can make it more accurate by adding the ceiling function. And for the number of PRB allowed is not sufficient for the HP/LP HARQ-ACK, we can further discuss it, it is a separate issue.  Not support the third proposal. For the ambiguity of size of HARQ-ACK codebook, we need do nothing for type-1 codebook generation as the robustness of type-1 codebook. For type-2 codebook generation, if we accept the sixth proposal, the T-DAI field for LP HARQ-ACK could help solve the ambiguity issue of size of HARQ-ACK information. Thus no semi-static size reservation for LP HARQ-ACK payload is needed. Again we should note that the ambiguity issue is also valid for the case of LP HARQ-ACK non-existence when the total number of UCI bits is no more than 2 bits which is showed in section 2.3 of R1-2108843. This issue is different with the ambiguity of size of type-2 HARQ-ACK codebook and should also be considered and specification solution is needed.  One clarification question: in the fifth proposal, why the proposal is confined to PF3/4, PUCCH format 2 can also support the total HARQ bits larger than 2 bits. |
| Sharp | Support the 1st proposal.  Don’t agree the 2nd proposal.   * + The RBs for HP HARQ-ACK and LP HARQ-ACK should ne determined independently using ceil function so that no coded UCI of different priorities are multiplexed in the same RB. Also, there is no need for multiple step determination. The RB for HP HARQ-ACK is determined first based on HP code rate. Then the RBs for LP HARQ-ACK is determined by the minimum of required RBs based on the LP HARQ-ACK code rate and the remaining RBs.   Don’t agree the 3rd proposal.   * + The added complexity is not necessary and introduce waste of resources. Also, this proposal seems violate the agreement from the last meeting, i.e. PUCCH resource is selected based on the total payload of HP and LP HARQ-ACK.   Support the 4st proposal.   * + The LP HARQ-ACK payload compression can be supported/configured at least when the total HARQ-ACK payload exceeds the PUCCH capacity. Especially, CBG to TB level bundle can provide efficient compression. if CBG is configured.   5th proposal: open for discussion. |
| Huawei/Hisi | 1st proposal: Support  2nd proposal: Support the version by Lenovo/Motorola Mobility or DOCOMO. Note that the output sequence of rate matching is integral number of REs.  3rd proposal: Not support. As the LP UCI payload could vary within a large range, the semi-statically reserved resources can hardly fit the LP UCI.  4th proposal: Not support. The gNB can take care of the scheduling to avoid too large LP payload that cannot be multiplexed into the PUCCH.  5th proposal: Support in principle. |
| Samsung | Support 1st proposal.  Partly support the 2nd proposal.  Multiplexing in PF2 is not supported yet – we request to remove until a conclusion.  A ceiling function is not needed – that can also be seen by multiplying everything by .  NOT support the 3rd proposal. It complicates the specification and degrades SE. Much simpler and consistent with Rel-16 specifications to provide that functionality with Proposal 5.  NOT support the 4th proposal. The details are unknown including how the compression is done, how the gNB knows, whether there is any problem often enough to affect HP reliability (not just degrade it by say 0.2 dB and instead of 10-5 BLER there is a 1.2 x 10-5 BLER), ….  Support the 5th proposal. |
| Quectel | 1st Proposal: Support.  2nd Proposal: we don’t think a HP bit and a LP bit could be modulated into a same modulation symbol, so we support Lenovo/Motorola that we should use and rather than and to determine the PRB number.  For the case where , we think the LP HARQ bits should be dropped due to insufficient number of PRBs in the PUCCH resource. If LP HARQ bits are dropped, the number of PRBs is determined based on only HP HARQ bits (i.e., Rel-15/16 PRB number determination is reused). We suggest to update the first sub-bullet as:   * + - If , the number of RBs is determined as the minimum number of , satisfying .   3rd Proposal: support in principle. We think the semi-static reserved size should be also used for PRB number determination as updated in red below:  For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs,   * Configuration of semi-static size reservation for LP HARQ-ACK payload is provided by RRC. LP HARQ-ACK semi-static size reservation is used instead of determined LP HARQ-ACK codebook size when selecting the PUCCH resource set and determining the PRB number.   4th Proposal: Not support. We think LP HARQ-ACK should be dropped in this case for simplicity.  5th Proposal: We are open for further discussion. In our mind, there may not be a need to introduce new field as QC pointed out. If a new field is introduced, it may not have to be the T-DAI for LP HARQ-ACK. For an example, an indicator for the semi-statically reserved size for LP HARQ-ACK could be another choice. |
| OPPO | For 1st, 2nd, 3rd ,4th proposal, we are fine. For 2nd proposal, we are open to Lenovo/Motorola Mobility’s version  For 5th proposal, if 3rd proposal is agreed, 5th proposal is not required due to DCI missing issue has been solved by 3rd proposal.  Comparing 3rd proposal, 5th proposal requires additional bits in DCI, which reduces DCI reliability. |
| Xiaomi | Support the 1st and 2nd proposal.  In fact, our proposal in contribution is the same as the 2nd proposal |
| CATT | We agree with the 1st proposal.  For the 2nd proposal, we agree with the update from Lenovo/Motorola Mobility.  For the 3rd and the 5th proposals, we think they do not need to be both supported. We are open to either proposal.  For the 4th proposal, we do not support compression. A much more simpler approach is to drop LP HARQ-ACK. |
| NEC | Support the 1st proposal and the 5th proposal.  For the 2nd proposal, we agree with the update from Lenovo/Motorola Mobility. |
| FGI/APT | 1st proposal: Support.  2nd proposal: Support in principle. When the first inequality holds, low priority UCI should be dropped.  3rd proposal: Support. Also fine with option 4 and option 5 as mentioned by Nokia.  4th proposal: Support.  5th proposal: Support. |

1st round discussion status:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, in case the total number of LP and HP HARQ-ACK bits is 2:

* Use a PUCCH resource in the second *PUCCH-Config* (the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK).
* Support: Sony, Lenovo, Intel, QC, E///, DCM, MTK, LG, vivo, Nokia, ITRI, ZTE, Sharp, HW, Samsung, Quectel, OPPO, Xiaomi, CATT, NEC, FGI/APT

1st round discussion status:

For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs,

* The number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format 2 and 3 is determined as following:
  + - If , the number of RBs is determined as ;
    - Otherwise, the number of RBs is determined as the minimum number of , satisfying .
* Support: Sony, Apple, Lenovo (add ceiling in equations), Intel (only for PF3), QC (add ceiling in equations), E/// (add ceiling in equations), DCM (add ceiling in equations), LG (add ceiling in equations), vivo, Nokia (add ceiling in equations and drop LP HARQ-ACK if resource is not sufficient), ITRI add ceiling in equations), ZTE (add ceiling equations), HW, Samsung, OPPO, Xiaomi, CATT, NEC, FGI/APT
* Not support: IDC (drop LP HARQ-ACK if resource is not sufficient), (drop LP HARQ-ACK if resource is not sufficient), Sharp, Quectel (use and to avoid modulating HP bits and LP bits into a same modulation symbol)

1st round discussion status:

For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs,

* Configuration of semi-static size reservation for LP HARQ-ACK payload is provided by RRC. LP HARQ-ACK semi-static size reservation is used instead of determined LP HARQ-ACK codebook size when selecting the PUCCH resource set.
* Support: QC (number of reservation sizes can be multiple), DCM, Nokia, Quectel, OPPO, FGI/APT
* Not support: Sony, Apple, Lenovo, IDC, E///, MTK, LG, vivo, ITRI, ZTE, Sharp, HW, Samsung
  + This is basically inventing a new semi-static CB which has an impact on the PUCCH reliability since it increases its size and introduces higher complexity.
  + Can use Type 1 CB if gNB is so concern about this issue.
  + We already have DAI mechanism to mitigate against misdetection of DL Grant.
  + For rare event where DAI cannot handle misdetection of DL Grant which some missing HARQ-ACK (most likely just one missing HARQ-ACK), the gNB can detect the DMRS to work out the PUCCH resource as described in Huawei’s Tdoc [2].

1st round discussion status:

In Rel-17 intra-UE UCI multiplexing between different priorities, support low priority HARQ-ACK compression.

* FFS conditions to trigger low priority HARQ-ACK compression
* FFS details of compression scheme.
* Support: Apple, QC, LG, ITRI, ZTE, Sharp, OPPO, FGI/APT
* Not support: Sony, Lenovo, IDC, Intel, E///, DCM, MTK, vivo, Nokia, HW, Samsung, Quectel, CATT

1st round discussion status:

For multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH format 3/4,

* RRC configures presence of a T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.

For multiplexing a LP Type-2 HARQ-ACK codebook in a HP PUSCH,

* RRC configures an additional T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.
* Support: IDC, Intel, Nokia, ZTE, HW, Samsung, NEC, FGI/APT
* Not support: vivo

## 2nd round discussion

The first proposal has been discussed for meetings, and pros and cons are clarified. It seems the two proposals are workable, although some companies think the other option is better for optimization. To make progress and save the precious GTW time, it is suggested to agree on them by email approval. It is suggested you show the objection only if you cannot live with the proposal.

The second and third proposals deserve the 2nd round discussion for checking.

Proposal for 2nd round discussion (for email approval):

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, in case the total number of LP and HP HARQ-ACK bits is 2:

* Use a PUCCH resource in the second *PUCCH-Config* (the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK).

|  |  |
| --- | --- |
| Supporting companies: | QC, Samsung, Intel, InterDigital, DOCOMO, CATT,TCL, Quectel, NEC, vivo, LG, Huawei/Hisi, Nokia/NSB,OPPO, ZTE, Panasonic, ITRI, Sony, Sharp |
| Objecting companies: |  |
| Company | Reason for objection |
| Nokia/NSB | Just a comment on the wording: we are a bit wondering if it’s better to be more precise and say “use the PUCCH resource of HP HARQ-ACK” instead of “a PUCCH resource …”. |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal for 2nd round discussion:

For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs,

* The number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format ~~2 and~~ 3 is determined as following:
  + - If , the number of RBs is determined as the minimum number of , satisfying .
    - Otherwise, the LP HARQ-ACK is dropped.
    - r\_HP\_UCI is maxCodeRate configured for HP bits and r\_LP\_UCI is maxCodeRate configured for LP bits.
      * FFS whether over one maxCodeRate can be configured for one priority.
    - FFS for PUCCH format 2.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Even though we prefer a different design, for the sake of progress, we can support FL’s proposal. |
| QC | We support this proposal. By the way, we don’t see any reason the proposal cannot be applied to PF2. For PF2, the details of multiplexing details such as RE mapping are still open. But this RB determination can be applied to PF2. We suggest to add PF2 back in the proposal. |
| Samsung | We think “-1” should be removed, if PRBs can satisfy the coding rate requirement, no need to drop LP HARQ-ACK.  Also as we clarified in the first round, the ceiling function is not needed. If needed to avoid mapping HP bit and a LP bit into a same modulation symbol, the ceiling function can be used when determine the number of REs same as in Rel-15 (TS 38.212 6.3.1.4). However, it is not clear why mapping HP/LP bits in the same QPSK-only modulation symbol has any problem.  The conditions for dropping LP HARQ-ACK may need further discussion. If HP HARQ-ACK is mapped first, LP HARQ-ACK won’t affect the reliability of HP HARQ-ACK. Table 6.3.1.4.1-1 of TS 38.212 6.3.1.4 can be reused instead.  Updated proposal  For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs,   * The number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format ~~2 and~~ 3 is determined as following:   + - If , the minimum number of RBs is determined as the ~~minimum~~ number of , satisfying .     - ~~Otherwise, the LP HARQ-ACK is dropped.~~     - Reuse Rel-15 for determining the number of REs     - r\_HP\_UCI is maxCodeRate configured for HP bits and r\_LP\_UCI is maxCodeRate configured for LP bits.       * FFS whether over one maxCodeRate can be configured for one priority.     - FFS for PUCCH format 2. |
| Intel | We’re fine with the proposal modified by Samsung, except the sub-bullet for drop.  We suggest to keep the sub-bullet For the drop of LP HARQ-ACK, and add FFS to discuss whether all LP HARQ-ACK is dropped, or partial dropping. |
| InterDigital | Support the proposal in principle. However, it seems that the “-1” should be removed.  Regarding “dropping”, the condition should be there because otherwise the maxCodeRate of LP bits would be exceeded and the reliability target of LP bits is not met (unless partial dropping would be supported). The network would not be able to rely on the LP HARQ-ACK information and resources would be wasted.  For the bullet “Reuse Rel-15 for determining the number of REs”, it is not needed since we already agreed to this at the last meeting. |
| DOCOMO | Basically fine with the FL proposal. However, we prefer to clarify that the maxCode rate configured for LP bits is the one configured in the second *PUCCH-Config* (the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK).  r\_HP\_UCI is maxCodeRate configured for HP bits and r\_LP\_UCI is maxCodeRate configured in the second *PUCCH-Config* (the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK) for LP bits.  Besides, we share similar view with QC for PF2. It should be added back in the proposal. |
| CATT | We are fine with the proposal and agree with Qualcomm to apply to PF2 as well. |
| Quectel | We support the proposal in principle. For the case where LP HARQ-ACK is dropped, it is better to clarify that the PRB number is determined based on Rel-15 rather than equal to .  For the question regarding mapping HP/LP bits in different modulation symbols and ceiling function:  In existing specification, the rate matching output sequence length is determined with a minimum granularity of modulation symbol, i.e., based on number of REs for separate coding, e.g,  is for HARQ-ACK+CSI part 1 and  is for CSI part 2. We think aligning the granularity of rate matching and the metric for PRB number determination can avoid unnecessary mismatch between rate matching and RE mapping (although we think the impact could be minimal and only for LP HARQ-ACK). The ceiling function can serve the same purpose in our understanding. |
| NEC | Fine with the proposal. |
| vivo | We also think the proposal can be applied to PF2. |
| LG | We support the proposal from FL in principle, with removal of “-1”.  And we need to use the ceiling function by respecting the previous agreement to reuse Rel-15 AN+CSI rate-matching for HP AN+LP AN. And we share same view with DOCOMO and QC to include PF2 as well.  Thus, we suggest the following update.  For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs,   * The number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format 2 and 3 is determined as following:   + - If , the number of RBs is determined as the minimum number of , satisfying .     - Otherwise, the LP HARQ-ACK is dropped.     - r\_HP\_UCI is maxCodeRate configured for HP bits and r\_LP\_UCI is maxCodeRate configured for LP bits.       * ~~FFS whether over one maxCodeRate can be configured for one priority.~~     - ~~FFS for PUCCH format 2.~~ |
| Huawei/Hisi R2 | Support in principle. But what is the meaning of ‘**over one maxCodeRate can be configured for one priority’**? We think one priority corresponds to one maxCodeRate for PF3. In addition, is there a typo error in the first equation?    @ Samsung: as we agreed that HP HARQ-ACK follow the original R15 rate matching equation for HARQ-ACK+CSI part1, we can take 38.212 for HARQ-ACK+CSI part 1 rate matching as a reference. It is clear that integral number of REs is derived. |
| Nokia/NSB | Support the proposal in principle.  We also think that ‘-1’ may not be needed, as mentioned by Samsung.  We don’t have a strong view on whether to keep the ceiling function or not. |
| OPPO | Support |
| ZTE | “-1” should be removed if is the maximum allowed RB number for PUCCH.  Agree Intel’s suggestion on “Drop LP HARQ-ACK”  Also agree to add PF2 back. |
| Panasonic | We are fine with the proposal. |
| Samsung2 | @Huawei: Agree with “It is clear that integral number of REs is derived.” As Huawei highlighted in yellow, without the ceiling function in the proposal, it still comes with an integral number. Why do we need the ceiling function? Could proponents clarify a bit what is the difference? We don’t have ceiling function in Rel-15 TS38.213 and we have integral number of REs for each UCI, why is it needed here? |
| ITRI | Support this proposal |
| Sony | We share Samsung’s view in removing the ceiling function as this proposal is regarding determinination of the number of RBs. The Rate Matching processs would anyhow apply the ceiling function as reference in 38.212 (as per Samsung’s comment). |
| InterDigital2 | @LG: Not OK with deleting the FFS on whether over one maxCodeRate can be configured for a priority, please see explanation below.  @Huawei/Hisi R2: With small number of LP bits (e.g. 1 or 2) and MPUCCHRB,min=1, there would be too much REs allocated to LP bits compared to HP bits if only a single maxCodeRate is possible (Table 6.3.1.4.1-1 allocates HP REs so that HP bits just meets the maxCodeRate and the remainder is left to LP bits). In such situation it would be better to allow HP bits to use more REs to decrease its code rate, as long as the maxCodeRate of LP bits is still satisfied. This can be achieved by configuring additional maxCodeRate for HP bits. Otherwise, there is unnecessary coverage loss.  We are also fine with including PF2 in the agreement.  On the ceiling function, no strong view but tend to agree with Samsung’s view that it is not necessary. |
| Sharp | Fine with the proposal for RB determination with Samsung’s revision by removing “-1”.  The same formula can be applied to PF2.  For dropping of LP UCI, we don’t see the case for LP UCI dropping. Note the PUCCH is selected based on total payload of HP and LP UCI, thus the PUCCH should be capable of transmitting all UCI even with the HP max code rate. Thus, once the RBs for HP UCI is determined, the LP UCI can use the required RBs up to all remaining RBs in the PUCCH resource.  However, the LP UCI payload reduction should be considered if the total payload exceeds the configured PUCCH capacity. |
| QC2 | We need the ceiling operation before addition on the left side of the inequalities. Otherise, how does UE/gNB implement two fractional number addition a+b? There are numerical issues in implementation (such as precision used in fixed point implementation) which could lead ambiguity on the addition outcome. |
| Lenovo/Motorola Mobility | We support the proposal, with removal of “-1” as pointed by LG. |
| Ericsson | Support. Also agree with QC to add back PF2. |

Proposal for 2nd round discussion:

For the problem of ambiguity on LP HARQ-ACK existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection, focus on the Rel-17 study on the following approach:

* For multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH format 3/4,
  + RRC configures presence of a T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.
* For multiplexing a LP Type-2 HARQ-ACK codebook in a HP PUSCH,
  + RRC configures an additional T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | We are not against the proposal per se. Yet we need to have a big picture in mind: we cannot cut corner on big design issues but at the same time pursue optimization for secondary issue. |
| QC | We don’t support this proposal. We are OK to take the routine via DAI mechanism to solve the missing LP DCI issue for HP + LP UCI multiplexing. But brutally adding a new DAI field to DAI is not the best approach, because of increased DCI overhead. We should consider other alternative to enhancement DAI mechanism without additional DCI overhead.  We suggest the following modification of the proposal  For the problem of ambiguity on LP HARQ-ACK existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection, focus on the Rel-17 study on the following approach:   * For multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH format 3/4,   + Alt 1: RRC configures presence of a T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.   + Alt 2: double-interpret/reuse of the T-DAI field in in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK * For multiplexing a LP Type-2 HARQ-ACK codebook in a HP PUSCH,   + Alt 1: RRC configures an additional T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.   + Alt 2: double-interpret/reuse of T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.   In the following, we provide an example to illustrate what we meant by double-interpret T-DAI. Example, if UE needs to multiplex a HP type 2 codebook and a low priority type 2 codebook on a PUSCH, the most recent C-DAI UE received for LP codebook is 3, UE missed the last DCI for LP which supposes to update the C-DAI to 4. The most recent C-DAI UE received for HP codebook is 1. UE does not miss any DCI for HP. In the UL grant for PUSCH, gNB can set T-DAI =1. For HP codebook, UE interpret the T-DAI =1 and know HP codebook size = 1 bit. For LP codebook, UE interpret the T-DAI = 5 (where 5 mod 4 = 1), because the most recent C-DAI UE received for LP is already indicate C-DAI=3. So UE assume it missed two DL DAI and transmit 1 more bit. Please notice each of the double interpretation is legacy behavior to interpret T-DAI. UE just run it twice and both based on a common T-DAI field rather than based on a legacy T-DAI field and a new T-DAI field.  The advantage of this scheme is that it can avoid introduce new DAI field and it can be applied to even legacy DCI format. The disadvantage is that it may send unnecessary bits for LP codebook. But please notice that at most 3 unnecessary bits are send in worst case. On average, it is 2 additional bits. Consider the LP codebook size is normally medium or large, 2 or 3 bits overhead on LP codebook is fine. |
| Intel | We’re fine with the proposal. |
| DOCOMO | We can compromise to the proposal modified by Qualcomm for the sake of progress although we still prefer the semi-static size reservation with no DCI impact. Between the two alternatives, we prefer Alt.2 because of no DCI overhead. Additional 4 bits overhead by Alt.1 would impact on the reliability of PDCCH reception and thus not preferred. |
| CATT | We are fine with the proposal. |
| Quectel | We are not against the proposal. But we think it is still premature and more details need to be discussed. As QC explained, other solutions such as reusing existing DAI could also be possible? And also note that dynamic enabling/disabling has been debated a long time due to possibly 1 bit extra DCI overhead. We don’t think DCI overhead is not an issue for DAI. |
| LG | We think the proposal needs more discussions including to consider the case where CBG-based PDSCH (which requires separate DAI from TB-based PDSCH) is configured for LP HARQ-ACK, with consideration of HP DCI overhead.  Regarding QC’s proposal, it also seems necessary to check further on potential HARQ-ACK size ambiguity by doing so. |
| Huawei/Hisi R2 | Support |
| Nokia/NSB | Support the intention of the proposal.  We think that this new T-DAI field could also be jointly used to (dynamically) enable/disable multiplexing. Specifically, different values in this field are used to indicate either (i) to not multiplex the low-priority HARQ-ACK or (ii) to multiplex the low priority HARQ-ACK and the corresponding total DAI (or CB size) for low-priority HARQ-ACK (to avoid discrepancy on the low-priority HARQ-ACK codebook size).  We thus propose the following updates on the proposal:  Proposal for 2nd round discussion:  For the problem of ambiguity on LP HARQ-ACK existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection, focus on the Rel-17 study on the following approach:   * For multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH format 3/4,   + RRC configures presence of a ~~T-DAI~~ field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK. * For multiplexing a LP Type-2 HARQ-ACK codebook in a HP PUSCH,   + RRC configures an additional ~~T-DAI~~ field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK. * FFS the field is also jointly used for dynamic indication to enable/disable multiplexing, if such indication is agreed.   In general, it’s preferrable to not touch or re-interpret the T-DAI of HP HARQ-ACK (as proposed by QC), but we are open for further discussion. |
| ZTE | Fine with the proposal. |
| Panasonic | We are fine with the proposal. |
| Sony | We still think this is a non-issue and can be easily solved by **dynamic enabling/disabling of multiplexing**. It is ironic that for the sake of ***just 1 bit***, companies prefer methods that either increase the PUCCH size by semi-statically configuring its size to some reserved value thereby totally defeating the purpose of Type 2 CB or increase the DCI size by introducing 2 or more additional DAI/T-DAI/C-DAI bits in the HP DCI.  Do note that **if you introduce extra DAI bits in the HP DCI you will also introduce extra bits in the LP DCI** because whether a DCI is HP or LP is indicated in the Priority Indicator field in the DCI, so the same DCI format with the SAME SIZE can be HP or LP. What is the use of this extra DAI bits in the LP DCI?  In contrast, if we just introduce a single multiplexing bit (**ONE BIT**) into the DL Grant, then the UE would just have to ensure that the Mux bit is enabled in the last LP DL Grant and the HP DL Grant to decide to multiplex. If it doesn’t see any in the LP DL Grant it means no multiplexing or it had missed the last DL Grant either of which would not lead to partial LP HARQ-ACKs in the PUCCH. Plus this gives significant flexibility for the gNB scheduling. |
| MediaTek | We have concern on unnecessarily increasing the DCI payload. |
| InterDigital | Support the proposal. Also fine with Nokia’s proposal. |
| QC 2 | To Sony & Nokia:  We would further like to emphasize our concern on dynamic enable/disable UCI mux is never on the 1 bit overhead in DCI. Our concern is on its huge impact to UE implementation complexity and spec impact on timeline.  To LG: The proposed Alt 2 from QC has no LP UCI size ambiguity. It just might increase a few dummy bits. But both gNB and UE knows how many dummy bits are added. |
| Ericsson | Not support at the moment.  We are not convinced that such enhancement is absolutely necessary. The proposal adds extra overhead in every HP DCI even if there is no overlapping HP HARQ-ACK and LP HARQ-ACK to multiplex. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 3rd round discussion

Proposal for 3rd round discussion:

For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs,

* The number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format ~~2 and~~ 3 is determined as following:
  + - If , the minimum number of RBs is determined as the ~~minimum~~ number of , satisfying .
    - Otherwise, the LP HARQ-ACK is dropped
      * FFS details, e.g. full/partial dropping, condition for dropping.
    - r\_HP\_UCI is maxCodeRate configured for HP bits and r\_LP\_UCI is maxCodeRate configured for LP bits in the second *PUCCH-Config* (the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK).
      * FFS whether over one maxCodeRate can be configured for one priority.
    - FFS for PUCCH format 2.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | We support the proposal. |
| Intel | We’re fine with the proposal. |
| InterDigital | Support the proposal |
| LG | We are not supportive to the proposal.  In order to respect (or not to revert) the previous agreement that the HP AN and LP AN reuse the rate-matching applied to Rel-15 AN+CSI part 1 and CSI part 2 respectively, the ceiling function should be included. |
| Sony | Support |
| Ericsson | * We can accept the proposal for PF2 in principle. But the description should be made more accurate by stating that is the minimum value that   + , and * For PF3, should not be the number of PRBs for tx. It should be increased to the nearest allowed value of *nrofPRBs* for *PUCCH-format3*. That is, the following sentence should be added: “For PUCCH format 3, if  is not equal  according to [4, TS 38.211],  is increased to the nearest allowed value of *nrofPRBs* for *PUCCH-format3*[12, TS 38.331].” |
| QC | Support the spirit of the proposal but not in its current form. Three comments from us:   1. Celing operation should be added. We need the ceiling operation before addition on the left side of the inequalities. Otherise, how does UE/gNB implement two fractional numbers addition a+b, say 45.34553+5.65423534534? There are numerical issues in implementation (such as precision used in fixed point implementation) which could lead ambiguity on the addition outcome in certain cases. Using celing can make sure the addition is addition of two integers. 2. PF2 should be included in the proposal, which I believe is majority view. 3. Agree with Ericosson on the PF3 (DFT-S-OFDM waveform) |
| Samsung | Support the proposal on condition “Otherwise, the LP HARQ-ACK is dropped” is removed.  There is no reason why LP HARQ-ACK should be dropped instead of being mapped to the rest of REs. Clearly there is a loss from dropping LP HARQ-ACK – the gNB knows the situation and can disregard the LP HARQ-ACK if it wants. In Rel-15, when the maximum number of RBs is not enough, the PUCCH with the HARQ-ACK is transmitted as usual using the maximum number of RBs – the situation is same. Also, if LP HARQ-ACK is dropped, does the UE need to recalculate the number of RBs for HP HARQ-ACK or use the maximum number? We do not support changing Rel-15 behavior and have worse operation and more complex specifications on top of that.  In addition, we do not support further considering partial dropping. Any benefit is questionable while the specification impact can be significant. There are much more important aspects to finalize for this AI and there is one meeting left before maintainance.  Regarding QC’s concern on “implement two fractional number addition”, there is no issue. In any case, that is an artificial aspect - can be multiplied on both sides of the inequality and avoid any fractions.  We suggest the following update  For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs,   * The number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format ~~2 and~~ 3 is determined as following:   + - If , the minimum number of RBs is determined as the ~~minimum~~ number of , satisfying .     - Otherwise, ~~the LP HARQ-ACK is dropped~~        * ~~FFS details, e.g. full/partial dropping, condition for dropping.~~     - r\_HP\_UCI is maxCodeRate configured for HP bits and r\_LP\_UCI is maxCodeRate configured for LP bits in the second *PUCCH-Config* (the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK).       * FFS whether ~~over~~ more than one maxCodeRate can be configured for one priority.     - FFS for PUCCH format 2.   Regarding “adding PF 2 back”, we cannot accept. We suggest to leave it FFS to make progress. |
| Sharp | Understand the principle of the propose, but we do not support the current formula.  The system should ensure the coded HP UCI and coded UCI are not multiplexed in the same RB. Thus, the ceiling function should be included at least for the HP UCI.  For LP UCI, since the PUCCH resource is selected based on total payload, and the LP UCI should have higher code rate than HP UCI, the remaining RBs in the PUCCH resource should be enough for the LP UCI.  To avoid recursive RE calculation, the number of RBs for HP UCI and LP UCI can be calaculated independently based on the corresponding max code rates. Then, if the total number of RBs for HP and LP UCI exceeds the #RBs configured for the PUCCH, the HP UCI is mapped to the calculated #REs, and the remaing RBs are used for LP UCI.  We are also fine if the LP UCI is dropped in case of code rate cannot be satisified by the remaining REs (e.g. due to ceiling function for HP UCI RBs, and/or CRC attachments, etc.) |
| LG2 | We agree with QC and Sharp that the ceiling function should be included for at least two reasons:   1. To be aligned with the previous agreement exactly stating that HP AN and LP AN reuse the rate-matching applied to Rel-15 AN+CSI part 1 and CSI part 2 respectively. 2. To minimize specification (and UE implementation) impact by just replacing Rel-15 AN+CSI part 1 and CSI part 2 into HP AN and LP AN respectively based on current spec.   For these reasons, we suggest the following update in yellow mark (besides, regarding the “minimum”, I think the “” is to be the minimum satisfying the condition).  [Updated proposal]  For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs,   * The number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format 2 and 3 is determined as following:   + - If , the ~~minimum~~ number of RBs for the multiplexing is determined as the minimum ~~number of~~ , satisfying .     - Otherwise, the LP HARQ-ACK is dropped       * FFS details, e.g. full/partial dropping, condition for dropping.     - r\_HP\_UCI is maxCodeRate configured for HP bits and r\_LP\_UCI is maxCodeRate configured for LP bits in the second *PUCCH-Config* (the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK).       * FFS whether ~~over~~ more than one maxCodeRate can be configured for one priority.     - ~~FFS for PUCCH format 2.~~ |
| ZTE | Support the proposal.  Also fine with Ericsson on the PF3 (DFT-S-OFDM waveform). |
| Quectel | We generally support LG’s udpates.  Firstly, as commented by a number of companies above, the ceiling function is needed. Otherwise it may cause numerical issues and unnecessary mismatch between RE mapping and rate matching.  Secondly, as commented by Ericsson, the limitation imposed by IFFT size for DFT-s-OFDM should be applied for PF3. |
| vivo | ok |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Timeline and latency requirements

## Inputs from Tdocs

**Latency requirements:**

* Option 1: The latency requirement can be defined as the ending symbol of PUCCH resource for multiplexed UCI transmission is not later than X symbols after the ending symbol of PUCCH for the higher priority UCI.
  + - Option 1a: X=0.
      * HW, TCL

**For the case where the timeline requirements are not met,**

* Option 1: UE behavior fallbacks to Rel-16 prioritization.
  + Intel
* Option 2:
  + If a UE doesn’t support Rel-16 prioritization, the UE doesn’t expect the multiplexing timeline conditions are not satisfied.
  + If the UE support Rel-16 prioritization, UE behavior fallbacks to Rel-16 prioritization.
  + OPPO

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 8: For HP HARQ-ACK overlapping with LP HARQ-ACK, the multiplexing is allowed only when the PUCCH carrying the multiplexed UCI ends no later than the PUCCH carrying only HP HARQ-ACK.*** |
| QC | ***Proposal 20:* For d1 defined for PUCCH vs PUCCH or PUCCH vs PUSCH cancellation with different priorities, support subcarrier spacing dependent d1 values. FFS exact d1 values for each subcarrier spacing.** |
| LGE | **Proposal #5: Consider additional condition for the processing of inter-priority multiplexing and the latency requirement for HP UCI.** |
| OPPO | ***Proposal 12: Reuse Rel-15 intra-UE PUCCH/PUSCH multiplexing timeline conditions for Rel-17 intra-UE multiplexing with different priorities:***   * ***For a UE doesn’t support Rel-16 prioritization, the UE doesn’t expect the multiplexing timeline conditions are not satisfied.*** * ***For the UE support Rel-16 prioritization, if the timeline conditions are not met, UE behavior fallbacks to Rel-16 prioritization.*** |
| TCL | **Proposal 5: Multiplexing for UCIs with different priorities should only be allowed when the PUCCH carrying the multiplexed UCI ends no later than the PUCCH carrying high-priority UCI.** |
| Xiaomi | ***Proposal 4: The R15 multiplexing timeline can be reused for PUCCH/PUSCH with different priorities.*** |
|  |  |

## Multiplexing HARQ-ACK and SR with different priorities

## Inputs from Tdocs

**When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0**

* Opt.1: The positive SR and HARQ-ACK are multiplexed and transmitted on the SR resource.
  + Opt.1a: The UE does not transmit negative SR.
  + Opt.1b: For negative SR, the UE transmit only HARQ-ACK on the HARQ-ACK resource.
    - E///, ZTE, Nokia, CATT, LGE, Quectel, DCM, Sharp, WILUS
  + Opt.1c: For negative SR, the UE transmits SR and HARQ-ACK on the SR resource
    - Nokia, IDC
  + Opt.1d: with a power boost
    - QC
* Opt.2: The SR and HARQ-ACK are multiplexed and transmitted on the HARQ-ACK resource.
  + Opt.2a: If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the HARQ-ACK PUCCH resource.
  + Opt.2b: Using 4 CS values as for SR+1-bit HARQ-ACK in Rel-15/16. For the case of 2-bit HARQ-ACK, the HARQ-ACK is reduced/compressed to 1-bit.
  + Opt.2c: If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.
    - HW, Intel, vivo, Pana, Spreadtrum, Sony
* Opt.3: No enhancement over Rel-16.
  + Samsung, OPPO (R15 or R16 according to the number of PUCCH symbols.)

**When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1**

* Opt.1: The positive SR and HARQ-ACK are multiplexed and transmitted on the SR resource.
  + Opt.1a: The UE does not transmit negative SR.
  + Opt.1b: For negative SR, the UE transmit only HARQ-ACK on the HARQ-ACK resource.
    - E///, Nokia, CATT, DCM, Sony, Sharp
  + Opt.1c: For negative SR, the UE transmits SR and HARQ-ACK on the SR resource
    - Nokia, IDC
* Opt.2: The SR and HARQ-ACK are multiplexed and transmitted on the HARQ-ACK resource.
  + Opt.2a: If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the HARQ-ACK PUCCH resource.
  + Opt.2b: Applying QPSK for SR+1-bit HARQ-ACK. For the case of 2-bit HARQ-ACK, the HARQ-ACK is reduced/compressed to 1-bit.
    - WILUS
* Opt.3: For positive SR, transmit HARQ-ACK on the SR resource. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.
  + ZTE, QC, LGE, DCM
* Opt.4: For positive SR, transmit SR on the SR resource and drop HARQ-ACK. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource (i.e. No enhancement over Rel-16).
  + HW, Samsung, Quectel, Intel, vivo, OPPO, Pana, Spreadtrum, Sharp

**When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0**

* Opt.1: The SR and HARQ-ACK are multiplexed and transmitted on the SR resource.
  + Opt.1a: For negative SR, the UE transmit only HARQ-ACK on the HARQ-ACK resource.
    - E///, CATT
  + Opt.1b: SR and HARQ-ACK are multiplexed and modulated to be transmitted on the SR resource
* Opt.2: The SR and HARQ-ACK are multiplexed and transmitted on the HARQ-ACK resource.
  + Opt.2a: If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the HARQ-ACK PUCCH resource.
  + Opt.2b: Using 4 CS values as for SR+1-bit HARQ-ACK in Rel-15/16. For the case of 2-bit HARQ-ACK, the HARQ-ACK is reduced/compressed to 1-bit.
  + Opt.2c: If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.
    - HW, Intel, vivo, Spreadtrum, Sony
  + Opt.2d: HP SR and LP HARQ-ACK are multiplexed by the Rel-15 cyclic shift only if latency requirement for HP SR is met. Otherwise, drop the LP HARQ-ACK and only transmit the HP SR on its resource.
* Opt.3: For positive SR, transmit HARQ-ACK on the SR resource. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.
  + ZTE, Nokia, CATT, QC, LGE, Quectel, IDC, DCM, Sharp
* Opt.4: No enhancement over Rel-16.
  + Samsung, OPPO, Pana

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 9: For multiplexing HP SR and LP HARQ-ACK with PF0/PF1,***   * ***For the case of HP SR with PF0 vs LP HARQ-ACK with PF0, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15 if SR is positive and transmit only HARQ-ACK on HARQ-ACK resource if SR is negative (i.e. option 2c);*** * ***For the case of HP SR with PF0 vs LP HARQ-ACK with PF1, drop LP HARQ-ACK if HP SR is positive (i.e. option 4/5);*** * ***For the case of HP SR with PF1 vs LP HARQ-ACK with PF0,*** ***Opt.2c should be supported. That is SR is multiplexed on HARQ-ACK resource in the same way as Rel-15 if SR is positive and transmit only HARQ-ACK on HARQ-ACK resource if SR is negative (i.e. option 2c);*** * ***For the case of HP SR with PF1 vs LP HARQ-ACK with PF1, reuse the resource selection method in Rel-15.***   ***Proposal 10: For multiplexing HP SR and LP HARQ-ACK with format2/3/4,***   * ***Adopt separate coding to HP SR and LP HARQ-ACK on one PUCCH resource*** * ***The PUCCH resource is selected from dedicated PUCCH resource sets in the second PUCCH-Config for multiplexing HP HARQ-ACK and LP HARQ-ACK*** * ***The multiplexing is only allowed if the ending symbol of the PUCCH resource carrying multiplexed SR and HARQ-ACK is no later than the ending symbol of the PUCCH resource carrying SR.*** |
| E/// | [Proposal 6 For multiplexing HP SR and LP HARQ-ACK: if SR is negative, transmit HARQ-ACK only on the HARQ-ACK resource; If SR is positive, multiplex SR with HARQ-ACK and transmit on the SR resource.](#_Toc84035006) |
| ZTE | ***Proposal 9:*** *For positive SR, transmit HARQ-ACK on the SR resource. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource. The principle is applied at least for three cases:*   * *PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0* * *PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1* * *PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0*   ***Proposal 10:*** *Adopt the following rules to multiplex high priority SR and low priority HARQ-ACK.*   |  |  |  |  | | --- | --- | --- | --- | | *HARQ-ACK*  *SR* | *PUCCH format 0* | *PUCCH format 1* | *PUCCH format 2/3/4* | | *PUCCH format 0* | *For positive SR, the UE transmits the PUCCH in the resource using PUCCH format 0 in PRB(s) for SR. The same way in Rel-15 can be reused for the UE to determine the value of  and  for computing the value of cyclic shift .*  *For negative SR, the UE transmits only a PUCCH with HARQ-ACK information.* | | *For positive SR, the UE Reuse Rel-15 rules.*  *For negative SR, the UE transmits only a PUCCH with HARQ-ACK information and drops the PUCCH with negative SR.* | | *PUCCH format 1* | *For positive SR, the UE transmits the PUCCH in the resource using PUCCH format 1 in PRB(s) for SR. The value of cyclic shift of sequence, i.e., , of this PUCCH format 1 is determined by HARQ-ACK, and the bit, i.e., b(0), of this PUCCH format 1 is determined by SR*  *For negative SR, the UE transmits only a PUCCH with HARQ-ACK information and drops the PUCCH with negative SR.* | *Reuse Rel-15 rules.* | |
| Nokia | **Proposal 3.11: For the scenario where a PUCCH carrying high-priority SR overlaps with a PUCCH carrying low-priority HARQ-ACK:**   * **If SR is with F0 and HARQ-ACK is with F0/F1, adopt one of the following options:**    + **Opt.1b: The positive SR and HARQ-ACK are multiplexed and transmitted on the SR resource. For negative SR, the UE transmits only HARQ-ACK on the HARQ-ACK resource.**   + **Opt.1c: The SR and HARQ-ACK are multiplexed and transmitted on the SR resource.** * **If SR is with F1 and HARQ-ACK is with F0/F1, adopt Opt.3: Transmit HARQ-ACK on the SR resource if SR is positive; and transmit HARQ-ACK on the HARQ-ACK resource when SR is negative.** * **If SR is with F0/F1 and HARQ-ACK is with F2/F3/F4: If SR is positive, transmit SR on the SR resource and drop HARQ-ACK; if SR is negative, transmit HARQ-ACK only on the HARQ-ACK resource.** |
| CATT | ***Proposal 8: For multiplexing of HP SR and LP HARQ-ACK with PF0/1,***   * ***positive SR and HARQ-ACK are multiplexed on the SR resource;*** * ***for negative SR, the UE transmits only HARQ-ACK on the HARQ-ACK resource.***   ***Proposal 9: For multiplexing of HP SR and LP HARQ-ACK with PF2/3/4,***   * ***for positive SR, drop LP HARQ-ACK;*** * ***for negative SR, transmit only HARQ-ACK on the HARQ-ACK resource.***   ***Proposal 10: For multiplexing of 1 bit HP HARQ-ACK, 1 bit LP HARQ-ACK and 1 bits HP SR, the following two options can be further considered:***   * ***Option 1: Multiplexing of 1 bit HP HARQ-ACK, 1 bit LP HARQ-ACK and 1 bit HP SR to a PUCCH resource with PF 2/3/4 for HP HARQ-ACK;*** * ***Option 2: Multiplexing of 1 bit HP HARQ-ACK, 1 bit LP HARQ-ACK and 1 bit HP SR to a PUCCH resource with PF 0/1 for HP HARQ-ACK.*** |
| QC | ***Proposal 11*: In NR Rel-17, if a HARQ-ACK (with single priority) transmission on PUCCH format 0 or PUCCH format 1 collide with one SR, the UE performs the actions in Table 1 to resolve the collision.**   * **FFS: collision resolution for 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK overlapping with 1-bit HP or LP SR**   Table 1. Collision resolution for overlapping HARQ-ACK and SR in NR Rel-17   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | Ack: PF0, LP | Ack: PF1, LP | Ack: PF0, HP | Ack: PF1, HP | | SR: PF 0, LP | Same as Rel-15 (i.e., multiplex on HARQ-ACK resource). | Same as Rel-15 (i.e., drop SR) | Multiplex the HARQ-ACK and SR on the HARQ-ACK resource (as in Rel-15), with a power boost to the multiplexed transmission. | Same as Rel-15 (drop SR). | | SR: PF1, LP | Same as rel-15 (i.e., multiplex on HARQ-ACK resource) | Same as Rel-15 (RB selection) | Multiplex the HARQ-ACK and SR on the HARQ-ACK resource (as in Rel-15), with a power boost to the multiplexed transmission. | RB selection (as in Rel-15) but with the enhancement that, if SR is positive, the power of the PUCCH transmission follows the power of the HARQ-ACK resource. | | SR: PF0, HP | Use the SR resource to transmit multiplexed SR and HARQ-ACK, with a power boost to the multiplexed transmission. | Perform RB selection (i.e., if SR is negative, then transmit HARQ-ACK on the HARQ-ACK resource. Otherwise, transmit HARQ-ACK on the SR resource.) | Same as Rel-15 | Same as Rel-15 | | SR: PF1, HP | Perform RB selection (i.e., if SR is negative, then transmit HARQ-ACK on the HARQ-ACK resource. If SR is positive, transmit HARQ-ACK on the SR resource.) | Same as Rel-15 (i.e., RB selection). | Same as Rel-15 | Same as Rel-15 |   ***Proposal 12*: In NR Rel-17, for the case of multiplexing 1 bit SR and up to 2 bits HARQ-ACK with different priorities in a PUCCH format 0, adopt the multiplexed payload to CS indices mapping as shown in Fig 9 and Fig 10.**  ***Proposal 13*: In NR Rel-17, if a HARQ-ACK transmission on PUCCH format 2/3/4 collide with K SR transmissions including HP SRs and LP SRs, the UE append bits to the HARQ-ACK payload. Furthermore, if any of the HP SR is positive, thebits shall indicate a positive HP SR.** |
| Samsung | **Proposal 7: Drop LP HARQ-ACK PUCCH when a LP HARQ-ACK PUCCH with PF0/1 overlaps with a HP SR PUCCH.**  **Proposal 8: Support multiplexing of LP HARQ-ACK and HP SR when HARQ-ACK is transmitted in a PUCCH using format 2/3/4**   * **Use Rel-15 mechanism as a baseline assuming HARQ-ACK and SR have same priority.** * **FFS: how to ensure latency and reliability of HP SR.** |
| LGE | **Proposal #11: Consider to support an unified handling for the multiplexing of HP SR PF0/1 + LP HARQ-ACK PF0/1 as the following way.**   * **For positive SR, transmit HARQ-ACK on the SR PUCCH resource.** * **For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.** |
| IDC | ***Proposal 12: In case PUCCH format 0 carrying HP SR overlaps with PUCCH format 0/1 carrying LP HARQ-ACK, the UE multiplexes HARQ-ACK and SR on the PUCCH resource for HP SR.***  ***Proposal 13: In case PUCCH format 1 carrying positive HP SR overlaps with PUCCH format 0/1 carrying LP HARQ-ACK, the UE transmits HARQ-ACK on the PUCCH resource for HP SR.***  ***Proposal 14: In case PUCCH format 1 carrying negative HP SR overlaps with PUCCH format 0/1 carrying LP HARQ-ACK, the UE transmits HARQ-ACK on the PUCCH resource for LP HARQ-ACK.*** |
| Quectel | **Proposal 18**: When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, Opt.1b (i.e., The positive SR and HARQ-ACK are multiplexed and transmitted on the SR resource, and the UE transmits only HARQ-ACK on the HARQ-ACK resource for negative SR) is supported.  **Proposal 19**: When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, Opt.4 (i.e., for positive SR, transmit SR on the SR resource and drop HARQ-ACK. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource) is supported.  **Proposal 20**: When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, Opt 3 (i.e., for positive SR, transmit HARQ-ACK on the SR resource. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource) is supported. |
| Intel | **Proposal 13:**  **HP SR PF0, LP HARQ PF0**:   * **If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.**   **HP SR PF0, LP HARQ PF1:**   * **For positive SR, transmit SR on the SR resource and drop HARQ-ACK. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource**   **HP SR PF1, LP HARQ PF0:**   * **If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.** |
| vivo | ***Proposal 1: Support multiplexing a high-priority HARQ-ACK and a low-priority SR into a PUCCH in Rel-17.***  ***Proposal 4: When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, option 2c is adopted, i.e.,***   * ***If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.***   ***Proposal 5: When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, option 4 is adopted, i.e.,***   * ***For positive SR, transmit SR on the SR resource and drop HARQ-ACK. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.***   ***Proposal 6: When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, option 2c is adopted, i.e.,***   * ***If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.***   ***Proposal 7: For the overlapping of different priorities between SR and HARQ-ACK with PUCCH format 2/3/4, Rel-15 mechanism can be reused.*** |
| OPPO | ***Proposal 14: Rel-15 or Rel-16 mechanism should be reused to support multiplexing of LP HARQ-ACK with PF 0/1 and HP SR with PF 0/1.***  ***Proposal 15: When PF0 is used by both HP SR and LPHARQ-ACK , whether to use Rel-15 multiplexing or Rel-16 prioritization can be determined according to the number of PUCCH symbols. The details are summarized in the table 2.***  Table 2: Multiplexing of LP HARQ-ACK and HP SR   |  |  |  |  | | --- | --- | --- | --- | |  | | LP HARQ-ACK | | | PF 0 | PF 1 | | HP SR  (positive) | PF 0 | If , Rel-15 multiplexing;  Otherwise, Rel-16 prioritization. | Rel-16 prioritization | | PF 1 | Rel-16 prioritization | Rel-15 multiplexing | |
| DOCOMO | **Proposal 6:**   * *Agree the table for UE behavior on multiplexing eMBB HARQ-ACK and URLLC SR as a baseline. Further considerations are needed for down-selection.*  |  |  |  | | --- | --- | --- | |  | **URLLC SR PF0** | **URLLC SR PF1** | | **eMBB HARQ-ACK PF0** | * Opt.1b: For positive SR, same as Rel-15/16 multiplexing for same priority to multiplex eMBB HARQ-ACK bit(s) and URLLC SR bit, but transmitted on URLLC SR PF0 resource. For negative SR, the UE transmits only HARQ-ACK on the HARQ-ACK resource. | * Opt 3: eMBB HARQ-ACK transmitted on URLLC PF1 resource if URLLC SR positive, while eMBB HARQ-ACK transmitted on eMBB PF0 resource if URLLC SR negative. | | **eMBB HARQ-ACK PF1** | * Opt.1b/Opt.3: eMBB HARQ-ACK transmitted on URLLC PF0 resource if URLLC SR positive, while eMBB HARQ-ACK transmitted on eMBB PF1 resource if URLLC SR negative. | * Same as Rel-15/16 multiplexing for same priority, i.e transmit eMBB HARQ-ACK on HARQ-ACK resource if SR negative, transmit eMBB HARQ-ACK on SR resource if SR positive. | | **eMBB HARQ-ACK PF2/3/4** | * Opt 1: If latency and reliability condition satisfied for eMBB HARQ-ACK resource, URLLC SR is appended after eMBB HARQ-ACK and transmitted on eMBB HARQ-ACK resource. Otherwise, eMBB HARQ-ACK is dropped and URLLC SR is transmitted. * Opt 2: eMBB HARQ-ACK is dropped and URLLC SR is transmitted. | |   **Proposal 7:**   * *For collision handling among LP HARQ-ACK, HP HARQ-ACK, and HP SR, following UE behaviour is proposed:*   + *Step 1: multiplexing of HP HARQ-ACK and HP SR by following Rel-16 procedure.*   + *Step 2: multiplexing of the outcome of step 1 and LP HARQ-ACK by following Case 1.* |
| Pana | **Proposal 5: When a PUCCH carrying HP SR with PUCCH format 0 overlaps with a PUCCH carrying LP HARQ-ACK with PUCCH format 0, the SR and HARQ-ACK are multiplexed and transmitted on the HARQ-ACK resource.**  **Proposal 6:**   * **When a PUCCH carrying HP SR with PUCCH format 0 overlaps with a PUCCH carrying LP HARQ-ACK with PUCCH format 1, either of following options is supported.**   + **Option 4: For positive SR, transmit SR on the SR resource and drop HARQ-ACK. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.**   + **Option 5: No enhancement over Rel.16**   **Proposal 7: When a PUCCH carrying HP SR with PUCCH format 1 overlaps with a PUCCH carrying LP HARQ-ACK with PUCCH format 0, no enhancement is necessary over Rel.16.**  **Proposal 8:**   * **When a PUCCH carrying HP SR with PUCCH format 1 overlaps with a PUCCH carrying LP HARQ-ACK with PUCCH format 1, either of following options is supported.**   + **Option 1: Same multiplexing mechanism as in Rel.15/16.**   + **Option 2: The SR and HARQ-ACK are multiplexed and transmitted on the SR resource.**     - **1-bit for LP HARQ-ACK information bit is appended to SR information bit. For 2-bits HARQ-ACK information, bundling is used.**   **Proposal 9:**   * **When a PUCCH carrying HP SR with PUCCH format 0 or 1 overlaps with a PUCCH carrying LP HARQ-ACK with PUCCH format 2, 3, or 4, following options are supported.**   + **The SR and HARQ-ACK are multiplexed and transmitted on the HARQ-ACK resource if the latency condition is satisfied; otherwise, LP HARQ-ACK is dropped, and HP SR is transmitted.** |
| Sony | **Proposal 6: When HP SR using PF0 multiplexes with LP HARQ-ACK using PF0:**   * **If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15.** * **If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.**   **Proposal 7: When HP SR using PF0 multiplexes with LP HARQ-ACK using PF1:**   * **The positive SR and HARQ-ACK are multiplexed and transmitted on the SR resource** * **For negative SR, the UE transmits only HARQ-ACK on the HARQ-ACK resource.**   **Proposal 8: When HP SR using PF1 multiplexes with LP HARQ-ACK using PF0:**   * **If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15.** * **If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.** |
| Spreadtrum | 1. ***If a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, if SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.*** 2. ***When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, for positive SR, LP HARQ-ACK can be dropped. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.*** 3. ***If a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, if SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.*** |
| Xiaomi | ***Proposal 6: Solutions such as direct puncture or treating HP SR as HARQ-ACK/CSI bit in multiplexing can be considered for HP SR on LP PUSCH.*** |
| Sharp | **Proposal 5: When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0 or PF1,**   * **Transmit LP HARQ-ACK on the HP SR resource for positive HP SR, and** * **Transmit LP HARQ-ACK on the LP HARQ-ACK resource for negative HP SR.**   **Proposal 6: When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0,**   * **Multiplex positive HP SR on LP HARQ-ACK PUCCH by a different CS is preferred.** * **Alternatively, multiplex positive HP SR and LP HARQ-ACK on a HP SR PUCCH can be considered if a HP SR PUCCH PF0 resource is configured with multiple reserved CS values.**   **Proposal 7: When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, the Rel-16 dropping behaviour may be applied.**   * **Alternatively, multiplex positive HP SR and LP HARQ-ACK on a HP SR PUCCH can be considered if a HP SR PUCCH PF0 resource is configured with multiple reserved CS values.**   **Proposal 8: For multiplexing of HP SR with LP HARQ-ACK with PUCCH format 2/3/4,**   * **HP SR bits can be generated based on the number of overlapping HP SR PUCCH resources.** * **FFS on the ordering of HP SR and LP HARQ-ACK** * **FFS on whether LP SR bits should be included.**   **Proposal 9: For multiplexing of HP HARQ-ACK, LP HARQ-ACK and SR, a HP PUCCH resource with more than 2 bits of payload is used.**   * **FFS on the SR bit generation methods, and order of multiplexing between HARQ-ACK codebooks and the SR.** |
|  | * ***Proposal 6:*** *We propose to support Option 2b for multiplexing with HP-SR with PF0 and LP HARQ-ACK with PF1.*   + *To multiplex HP-SR with PF0 and LP HARQ-ACK with PF1, use the HARQ-ACK resource.*      - *Applying QPSK for SR+1-bit HARQ-ACK. For the case of 2-bit HARQ-ACK, the HARQ-ACK is reduced/compressed to 1-bit.* * ***Proposal 7:*** *To multiplex HP-SR with PF1 and LP HARQ-ACK with PF0, reuse multiplexing rule for HP-SR with PF0 and LP HARQ-ACK with PF0.* |
|  |  |

## 1st round discussion

Proposal for 1st round discussion:

When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1,

* For positive SR, transmit HARQ-ACK on the SR PUCCH resource.
* For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | I think we can agree on this for the case where SR & HARQ-ACK uses different PUCCH Format, i.e.:   * HP SR in PF0 + LP HARQ-ACK in PF1 * HP SR in PF1 + LP HARQ-ACK in PF0 |
| Lenovo/Motorola Mobility | For negative SR, agree with the proposal “transmit HARQ-ACK on the HARQ-ACK PUCCH resource”.  For positive SR, UE should determine a HARQ-ACK PUCCH resource from the second *PUCCH-Config* and multiplex HP SR and LP HARQ-ACK on the determined PUCCH resource according to Rel-15 rules for multiplexing SR and HARQ-ACK.  A PUCCH resource for multiplexing UCI of mixed priorities including HARQ-ACK is selected from a PUCCH resource set configured by the second *PUCCH-Config*, based on:   * a last DCI format indicating a higher priority index, or * a last DCI format if no DCI format indicating a higher priority index is detected, or   a PUCCH resource configured for UCI of mixed priorities for a given UCI size range, when there is no corresponding DCI format. |
| Intel | We don’t support to always transmit HARQ-ACK on SR PUCCH resource.  To avoid much additional complexity, it is desirable to reuse Rel-15 mechanism as much as possible, except the new behavior for SR PF 0+ LP HARQ-ACK PF1 case, wherein HP SR should be transmitted.  Another concern for always using SR resource is, the flexibility of PUCCH resource is materially degraded in case of HARQ-ACK+SR, because SR PUCCH resource is semi-statically configured, then, multiple CS for HARQ-ACK+SR is semi-statically configured. |
| QC | A high level question to FL to clarify: are we considering just design a unified solution to SR and HARQ-ACK multiplexing with different combination of PFs? In our view, there are two high level alternatives we can consider to solve this issue. Alternative 1 is developing a unified solution regardless of the PF for SR and HARQ-ACK. Alternative 2 is developing customized/specific solution for different combination of PFs, i.e., developing solution case by case. Is FL suggesting to take alternative 1 to develop a unified solution regardless of the PF of SR and HARQ-ACK? We are fine with taking this alternative. But we like to understand if that is FL’s intention. |
| Ericsson | Fine with the proposal.  Also: our understanding of the proposal is, it applies regardless of the combination of PF. |
| DOCOMO | Support the proposal. In our understanding, the proposal includes the following PF cases; HP SR of PF0 + LP HARQ-ACK of PF0, HP SR of PF0 + LP HARQ-ACK of PF1, HP SR of PF1 + LP HARQ-ACK of PF0, and HP SR of PF1 + LP HARQ-ACK of PF1. |
| MediaTek | We prefer to reuse R15 procedure as much as possible. |
| Panasonic | We have same clarification as Qualcomm. |
| LG | Fine with the proposal, and same understanding with Ericsson. |
| vivo | we share the same view with Intel. |
| Nokia/NSB | We have similar clarification questions as QC. So we would like the FL to first clarify to which PF combinations the proposal would be applicable, before we decide on the support or not of the proposal. |
| ITRI | Fine with the proposal. |
| TCL | We support the proposal. |
| ZTE | Support. I assume that for positive SR case, the first sub-bullet means the SR and HARQ-ACK will multiplex on the SR PUCCH resource. |
| Sharp | We support the proposal in principle.  For positive HP SR with PF1 and LP HARQ-ACK with PF0/1, the HP SR PUCCH with PF1 should be used since it can carry up to 2 bits of HARQ-ACK without comprise on the performance.  For positive HP SR with PF0 and LP HARQ-ACK with PF0/1, the HP SR PUCCH with PF0 can be used to carry LP HARQ-ACK with different cyclic shift values if multiple CSs are reserved for the SR PF0 PUCCH resource.  (Note this will reduce the SR PUCCH multiplexing capability in the RB. RAN1 should clarify the impact.) |
| Samsung | NOT support.  The overall benefit from supporting multiplexing for this case is marginal – there is only specification/implementation cost.  A unified solution is preferred for resolving overlapping HP SR and LP HARQ-ACK and the proposal doesn’t work for LP HARQ-ACK with more than 2 bits. Even if the proposal is agreed, the issue is not addressed.  We do not support dependence of the PUCCH format on whether or not there is multiplexing of SR and HARQ-ACK – same as in Rel-15/16. We propose to drop LP HARQ-ACK.  **Proposal: Reuse Rel-16 to resolve overlapping HP SR and LP HARQ-ACK.** |
| Quectel | We support the second bullet. For the first bullet, we think case-by-case discussions may be needed. We don’t support this solution for HP SR PF 0+ LP HARQ-ACK PF1 case. |
| OPPO | Support |
| InterDigital | Ok with the proposal |
| Xiaomi | We are OK with the proposal. |
| CATT | We support the proposal. |
| NEC | We are fine with the proposal. |
| FGI/APT | Support. |
|  |  |

## Other enhancements

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| E/// | 1. In case of overlapping between PUCCH and/or PUSCH resources in a slot with different priorities, methods based on partial puncturing with or without resuming and HARQ-ACK bundling as part of overlapping resolution procedures are not supported. 2. In case of overlapping between PUCCH and/or PUSCH resources in a slot with different priorities, only UCI multiplexing methods on PUCCH or PUSCH resources that are extension of already existing UCI multiplexing methods are supported. |
| LGE | **Proposal #9: Consider how to generate the HARQ-ACK payload per each of LP and HP for the multiplexing of LP/HP HARQ-ACK on PUCCH (or PUSCH), according to HARQ-ACK codebook type (e.g. Type-1/2/3 codebook).**  **Proposal #10: Consider to introduce an additional field in the DL/UL HP DCIs for determining the number of LP HARQ-ACK bits multiplexed on PUCCH/PUSCH for both Type-1 and Type-2 codebooks, in order to handle potential ambiguity on the presence of LP HARQ-ACK feedback or the size of LP HARQ-ACK codebook.** |
| Leno/Moto | * **Proposal 4:** If LP HARQ-ACK not multiplexed due to payload size limitation, UE can further check possible multiplexing in the next sub-slot, unless a PUCCH of low priority index for LP HARQ-ACK is limited up to a current sub-slot. |
|  |  |

# Multiplexing UCIs of different priorities in a PUSCH

## Agreements in previous meetings

Agreements:

*Support multiplexing for following scenarios in R17:*

* *Multiplexing a low-priority HARQ-ACK in a high-priority PUSCH (conveying UL-SCH only).*
* *Multiplexing a high-priority HARQ-ACK in a low-priority PUSCH (conveying UL-SCH only)*
* *Multiplexing a low-priority HARQ-ACK, a high-priority PUSCH conveying UL-SCH, a high-priority HARQ-ACK and/or CSI.*
* *Multiplexing a high-priority HARQ-ACK, a low-priority PUSCH conveying UL-SCH, a low-priority HARQ-ACK and/or CSI.*

*For the above multiplexing scenarios,*

* *Support separate configurations of at least beta-offset values (FFS for alpha) for multiplexing with different priority combinations.*
  + *FFS for other separate configurations.*
  + *FFS: value range of beta-offset (e.g. <1).*
* *FFS the conditions, if needed, for multiplexing, e.g.*
  + *FFS: Whether to support multiplexing in case a PUCCH/PUSCH overlaps with more than one PUCCH/PUSCH.*
  + *Timeline requirements.*
* *FFS: details, if needed, of the multiplexing scheme, e.g.*
  + *How to minimize impact on the latency for high-priority HARQ-ACK.*
  + *How to multiplex the HARQ-ACK bits (e.g. multiplexing, bundling)?*
  + *How to encode the UCIs with different priorities (e.g. separate coding vs. joint coding).*
  + *How to guarantee the target code rate (e.g. payload control, multiplexing priority, LP HARQ-ACK compression/compaction).*
  + *Explicit indication for multiplexing.*
  + *Multiplexing rule and order (e.g. HP/LP multiplexing is after resolving collision within the same priority).*
  + *How to handle multiplexing of UCI of different priorities and CG-UCI in a CG-PUSCH*

Agreements:

*For HARQ-ACK multiplexing on PUSCH of different priority in R17, support a mechanism for gNB to enable/disable the multiplexing.*

* *FFS the type of the mechanism, e.g. DCI indication and/or RRC configuration, beta\_offset=0*
* *FFS: Interaction between the enable/disable mechanism and other multiplexing conditions*
* *FFS for other types of UCI.*

Working assumption:

*Reuse Rel-15 intra-UE PUCCH/PUSCH multiplexing timeline requirements for Rel-17 intra-UE PUCCH/PUSCH multiplexing with different priorities*

* *FFS whether or not to specify a different behavior than Rel-15 when the timeline requirements are not met*

Agreements:

*For multiplexing LP HARQ-ACK in a HP PUSCH, support 0< beta-offset <1.*

* *FFS value(s)*
* *FFS to additionally support beta-offset =0 or a value disabling the multiplexing*
* *Aim to NOT increase the corresponding bitwidth in the DCI (compared to Rel-16)*

Agreement:

*For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, support separate coding for the two HARQ-ACKs.*

* *It is understood that it is intended that the number of encoding chains for all UCI multiplexing combinations in Rel-17 should not exceed that in Rel-15/16.*

Agreement

*In NR Rel-17, [at least] 2 new set of beta offset values can be configured to the UE to indicate separate beta\_offset values for the following cases:*

* *Multiplexing LP HARQ-ACK on HP PUSCH*
* *Multiplexing HP HARQ-ACK on LP PUSCH*

## Details of separate coding, rate matching and RE mapping

## Inputs from Tdocs

**Encoder and CSI dropping:**

* If HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI,
  + Reuses R15 TS 38.212 Clause 5.3.1 and Clause 5.3.3 for LP HARQ-ACK.
    - HW, ZTE, Apple, OPPO, DCM, Pana, Spreadtrum
* If HP HARQ-ACK, LP HARQ-ACK, and LP CSI would be transmitted on LP PUSCH,
  + Option 1: Both CSI part 1 and part 2 are dropped, the LP HARQ-ACK can be multiplexed by reusing the encoder chain, rate matching and RE mapping for Rel-15 CSI part 1.
    - Nokia, vivo
* Option 2: The CSI part 2 is dropped. LP HARQ-ACK and CSI part 1 can be multiplexed by reusing the encoder chain, rate matching and RE mapping for Rel-15 CSI part 1 and part 2 respectively.
  + Option 2a: LP HARQ-ACK has lower priority than LP CSI part 1, and LP HARQ-ACK may be dropped (similar to Rel-15 CSI-part2);
  + Option 2b: LP HARQ-ACK has higher priority than LP CSI part 1, and LP CSI part 1 may be dropped (similar to Rel-15 CSI-part1);
    - HW, ZTE, CATT, QC, Samsung, Quectel, Intel, vivo, OPPO, Pana, Spreadtrum
* Option 3: The CSI part 1 is dropped. CSI part 2 is similarly treated as CSI part 1 in Option 2.
* Option 4: No CSI is dropped. LP HARQ-ACK and LP CSI part 1 are jointly encoded and reuse the coding method used for CSI part 1 in Rel-15. CSI part 2 reuses the coding method used for CSI part 2 in Rel-15.
  + - vivo, DCM, Apple
* If HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI would be transmitted on HP PUSCH,
  + LP HARQ-ACK is dropped. CSI part 1 and CSI part 2 can be multiplexed by reusing the encoder chain, rate matching and RE mapping for Rel-15 CSI part 1 and part 2 respectively.
    - HW, Nokia, CATT (if HP CSI includes two parts), QC, Quectel (if HP CSI includes two parts), Intel, Spreadtrum
  + The CSI part 2 is dropped. LP HARQ-ACK and CSI part 1 can be multiplexed by reusing the encoder chain, rate matching and RE mapping for Rel-15 CSI part 1 and part 2 respectively.
    - ZTE, Quectel
  + LP HARQ-ACK is jointly encoded with CSI part 1 or CSI part 2.
    - Apple, vivo, DCM, Pana

**Rate matching and RE mapping:**

* Reuse Rel-15 rate matching and RE mapping as the baseline.
  + HW, Nokia, Apple
* HP HARQ-ACK is rate match around by other UCIs (if exist) and UL-SCH (if exist).

LP HARQ-ACK is padded to 2 bits if it is 0 or 1 bit. The padded LP HARQ-ACK is rate matched around by other UCIs (if exist) and UL-SCH (if exist).

* + QC
* Different RE mapping rules considering whether the multiplexed CSI consists of two parts or single part and whether the PUSCH for multiplexing of the UCIs is conveying UL-SCH or not.
  + LGE
* Coded LP HARQ-ACK bit(s) (if exist) is(are) concatenated to coded HP HARQ-ACK bits as an input to the HARQ-ACK multiplexer in PUSCH. LP HARQ-ACK is multiplexed on a number of last symbols occupied by the HP PUSCH.
  + Quectel

**Power control:**

* For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, reuse the same power control formula as in Rel-15.
  + QC

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 15: If HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI, the LP HARQ-ACK can be multiplexed by reusing the encoding chain for legacy CSI part 1 or CSI part 2.***  ***Proposal 16: If HP HARQ-ACK, LP HARQ-ACK, and CSI would be transmitted on LP PUSCH, or, if HP HARQ-ACK, LP HARQ-ACK, and semi-static CSI would be transmitted on HP PUSCH, the CSI part 2 should be dropped if any, and following two candidates can be further studied:***   * ***Candidate 1: HP HARQ-ACK reuses the encoding chain for legacy HARQ-ACK, and LP HARQ-ACK reuses the encoding chain for legacy CSI part 2.*** * ***Candidate 2: HP HARQ-ACK reuses the encoding chain for legacy HARQ-ACK, LP HARQ-ACK reuses the encoding chain for legacy CSI part 1, and CSI part 1 reuses the encoding chain for legacy CSI part 2.***   ***Proposal 17: If HP HARQ-ACK, LP HARQ-ACK, and A-CSI including two parts would be transmitted on HP PUSCH, the LP HARQ-ACK should be dropped.***  ***Proposal 18: For collision of HP HARQ-ACK and LP HARQ-ACK with PUSCH, if the LP HARQ-ACK is to be multiplexed on PUSCH, it should be rate matched with the UL-SCH and/or CSI regardless of the LP HARQ-ACK payload.*** |
| ZTE | ***Proposal 13:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, the coding scheme, rate matching and RE mapping of HP HARQ-ACK reuse the mechanism of HARQ-ACK multiplexed in PUSCH in Rel-15.*  ***Proposal 14:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI, the coding scheme, rate matching and RE mapping of LP HARQ-ACK reuse the mechanism of CSI-part 1 in Rel-15.*  ***Proposal 16:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,*   * *The LP CSI part 2 is dropped firstly.* * *LP HARQ-ACK is coded separately from HP HARQ-ACK and CSI part 1.* * *The coding scheme, rate matching and RE mapping of LP HARQ-ACK and LP CSI part 1 will respectively follow the rules of Rel-15 CSI-part 1 and Rel-15 CSI-part 2.* * *If the leftover resources for LP HARQ-ACK and LP CSI part 1 is not sufficient, LP HARQ-ACK has higher priority than LP CSI part 1, and LP CSI part 1 may be partially dropped or compressed.*   ***Proposal 17:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and HP CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH,*   * *Dropping HP A-CSI part 2.* * *The coding scheme, rate matching and RE mapping of LP HARQ-ACK and HP CSI part 1 will respectively follow the rules of Rel-15 CSI-part 1 and Rel-15 CSI-part 2.* * *If the leftover resources for LP HARQ-ACK and HP CSI part 1 is not sufficient, LP HARQ-ACK has lower priority than HP CSI part 1, and LP HARQ-ACK may be partially dropped or compressed.*   ***Proposal 18:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH, LP CSI is dropped and multiplexing with HP PUSCH is not allowed.*  ***Proposal 19:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and HP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,* *HP CSI is allowed to multiplex with LP PUSCH. The multiplexing principle follows the way which HP HARQ-ACK, LP HARQ-ACK, and HP CSI consisting of two parts are transmitted on HP PUSCH conveying UL-SCH.*  ***Proposal 20:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and HP/LP CSI consisting of two parts would be transmitted on HP/LP PUSCH not conveying UL-SCH, UE follows the same behaviour as that in case of PUSCH conveying UL-SCH.* |
| Nokia | **Proposal 3.21: For the scenario of the multiplexing between HARQ-ACK and PUSCH with different priorities, RAN1 should not support joint coding of different UCI types, for example low-priority HARQ-ACK and CSI.**  **Proposal 3.22: For the scenario where high-priority HARQ-ACK bits, low-priority HARQ-ACK bits and CSI would be multiplexed into a low-priority PUSCH, drop CSI (including part 1 and part 2, if exist).**  ***Observation 3.3: For the scenario where multiplexing both high-priority HARQ-ACK bits and low-priority HARQ-ACK bits into a high-priority PUSCH without CSI, the number of encoding chains is sufficient.***  **Proposal 3.23: For the scenario where both high-priority HARQ-ACK bits and low-priority HARQ-ACK bits would be multiplexed into a high-priority PUSCH carrying CSI, drop low-priority HARQ-ACK.**  **Proposal 3.24: For the scenarios where both high-priority HARQ-ACK bits and low-priority HARQ-ACK bits are multiplexed into a PUSCH, reuse Rel-15 rate matching and RE mapping as the baseline.** |
| CATT | ***Proposal 16: For multiplexing HP HARQ-ACK, LP HARQ-ACK and HP A/SP-CSI on PUSCH, LP HARQ-ACK can be dropped in case the HP A/SP-CSI includes two parts.***  ***Proposal 17: For multiplexing HP HARQ-ACK, LP HARQ-ACK and LP CSI on PUSCH, it is proposed to drop CSI part 2 if exists.***  ***Proposal 18: For separate coding of HP HARQ-ACK and LP HARQ-ACK when multiplexing on PUSCH,***   * ***both HP HARQ-ACK and LP HARQ-ACK reuse the rate matching equation, and RE mapping rules in Rel-15 for HARQ-ACK on PUSCH with same priority;*** * ***LP HARQ-ACK mapped on PUSCH after the reserved RE resources for HP HARQ-ACK in case 0~2 bits HP HARQ-ACK and after the actual RE resources for HP HARQ-ACK in case >2 bits HP HARQ-ACK.*** |
| QC | ***Proposal 14*: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if CSI would multiplex on the same PUSCH,**   * **Drop CSI part 2, if CSI is a low priority CSI.**    + **HP A/N reuse encoder and rate matching equation for Rel-15 A/N**   + **LP A/N reuse encoder and rate matching equation for Rel-15 CSI part 1**   + **LP CSI part 1 reuse encoder and rate matching equation for Rel-15 CSI part 2** * **Drop LP HARQ-ACK, if CSI is a high priority CSI.**    + **HP A/N reuse encoder and rate matching equation for Rel-15 A/N**   + **HP CSI part 1 reuse encoder and rate matching equation for Rel-15 CSI part 1**   + **HP CSI part 2 reuse encoder and rate matching equation for Rel-15 CSI part 2** * **FFS: RE mapping rules.**   ***Proposal 16*: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, the following RE mapping rules are supported.**   * **HP HARQ-ACK is rate match around by other UCIs (if exist) and UL-SCH (if exist)** * **LP HARQ-ACK is padded to 2 bits if it is 0 or 1 bit. The padded LP HARQ-ACK is rate matched around by other UCIs (if exist) and UL-SCH (if exist)**   ***Proposal 17*: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, reuse the same power control formula as in Rel-15.** |
| Samsung | **Proposal 21: For multiplexing LP/HP HARQ-ACK and CSI in a PUSCH, LP HARQ-ACK is treated as CSI part 1, CSI part 1 is treated as CSI part 2, and CSI part 2 is dropped.** |
| LGE | **Proposal #12: Consider at least the following aspects for determining UCI RE mapping rule (order) on PUSCH, according to various combinations of UCI and PUSCH.**   * **Whether the CSI to be multiplexed on PUSCH consists of two parts or single part.**   + **UCI RE mapping rule (order) could be different according to the above.** * **Whether the PUSCH for multiplexing of the UCIs is conveying UL-SCH or not.**   + **UCI RE mapping rule (order) could be different according to the above.**   **Proposal #13: Consider to decide the following two cases first for determining the UCI RE mapping rule (order) on PUSCH.**   * **Case 1: Overlapping of {HP HARQ-ACK, LP HARQ-ACK, HP CSI part 1, HP CSI part 2} and HP PUSCH with UL SCH**   + **{HP HARQ-ACK, LP HARQ-ACK, HP CSI part 1} are multiplexed on the HP PUSCH, by dropping HP CSI part 2.** * **Case 2: Overlapping of {HP HARQ-ACK, LP HARQ-ACK, LP CSI part 1, LP CSI part 2} and LP PUSCH with UL SCH**   + **{HP HARQ-ACK, LP HARQ-ACK, LP CSI part 1} are multiplexed on the HP PUSCH, by dropping LP CSI part 2.** |
| Quectel | **Proposal 4**: Rate matching equation in Rel-15 for PF3/4 A/N+CSI-1 and rate matching equation in Rel-15 for PF3/4 CSI-2 are reused respectively for PF2 HP A/N and PF2 LP A/N.  **Proposal 11**: LP CSI part 2 (if exists) is dropped when HP HARQ-ACK and LP HARQ-ACK are multiplexed in a LP PUSCH.  **Proposal 12**: Multiplexing of LP HARQ-ACK in a HP PUSCH is not supported when HP A/N and HP CSI part 2 simultaneously exist in the HP PUSCH.  **Proposal 14**: Coded LP HARQ-ACK bit(s) (if exist) is(are) concatenated to coded HP HARQ-ACK bits as an input to the HARQ-ACK in PUSCH multiplexer.  **Proposal 15**: LP HARQ-ACK is multiplexed on a number of last symbols occupied by the HP PUSCH.  **Proposal 16**: for Type-1 HARQ-ACK codebook or for Type-2 HARQ-ACK codebook disables multiplexing of HARQ-ACK in PUSCH with different priorities.  **Proposal 17**: When multiplexing of a HP HARQ-ACK associated to a later DCI and a LP PUSCH scheduled by an earlier DCI is enabled, two possible solutions (or a hybrid of the two solutions) could be considered:   * The HP HARQ-ACK is punctured in the LP PUSCH; * The multiplexing is expected to be applied only when certain timeline criterion are met. |
| Intel | **Proposal 14: For multiplexing a HP HARQ-ACK and LP HARQ-ACK onto a PUSCH**   * **If there is no A-CSI, reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK, and Rel-15 CSI part 1 for LP HARQ-ACK.** * **If there is A-CSI on LP PUSCH, reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK, Rel-15 CSI part 1 for LP HARQ-ACK, Rel-15 CSI part 2 for LP CSI part 1, and drop LP CSI part 2, if any.** * **If there is A-CSI on HP PUSCH, reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK, Rel-15 CSI part 1 for HP CSI part 1, Rel-15 CSI part 2 for HP CSI part 2 or LP HARQ-ACK (if no HP CSI part2).** |
| Apple | **Proposal 11-1: Between two options of mapping LP HARQ-ACK into UCI Part I and UCI Part II, RAN1 select one of them consistently across multiplexing scenarios.**  **Proposal 11-2: Adopt Alt. 1 or Alt. 2 design from Tables 11-1 and 11-2.**  **Observation 11-1: multiplexing of CSI part I and HARQ-ACK is supported over PUCCH and there is no fundamental difference in terms of implementation complexity between PUCCH and PUSCH.**  **Observation 11-2: If CSI part II is dropped in total by design when accommodating HP/LP HARQ-ACK multiplexing, then the CSI feedback is useless.**  Proposal 11-4: LP HARQ-ACK can be multiplexed to either CSI part 1 or CSI part 2, CSI part 2 is NOT dropped by design due to the presence of LP HARQ-ACK on PUSCH. |
| vivo | ***Proposal 11: When HP and LP HARQ-ACK are multiplexed on a PUSCH without CSI, LP HARQ-ACK is handled as the same manner as CSI part 1. For HP HARQ-ACK, Rel-15 mechanism is reused.***  ***Proposal 12: When HP and LP HARQ-ACK are multiplexed on a LP PUSCH with LP CSI, the following alternatives can be investigated:***   * + ***Alt 1: drop LP CSI part 2, LP HARQ-ACK is handled as the same manner as CSI part 2.***   + ***Alt 2: LP HARQ-ACK and LP CSI part 1 are encoded jointly and the same manner with CSI part 1 is reused for LP HARQ-ACK and LP CSI part 1.***   + ***Alt 3: drop LP CSI, LP HARQ-ACK is handled as the same manner as CSI part 1.***   ***Proposal 13: When HP and LP HARQ-ACK are multiplexed on a HP PUSCH with HP CSI, LP HARQ-ACK is jointly encoded with CSI part 1 or CSI part 2.*** |
| OPPO | ***Proposal 17: To support multiplexing UCI in one PUSCH with different priority, reuse the encoder, rate matching equation, and RE mapping rules in Rel-15:***   * + ***Treat HP HARQ-ACK as Rel-15 HARQ-ACK;***   + ***Treat LP HARQ-ACK as Rel-15 CSI-Part1;***   + ***Treat CSI-Part1 as Rel-15 CSI-Part 2;***   + ***CSI-Part 2 is dropped.*** |
| DCM | **Proposal 8:**   * *If HP HARQ-ACK and LP HARQ-ACK with/without CSI would be transmitted on HP or LP PUSCH, reuse the Rel-15 coding scheme, rate matching, and RE mapping of HARQ-ACK for HP HARQ-ACK.* * *If HP HARQ-ACK and LP HARQ-ACK without CSI would be transmitted on HP or LP PUSCH, reuse the Rel-15 coding scheme, rate matching, and RE mapping of CSI part 1 for LP HARQ-ACK.* * *If HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP PUSCH with HP CSI, HP CSI is jointly encoded with LP HARQ-ACK and reuse the Rel-15 coding scheme, rate matching, and RE mapping of CSI part 1.* * *If HP HARQ-ACK and LP HARQ-ACK would be transmitted on LP PUSCH with LP CSI, LP CSI is jointly encoded with LP HARQ-ACK and reuse the Rel-15 coding scheme, rate matching, and RE mapping of CSI part 1.* |
| Pana | **Proposal 11: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUSCH in Rel.17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI**   * **HP HARQ-ACK and LP HARQ-ACK are separately encoded according to Rel.15 TS38.212 Clause 5.3.1 and Clause 5.3.3.** * **Reuse Rel.15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle.** * **Reuse Rel.15 Part 1 CSI rate matching and RE mapping for LP HARQ-ACK in principle.**   **Proposal 12: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUSCH in Rel.17, if HP HARQ-ACK and LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH**   * **CSI part 2 is dropped.** * **Reuse Rel.15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle.** * **Reuse Rel.15 Part 1 CSI rate matching and RE mapping for LP HARQ-ACK in principle.** * **Reuse Rel.15 Part 2 CSI rate matching and RE mapping for LP CSI Part 1 in principle.**   **Proposal 13: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUSCH in Rel.17, if HP HARQ-ACK and LP HARQ-ACK, and HP A-CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH**   * **Reuse Rel.15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle.** * **Reuse Rel.15 Part 1 CSI rate matching and RE mapping for HP CSI Part 1 in principle.** * **Reuse Rel.15 Part 2 CSI rate matching and RE mapping for HP CSI Part 2 + LP HARQ-ACK in principle.**   **Proposal 14: Multiplexing a HP SR in a LP PUSCH (conveying UL-SCH only) should be supported by the identical design with multiplexing a HP HARQ-ACK in a LP PUSCH (conveying UL-SCH only).** |
| Spreadtrum | 1. ***Support the following proposal from last meeting:***   *Proposal after 2nd round discussion:*  *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI,*   * *HP HARQ-ACK and LP HARQ-ACK are separately encoded according to R15 TS 38.212 Clause 5.3.1 and Clause 5.3.3.* * *Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details.* * *Reuse R15 Part 1 CSI rate matching and RE mapping for LP HARQ-ACK in principle. FFS details.*  1. ***Support the updates of following proposal from last meeting:***   *Proposal after 2nd round discussion:*  *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a LP PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,*   * *The CSI part 2 is dropped.* * *Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details.* * *Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK in principle. FFS details.* * *Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part 1 in principle. FFS details.* * *~~FFS for the case where LP CSI consisting of two parts is transmitted on HP PUSCH conveying UL-SCH.~~* * *~~FFS for LP CSI consisting of single part.~~* * *~~FFS for LP PUSCH not conveying UL-SCH.~~*  1. ***Do not support HP HARQ-ACK multiplexing into a LP PUSCH without UL-SCH, LP PUSCH is dropped.*** 2. ***Support the updates of following proposal from last meeting:***   *Proposal after 2nd round discussion:*  *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK and HP A-CSI consisting of two parts would be transmitted on HP PUSCH ( with or without UL-SCH),*   * *LP HARQ-ACK is dropped.* * *Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details.* * *Reuse R15 CSI part 1 rate matching and RE mapping for HP CSI part 1 in principle. FFS details.* * *Reuse R15 CSI part 2 rate matching and RE mapping for HP CSI part 2 in principle. FFS details.* * *~~FFS for HP A-CSI consisting of single part.~~* * *~~FFS for HP PUSCH not conveying UL-SCH.~~* |
| Leno/Moto | * **Proposal 5:** If a PUCCH resource to multiplex HP UCI and LP UCI overlaps in time with one or multiple PUSCHs including at least one HP PUSCH, a PUSCH to multiplex the HP UCI and the LP UCI is selected from the at least one HP PUSCH. * **Proposal 6:** If a PUCCH resource to multiplex HP UCI and LP UCI overlaps in time with one or multiple PUSCHs without at least one HP PUSCH, a PUSCH to multiplex the HP UCI and the LP UCI is selected according to Rel-15 PUSCH selection rules. * **Proposal 7:** UE does not multiplex SR of a given physical layer priority into a PUSCH of the given physical layer priority but may multiplex SR of a physical layer priority different than the given physical layer priority into the PUSCH. * **Proposal 8:** If a UE would transmit semi-persistent or aperiodic CSI on a PUSCH determined for multiplexing mixed priority UCI of PUCCH, the UE may multiplex the semi-persistent or aperiodic CSI with the mixed priority UCI of PUCCH in the PUSCH. |
| NEC | * ***Proposal 3:*** *When multiplexing both low-priority HARQ-ACK and high-priority HARQ-ACK on a PUSCH scheduled by an UL non-fallback DCI with a DAI field, which HARQ-ACK codebook the DAI field is applied to should be configured by gNB.* |
| Sharp | **Proposal 10: For multiplexing of HP HARQ-ACK on LP PUSCH, FFS on the detailed multiplexing methods, e.g. the multiplexing location and multiplexing symbol restrictions.**  **Proposal 11: For multiplexing of HP HARQ-ACK and LP HARQ-ACK on LP PUSCH, FFS on the order of HARQ-ACK multiplexing.**  **Proposal 12: Support HP SR multiplexing on LP PUSCH if timeline can be satisfied; and specify enhanced channel dropping rules based on whether HP UCI is multiplexed on LP PUSCH.** |
| WILUS | * ***Proposal 8:*** *To multiplex LP HARQ-ACK and HP HARQ-ACK into a PUSCH in case of UCI on PUSCH, reuse Rel-15 rules as much as possible.*   + *The number of REs for LP HARQ-ACK and HP HARQ-ACK is determined by Rel-15 RE calculation rules for HARQ-ACK.*   + *RE positions for LP HARQ-ACK and HP HARQ-ACK in a PUSCH are determined by Rel-15 RE mapping rules for HARQ-ACK.* |
|  |  |

## 1st round discussion

Proposal for 1st round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI,

* HP HARQ-ACK and LP HARQ-ACK are separately encoded according to R15 TS 38.212 Clause 5.3.1 and Clause 5.3.3.
* Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details.
* FFS for LP HARQ-ACK, e.g. Reuse R15 Part 1 CSI rate matching and RE mapping or Reuse R15 HARQ-ACK rate matching and RE mapping.

Proposal for 1st round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,

* The CSI part 2 is dropped.
* Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details.
* Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK in principle. FFS details.
* Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part 1 in principle. FFS details.
* FFS for the case where LP CSI consisting of two parts is transmitted on HP PUSCH conveying UL-SCH.
* FFS for LP CSI consisting of single part.
* FFS for LP PUSCH not conveying UL-SCH.

Proposal for 1st round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK and HP A-CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH,

* LP HARQ-ACK is dropped.
* Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details.
* Reuse R15 CSI part 1 rate matching and RE mapping for HP CSI part 1 in principle. FFS details.
* Reuse R15 CSI part 2 rate matching and RE mapping for HP CSI part 2 in principle. FFS details.
* FFS for HP A-CSI consisting of single part.
* FFS for HP PUSCH not conveying UL-SCH.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | 1st Proposal: Agree  2nd Proposal: Agree  3rd Proposal: Agree. I think this is just Rel-16 prioritisation behaviour. |
| Apple | 2nd proposal: not agree  3rd proposal: not agree.  The detailed analysis can be found in Section 11 of our contribution. The 2nd is moving toward a wrong direction, which cripples existing functionality to support a new one. The 3rd proposal is in conflict with an earlier agreement. Those proposals raise strong concerns on the usefulness and useableness of UCI multiplexing in Rel-17  **Observation 11-1: multiplexing of CSI part I and HARQ-ACK is supported over PUCCH and there is no fundamental difference in terms of implementation complexity between PUCCH and PUSCH.**  **Observation 11-2: If CSI part II is dropped in total by design when accommodating HP/LP HARQ-ACK multiplexing, then the CSI feedback is useless.**  Proposal 11-4: LP HARQ-ACK can be multiplexed to either CSI part 1 or CSI part 2, CSI part 2 is NOT dropped by design due to the presence of LP HARQ-ACK on PUSCH. |
| Lenovo/Motorola Mobility | 1st proposal: Support. For LP HARQ-ACK, we prefer to reuse R15 Part 1 CSI rate matching and RE mapping.  2nd proposal: When a few HP HARQ-ACK bits are multiplexed on a few REs, CSI-part2 can still be transmitted. Thus, we suggest the following modifications:   * ~~The CSI part 2 is dropped~~. * Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK and LP CSI part 1 in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for ~~LP CSI part 1~~ LP CSI part 2 in principle. FFS details. * For LP CSI consisting of single part,   + Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details.   + Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK in principle. FFS details.   + Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI in principle. FFS details.   3rd proposal: Depending on payload sizes of A-CSI and LP HARQ-ACK, LP HARQ-ACK can still be multiplexed without performance degradation. Thus, we suggest the following modification:   * ~~LP HARQ-ACK is dropped.~~ * Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 1 rate matching and RE mapping for HP CSI part 1 in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for HP CSI part 2 and LP HARQ-ACK in principle. FFS details. * For HP A-CSI consisting of single part,   + Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details.   + Reuse R15 CSI part 1 rate matching and RE mapping for HP CSI in principle. FFS details.   + Reuse R15 CSI part 2 rate matching and RE mapping for LP HARQ-ACK in principle. FFS details. |
| Intel | For these 3 proposals, we’re generally fine.  For the case of HP A-CSI only consists of single part, we think LP HARQ-ACK can be transmitted using Rel-15 CSI part 2 chain. |
| QC | For all three Proposals: Agree in principle. For the second sub-bullet in the three proposals, since HP HARQ-ACK payload size is pretty robust, for <2 bits HP HARQ-Ack, there is no need to do RE reservation and puncturing PUSCH/CSI-part 2. We suggest add the following in the second sub-bullet: “Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS potential simplification to always let other UCI and PUSCH rate match around HP HARQ-ACK regardless HP HARQ-ACK payload size, and FFS other details.” |
| Ericsson | 1st proposal: support  2nd proposal: support  3rd proposal: First, this proposal can be shortened to “Do not support multiplexing ….”. When LP HARQ-ACK is excluded, the multiplexing case is already covered by the existing procedure. Second, this proposal contradicts with the previous agreement to support this case (see agreement copied below). Suggest to drop HP CSI part2, and keep LP HARQ-ACK.   |  | | --- | | Agreements:  Support multiplexing for following scenarios in R17:   * … * Multiplexing a low-priority HARQ-ACK, a high-priority PUSCH conveying UL-SCH, a high-priority HARQ-ACK and/or CSI. | |
| DOCOMO | 1st proposal: agree  2nd proposal: not agree. Share the similar view with Apple and Lenovo. LP CSI part 1 can be jointly encoded with LP HARQ-ACK  3rd proposal: not agree. Share the similar view with Apple and Lenovo. |
| MediaTek | 1st proposal: Fine.  2nd & 3rd proposals: Do not support. Share the similar view with Apple. |
| Panasonic | We are fine with all three proposals. On 3rd proposal, we share similar view with Sony that the outcome is just Rel.16 behavior. |
| LG | 1st proposal: Need to add “puncturing” in 2nd sub-bullet to cover the case of up to 2 HP HARQ-ACK bits as below.   * Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details.   With the above addition, we are fine with the proposal.  2nd proposal: Need to add “puncturing” in 2nd sub-bullet to cover the case of up to 2 HP HARQ-ACK bits as below.   * Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details.   With the above addition, we are fine with the proposal.  3rd proposal: Not agree.  Dropping LP HARQ-ACK always would not be reasonable since it actually means no multiplexing for different priority UCI and PUSCH as in Rel-16, even in Rel-17 case where UCI on PUCCH with different priority is enabled. Rather, by defining to drop HP CSI part 2 as default, (as discussed for LP HARQ-ACK size ambiguity handling), gNB can indicate LP HARQ-ACK size as 0-bit by HP DCI whenever it want to get HP CSI rather than LP HARQ-ACK. Otherwise, there would be no way for the gNB to select between LP HARQ-ACK and HP CSI part 2. For this reason, we suggest the following way.  [modified 3rd proposal]  For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK and HP A-CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH,   * HP CSI part 2 ~~LP HARQ-ACK~~ is dropped. * Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK ~~HP CSI part 1~~ in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for HP CSI part 1 ~~2~~ in principle. FFS details. * FFS for HP A-CSI consisting of single part. * FFS for HP PUSCH not conveying UL-SCH. |
| vivo | 1st proposal: ok  2nd proposal: can accept for progress. Lenovo’s update is also fine.  3rd proposal: agree with Apple, the current proposal is in conflict with an earlier agreement. LP HARQ-ACK shouldn’t be dropped. It can be jointly encoded with either CSI part 1 or CSI part 2. Lenovo’s update is also fine |
| Nokia, NSB | - 1st proposal: Support; Similar as Lenovo, for LP HARQ-ACK, reuse R15 Part 1 CSI rate matching and RE mapping is preferred.  - 2nd proposal: Agree with the intention.  In our review, dropping entire CSI is simple and preferred. In addition, if RAN1 agree dropping CSI part 2 only, we suggest updating the proposal as following since the proposal is mainly about multiplexing UCIs on LP PUSCH:  “For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,   * The CSI part 2 is dropped. * Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part 1 in principle. FFS details. * ~~FFS for the case where LP CSI consisting of two parts is transmitted on HP PUSCH conveying UL-SCH.~~ * FFS for LP CSI consisting of single part. * FFS for LP PUSCH not conveying UL-SCH.”   - 3rd proposal: Support. |
| ITRI | Fine with these proposals. |
| TCL | Fine with these proposals. |
| ZTE | Fine with the first proposal. For the FFS sub-bullet, if the T-DAI indication for LP HARQ-ACK is carried in UL grant DCI for PUSCH, we can simply adopt the solution of reusing R15 Part 1 CSI rate matching and RE mapping as the ambiguity of number of LP HARQ-ACK bits is resolved.  Fine with the second proposal.  Concerns about the third proposal. For the third proposal, we think LP HARQ-ACK priories than HP CSI-part 2 as CSI-part 2 is only the sub band channel information, and the performance loss of MIMO can be accepted.  Furthermore, for proposal 2 and 3, the “FFS for HP/LP PUSCH not conveying UL-SCH” should be deleted, as the coding chain for UL-SCH is LDPC codec, anyway the LDPC coding chain for UL-SCH is not suitable to UCI coding. |
| Sharp | Fine with the proposals in principle.  For all cases, the HP HARQ-ACK multiplexing may need to consider the delay for RE mapping, e.g. HP HARQ-ACK is mapped to the first hop only even if frequency hopping is configured on a LP PUSCH. |
| Huawei/Hisi | 1st proposal: support. For the FFS part, we prefer to reuse R15 Part 1 CSI encoder chain for LP HARQ-ACK since it need less spec impact than reusing HARQ-ACK rate matching/RE mapping.  2nd proposal: support.  3rd proposal: Support in principle. As the LP HARQ-ACK is dropped, it simply falls back to the normal R15 case where only one type of UCI is piggybacked on the PUSCH, so we recommend to remove the 2nd ~ 4th bullets.  “For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK and HP A-CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH,   * LP HARQ-ACK is dropped. * ~~Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details.~~ * ~~Reuse R15 CSI part 1 rate matching and RE mapping for HP CSI part 1 in principle. FFS details.~~ * ~~Reuse R15 CSI part 2 rate matching and RE mapping for HP CSI part 2 in principle. FFS details.~~ * FFS for HP A-CSI consisting of single part. * FFS for HP PUSCH not conveying UL-SCH.   ” |
| Samsung | Support the 1st and 2nd proposal.  NOT support the 3rd proposal, it contradicts with previous agreements. Part 2 CSI should be dropped. |
| Quectel | We support the 3 proposals. We think the 3rd proposal is just Rel-16 behavior. |
| OPPO | For 1st proposal, we are fine in principle. For LP HARQ-ACK, we prefer to reuse R15 Part 1 CSI rate matching and RE mapping.  For 2nd proposal, we are fine in principle except 1st FFS and 3rd FFS which is out of agreed scenario.  Updated proposal:  For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,   * The CSI part 2 is dropped. * Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part 1 in principle. FFS details. * ~~FFS for the case where LP CSI consisting of two parts is transmitted on HP PUSCH conveying UL-SCH.~~ * FFS for LP CSI consisting of single part. * ~~FFS for LP PUSCH not conveying UL-SCH.~~   For 3rd proposal, we are fine in principle except 2rd FFS which is out of agreed scenario. For the 1st FFS, we prefer to unified design for A-CSI consisting of single part and two parts.  Updated proposal:  For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK and HP A-CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH,   * LP HARQ-ACK is dropped. * Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 1 rate matching and RE mapping for HP CSI part 1 in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for HP CSI part 2 in principle. FFS details. * FFS for HP A-CSI consisting of single part. * ~~FFS for HP PUSCH not conveying UL-SCH.~~ |
| InterDigital | Support 1st and 2nd proposals.  For the 3rd proposal, it seems better to leave possibility to the network to multiplex LP HARQ-ACK even if A-CSI is requested. |
| CATT | We are fine with the 1st and the 3rd proposals.  For the 2nd proposal, similar as for the 1st proposal, we would like to keep it open to reuse HARQ-ACK RM and RE mapping for LP HARQ-ACK considering the potential LP DCI miss.  For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,   * The CSI part 2 is dropped. * Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details. * FFS: Reuse R15 CSI part 1 rate matching and RE mapping or Reuse R15 HARQ-ACK rate matching and RE mapping for LP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part 1 in principle. FFS details. * FFS for the case where LP CSI consisting of two parts is transmitted on HP PUSCH conveying UL-SCH. * FFS for LP CSI consisting of single part. * FFS for LP PUSCH not conveying UL-SCH. |
| NEC | Support the 1st proposal and the 2nd proposal. |
| FGI/APT | Support the proposals. |

1st round discussion status:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI,

* HP HARQ-ACK and LP HARQ-ACK are separately encoded according to R15 TS 38.212 Clause 5.3.1 and Clause 5.3.3.
* Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details.
* FFS for LP HARQ-ACK, e.g. Reuse R15 Part 1 CSI rate matching and RE mapping or Reuse R15 HARQ-ACK rate matching and RE mapping.
* Support: Sony, Lenovo, Intel, QC, E///, DCM, MTK, LG, vivo, Nokia, ITRI, TCL, ZTE, Sharp, HW, Samsung, Quectel, OPPO, IDC, CATT, NEC, FGI/APT

1st round discussion status:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,

* The CSI part 2 is dropped.
* Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details.
* Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK in principle. FFS details.
* Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part 1 in principle. FFS details.
* ~~FFS for the case where LP CSI consisting of two parts is transmitted on HP PUSCH conveying UL-SCH.~~
* FFS for LP CSI consisting of single part.
* ~~FFS for LP PUSCH not conveying UL-SCH.~~
* Support: Intel, QC, E///, LG, vivo, Nokia, ITRI, TCL, ZTE, Sharp, HW, Samsung, Quectel, OPPO, IDC, NEC, FGI/APT
* Not support: Apple, Lenovo, DCM, MTK

1st round discussion status:

~~For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH~~ In R17, if HP HARQ-ACK, LP HARQ-ACK and HP A-CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH,

* LP HARQ-ACK is dropped.
* Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle. FFS details.
* Reuse R15 CSI part 1 rate matching and RE mapping for HP CSI part 1 in principle. FFS details.
* Reuse R15 CSI part 2 rate matching and RE mapping for HP CSI part 2 in principle. FFS details.
* FFS for HP A-CSI consisting of single part.
* ~~FFS for HP PUSCH not conveying UL-SCH.~~
* Support: Intel, QC, Nokia, ITRI, TCL, Sharp, HW, Quectel, OPPO, CATT, FGI/APT
* Not support (violate previous agreement): Apple, Lenovo, E///, DCM, MTK, LG, vivo, ZTE, Samsung

## 2nd round discussion

The first proposal has been discussed for meetings, and pros and cons are clarified. It seems the two proposals are workable, although some companies think the other option is better for optimization. To make progress and save the precious GTW time, it is suggested to agree on them by email approval. It is suggested you show the objection only if you cannot live with the proposal.

The second and third proposals deserve the 2nd round discussion for checking.

Proposal for 2nd round discussion (for email approval):

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI,

* HP HARQ-ACK and LP HARQ-ACK are separately encoded according to R15 TS 38.212 Clause 5.3.1 and Clause 5.3.3.
* Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details.
* FFS for LP HARQ-ACK, e.g. Reuse R15 Part 1 CSI rate matching and RE mapping or Reuse R15 HARQ-ACK rate matching and RE mapping.

|  |  |
| --- | --- |
| Supporting companies: | Samsung, Intel, DOCOMO, CATT (with modification),TCL, Quectel (with udpates), NEC, vivo, LG Huawei/Hisi, Nokia/NSB (Modified proposal version 2 from QC is fine as well),OPPO, ZTE, Panasonic, ITRI, Sony, Sharp |
| Objecting companies: | QC, MediaTek |
| Company | Reason for objection |
| QC | We cannot accept the adding “/puncturing”. Like we explained, HP HARQ-ACK codebook size is pretty robust, there is no need to do RE reservation and puncturing for HP HARQ-ACK. Furthermore, for LP HARQ-ACK, the puncturing is not included in the FFS. To us, the LP codebook size has ambiguity and it is LP HAQR-ACK that need puncturing. However, if puncturing is applied to both HP and LP HARQ-ACK, it is too complicated. Therefore, we can accept introduce at most 1 potential puncturing for one UCI type.  With the above, we can accept either one version of the following modifications (prefer version 1). But we cannot accept the current proposal.  **Modified proposal version 1:** For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI,   * HP HARQ-ACK and LP HARQ-ACK are separately encoded according to R15 TS 38.212 Clause 5.3.1 and Clause 5.3.3. * Reuse R15 HARQ-ACK rate matching~~/puncturing~~ and RE mapping for HP HARQ-ACK in principle. FFS details. * FFS for LP HARQ-ACK, e.g. Reuse R15 Part 1 CSI rate matching and RE mapping or Reuse R15 HARQ-ACK rate matching and RE mapping.   **Modified proposal version 2:** For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI,   * HP HARQ-ACK and LP HARQ-ACK are separately encoded according to R15 TS 38.212 Clause 5.3.1 and Clause 5.3.3. * Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details. * ~~FFS~~ for LP HARQ-ACK, ~~e.g.~~ Reuse R15 Part 1 CSI rate matching and RE mapping ~~or Reuse R15 HARQ-ACK rate matching and RE mapping~~. |
| CATT | We are fine with the proposal with the following addition to be aligned.  For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI,   * HP HARQ-ACK and LP HARQ-ACK are separately encoded according to R15 TS 38.212 Clause 5.3.1 and Clause 5.3.3. * Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details. * FFS for LP HARQ-ACK, e.g. Reuse R15 Part 1 CSI rate matching and RE mapping or Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping. |
| Quectel | We understand the motivation is to try to reuse all the existing design for HP HARQ-ACK and LP HARQ-ACK. However, as pointed out by QC, it doesn’t make sense to apply puncturing for HP HARQ-ACK while rate matching for LP HARQ-ACK. One solution could be rate matching is applied to both HP HARQ-ACK and LP HARQ-ACK as suggested by QC version 1. In this way, RE reservation is not needed and we can start from Step 2 of existing data and control multiplexing procedure in 38.212 section 6.2.7. |
| LG | We are also OK with the “Modified proposal version 2” from QC. |
| Nokia/NSB | We are also OK with the “Modified proposal version 2” from QC. |
| MediaTek | We are fine with “Modified proposal version 1” from QC |
| Apple | We are also OK with the “Modified proposal version 2” from QC. |
| Lenovo/Motorola Mobility | Support **Modified proposal version 2** of QC |

Proposal for 2nd round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,

* The CSI part 2 is dropped.
* Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details.
* Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK in principle. FFS details.
* Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part 1 in principle. FFS details.
* ~~FFS for the case where LP CSI consisting of two parts is transmitted on HP PUSCH conveying UL-SCH.~~
* FFS for LP CSI consisting of single part.
* ~~FFS for LP PUSCH not conveying UL-SCH.~~

|  |  |
| --- | --- |
| Company | Comments |
| Apple | A consistent design for multiplexing over LP PUSCH and multiplexing over HP PUSCH is important. We don’t support this proposal. |
| QC | Similar comment as for previous proposal. Adding “puncturing” for second bullet is not a good idea. HP HARQ-ACK does not need puncturing. Rate matching is good enough. We should revert the change as below.   * Reuse R15 HARQ-ACK rate matching~~/puncturing~~ and RE mapping for HP HARQ-ACK in principle. FFS details. |
| Intel | We’re fine with proposal |
| DOCOMO | Not support. The reason is what commented in the previous round and meeting. LP HARQ-ACK can be jointly encoded with CSI part 1. |
| CATT | Similar as our previous comment, the 3rd bullet should be FFS  For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,   * The CSI part 2 is dropped. * Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details. * FFS Reuse R15 CSI part 1 rate matching and RE mapping or R15 HARQ-ACK rate matching/puncturing and RE mapping for LP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part 1 in principle. FFS details. * ~~FFS for the case where LP CSI consisting of two parts is transmitted on HP PUSCH conveying UL-SCH.~~ * FFS for LP CSI consisting of single part. * ~~FFS for LP PUSCH not conveying UL-SCH.~~ |
| TCL | We’re fine with proposal |
| Quectel | Support CATT’s update. |
| NEC | Fine with proposal in general. |
| vivo | For the sake of process, we are fine with the proposal, although we think LP HARQ-ACK can jointly encoded with CSI part 1. |
| LG | We support the proposal from FL. |
| Huawei/Hisi R2 | Support |
| Nokia/NSB | Support |
| OPPO | Support |
| ZTE | Fine with the proposal. |
| Panasonic | We are fine with the proposal. |
| Samsung | Support |
| ITRI | Support |
| Sony | Fine with the proposal. |
| Apple | We propose to consider the. Following  For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,   * ~~The CSI part 2 is dropped.~~ * Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 1 rate matching and RE mapping for ~~LP HARQ-ACK~~ CSI Part 1 in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part ~~1~~ 2 and LP HARQ-ACK in principle. FFS details.   + If CSI part 2 is not sufficient for LP CSI part 2 and LP HARQ-ACK, then LP CSI part 2 is dropped. |
| Lenovo/Motorola Mobility | By jointly encoding LP HARQ-ACK and CSI part 1, can transmit CSI part 2 if there is enough REs. This would be better than blindly dropping CSI part 2.  Thus, we suggest the following:   * ~~The CSI part 2 is dropped~~. * Reuse R15 HARQ-ACK rate matching and RE mapping/puncturing for HP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK and LP CSI part 1 in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part 2 in principle. FFS details. |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal for 2nd round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK and HP A-CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH,

* HP CSI part 2 ~~LP HARQ-ACK~~ is dropped.
* Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details.
* Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK ~~HP CSI part 1~~ in principle. FFS details.
* Reuse R15 CSI part 2 rate matching and RE mapping for HP CSI part 1~~2~~ in principle. FFS details.
* FFS for HP A-CSI consisting of single part.
  + FFS for HP PUSCH not conveying UL-SCH.

Note: It has been agreed to support multiplexing a low-priority HARQ-ACK, a high-priority PUSCH conveying UL-SCH, a high-priority HARQ-ACK and/or CSI.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | It would be wrong to agree this proposal. We can repeat our comment:   1. The detailed analysis is provided in Section 11 of our contribution. Technically simple solution is available to avoid this self-inflicted damage to NR design 2. The proposal is moving toward a wrong direction: it cripples a vital existing functionality to support a new one. It raises strong concerns on the usefulness and useableness of UCI multiplexing in Rel-17   **Observation 11-1: multiplexing of CSI part I and HARQ-ACK is supported over PUCCH and there is no fundamental difference in terms of implementation complexity between PUCCH and PUSCH.**  **Observation 11-2: If CSI part II is dropped in total by design when accommodating HP/LP HARQ-ACK multiplexing, then the CSI feedback is useless.**  Proposal 11-4: LP HARQ-ACK can be multiplexed to either CSI part 1 or CSI part 2, CSI part 2 is NOT dropped by design due to the presence of LP HARQ-ACK on PUSCH. |
| QC | We disagree the proposal. Dropping HP CSI to save the LP HARQ-ACK is very counter-intuitive. LP HARQ-ACK should be dropped in our opinion. But if no consensus can be made on how to support this case, we are OK to not support this case in Rel-17. Therefore, Rel-16 priority rule is applied for this case, which is a reasonable solution and better than this proposal anyway. |
| Intel | We don’t support the proposal. We don’t think it is right way to just sacrifice HP UCI performance for LP UCI.  In some cases, e.g., there is only one CSI part, it is ok to transmit LP HARQ-ACK, which is also aligned with previous agreement. |
| DOCOMO | We are fine with this proposal. |
| CATT | We share the same view as QC that LP HARQ-ACK should be dropped. |
| TCL | We do not support the proposal. We share the similar view as QC and Intel, LP HARQ-ACK should be dropped. |
| Quectel | Not support. It doesn’t make sense to drop HP CSI due to LP HARQ-ACK multiplexing. And also, we don’t think in this case dropping LP HARQ-ACK contradicts previous agreements. We can still support multiplexing LP HARQ-ACK when this is only a single part HP CSI or there is no HP CSI, which is aligned with previous agreements. |
| vivo | Do not support. HP CSI should not be dropped. If HP CSI is only CSI part 1, it is ok to transmit it. If HP CSI is two parts, LP HARQ-ACK can be jointly encoded with CSI part 1/2. |
| LG | We support the proposal from FL, by respecting the previous agreement as in Note. |
| Nokia/NSB | Not support  As commented by other companies (e.g. QC & Intel), comparing to dropping HP CSI, LP HARQ-ACK should be dropped which is more inline with the specified PHY priority. With the option of dropping LP HARQ-ACK, the current Rel-15 procedure can be reused for all 3 UCIs, i.e. HP HARQ-ACK, HP CSI part 1 and HP CSI part 2. |
| ZTE | Fine with the proposal. |
| Samsung | Support |
| Sony | Strange that we want to drop HP CSI Part 2 whereas in Rel-16 we are able to transmit it. |
| Apple | If there is any concern on UCI omission rule, we suggest to consider the following proposal:  For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and HP CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH,   * ~~The CSI part 2 is dropped.~~ * Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 1 rate matching and RE mapping for ~~LP HARQ-ACK~~ HP CSI Part 1 in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for HP CSI part ~~1~~ 2 and LP HARQ-ACK in principle. FFS details.   + If CSI part 2 is not sufficient for HP CSI part 2 and LP HARQ-ACK, then HP CSI part 2 is dropped. |
| Lenovo/Motorola Mobility | Depending on payload sizes of A-CSI and LP HARQ-ACK, LP HARQ-ACK can still be multiplexed without performance degradation. Thus, we suggest the following:   * Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details. * Reuse R15 CSI part 1 rate matching and RE mapping for HP CSI part 1 in principle. FFS details. * Reuse R15 CSI part 2 rate matching and RE mapping for HP CSI part 2 and LP HARQ-ACK in principle. FFS details. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 3rd round discussion

Proposal for 3rd round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI,

* HP HARQ-ACK and LP HARQ-ACK are separately encoded according to R15 TS 38.212 Clause 5.3.1 and Clause 5.3.3.
* Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details.
* ~~FFS~~ for LP HARQ-ACK, ~~e.g.~~ Reuse R15 Part 1 CSI rate matching and RE mapping ~~or Reuse R15 HARQ-ACK rate matching and RE mapping~~.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support |
| Intel | We support the proposal. |
| InterDigital | Support |
| LG | We are fine with the proposal. |
| Sony | Support |
| Apple | Support FL’s proposal |
| Huawei/Hisi R3 | Support |
| Ericsson | Support |
| QC | We are fine with the proposal.  To make things crystal clear, for the last bullet, we think it is better to add a note:   * ~~FFS~~ for LP HARQ-ACK, ~~e.g.~~ Reuse R15 Part 1 CSI rate matching and RE mapping ~~or Reuse R15 HARQ-ACK rate matching and RE mapping~~.   + Note: <=2 bits LP HARQ-ACK is padded to 3 bits and use RM encoding. |
| Samsung | Support. |
| Sharp | Support |
| ZTE | Support |
| Quectel | We prefer the original version, i.e., LP HARQ-ACK is FFS at this stage. The ambiguitiy of the number of LP HARQ-ACK bits may have impact to HP UL-SCH rate matching. The updates proposed by QC could be one solution. Other solutions (e.g, pucturing instead of rate matching for 1or 2 bits) should not be precluded at this stage as this issue has not been comprehensively discussed. |
| vivo | support |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Enhancements for multiplexing parameters

## Beta-offset value and configuration

#### Inputs from Tdocs

**Support Beta-offset =0?**

* Yes
  + HW, E///, Nokia, CATT, DCM, Pana
* No
  + ZTE

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 11: For multiplexing LP HARQ-ACK on HP PUSCH scheduled dynamically by UL grant, support beta-offset = 0 to disable the multiplexing.***  ***Proposal 13: For DCI format 0\_1/0\_2 with existing beta-offset bit-field, one codepoint of the field is linked to a quadruple {,,,} to jointly indicate the beta-offset values for HP HARQ-ACK, LP HARQ-ACK, CSI part 1 and CSI part 2.*** |
| E/// | [Proposal 10 For UCI multiplexing on PUSCH, a different target code rate and beta factor is considered for high priority HARQ-ACK.](#_Toc84035010)  [Proposal 11 Support dynamically enable/disable multiplexing by beta factor (e.g. beta=0 to disable mux).](#_Toc84035011) |
| ZTE | ***Proposal 23****: Up to 3 sets of beta offset values can be configured to the UE to indicate separate beta\_offset values for the following cases:*   * *Multiplexing HARQ-ACK on the PUSCH with same priority* * *Multiplexing LP HARQ-ACK on HP PUSCH* * *Multiplexing HP HARQ-ACK on LP PUSCH* |
| Nokia | **Proposal 3.17: For the scenarios of multiplexing HARQ-ACK bits in DG PUSCH of different priorities,** gNB dynamically indicates via beta-offset in the corresponding scheduling DCI whether to multiplex HARQ-ACK in PUSCH of different PHY priority or not (e.g. beta-offset = 0)**. FFS whether to support multiplexing of HARQ-ACK bits on CG PUSCH of a different PHY priority.**  **Proposal 3.18: For the scenarios of multiplexing HARQ-ACK bits in PUSCH of different priorities, RAN1 should specify:**   * **three sets of beta-offset values (i.e. Option 1) for:**   + **multiplexing HARQ-ACK bits on the PUSCH with the same priority (specified already);**   + **multiplexing low-priority HARQ-ACK bits on high-priority PUSCH;**   + **multiplexing high-priority HARQ-ACK bits on low-priority PUSCH;** * **for multiplexing of both low-priority and high-priority HARQ-ACK bits, the beta-offset indicator field in the DCI points to the respective two sets of beta-offset values to be applied respectively for low- and high-priority HARQ-ACK.** |
| QC | ***Proposal 15*: In NR Rel-17, up to four sets of scaling factors alpha can be configured to the UE to indicate separate alpha values for the following cases:**   * **Multiplexing LP HARQ-ACK/UCI on LP PUSCH** * **Multiplexing LP HARQ-ACK/UCI on HP PUSCH** * **Multiplexing HP HARQ-ACK/UCI on LP PUSCH** * **Multiplexing HP HARQ-ACK/UCI on HP PUSCH** |
| IDC | ***Proposal 15: DCI format 0\_1 and 0\_2 can be configured with two beta\_offset indicator fields, where one is applicable to LP HARQ-ACK and the other to HP HARQ-ACK.*** |
| Apple | **Proposal 12-1: a beta offset set can be looked up according to physical layer priority, beta offset selection, and the presence of mixed UCIs.** |
| vivo | ***Proposal 10: In Rel-17, the same set of beta-offset value is used for UCI multiplexing with the same priority on PUSCH.*** |
| DOCOMO | **Proposal 9:**   * *Support beta-offset =0 or a value disabling the UCI multiplexing on PUSCH of different priorities* |
| Pana | **Proposal 10:**   * **For multiplexing a LP HARQ-ACK in a HP PUSCH (conveying UL-SCH only), enhancement of beta-offset values including , which allows for dropping LP HARQ-ACK should be supported.** * **For multiplexing a HP HARQ-ACK in a LP PUSCH (conveying UL-SCH only), enhancement of beta-offset values including specific or non-numerical value, which allows for dropping LP PUSCH should be supported.** |
| Spreadtrum | 1. ***update the agreement:***   ***In NR Rel-17, ~~[at least]~~ 2 new set of beta offset values can be configured to the UE to indicate separate beta\_offset values for the following cases:***   * ***Multiplexing LP HARQ-ACK on HP PUSCH*** * ***Multiplexing HP HARQ-ACK on LP PUSCH*** |
| ITRI | **Proposal 7:**  When UCIs corresponding to different priorities multiplexed in a PUSCH, the beta-offset of UCI with the priority equal to PUSCH is determined by RRC; while the beta-offset of UCI with the priority different from the PUSCH is determined by the scheduling DCI. |
|  |  |

#### 1st round discussion

Proposal for 1st round discussion:

In NR Rel-17, support Beta-offset =0.

|  |  |
| --- | --- |
| Company | Comments |
| InterDigital | Support |
| Intel | No.  We understand the motivation of beta\_offset =0 is to support dynamic enable/disable of UCI multiplexing on PUSCH without introducing additional 1 bit in the DCI.  We support dynamic enable/disable of UCI multiplexing on PUSCH by DCI, but we don’t think it is worth to degrade the coding rate flexibility for 1 bit DCI overhead reduction. In our view, separate 1 bit field is a more clean solution. |
| QC | We don’t support this proposal, as we don’t see the need to dynamically enable/disable UCI multiplexing on PUSCH. The enabling/disabling this feature based on RRC is sufficient enough. |
| Ericsson | Support |
| DOCOMO | Support |
| MediaTek | No need for dynamically enabling/disabling UCI multiplexing. |
| Panasonic | We support the proposal. |
| LG | Not support.  As discussed for LP HARQ-ACK size ambiguity handling, we have a possibility to indicate LP HARQ-ACK size as 0-bit, rather than using beta offset. |
| Nokia, NSB | Support. |
| ITRI | Support the proposal. |
| ZTE | Not support. Because supporting of beta\_offset is an optional UE feature, the functionality of beta\_offset is also disabled for HP HARQ-ACK, it is not our intention. |
| Sharp | Not support. RRC enable/disable signaling is sufficient. |
| Huawei/Hisi | Not support, as there is no need for dynamic enable/disable. |
| Samsung | NOT support.  Beta\_offset by DCI is an optional UE feature – cannot be used for enabling/disabling LP multiplexing. The functionality of beta\_offset for HP is lost in order to support a different functionality. There is no benefit from trying to avoid using 1 bit and RAN1 should not be spending time discussing such marginal aspects especially when there is significant negative impact, or the intended functionality cannot be guaranteed to be supported by a UE. |
| Quectel | Not support. Although we support dynamic enabling/disabling, we don’t think Beta-offset=0 is the only choice. In Rel-15/Rel-16, dynamic enabling/disabling for UCI multiplexing in PUSCH based on UL DAI indication has already been supported. We think Rel-15/Rel-16 design is sufficient for dynamic enabling/disabling. |
| OPPO | Support |
| CATT | Support |
| NEC | Support. |
| FGI/APT | Do not support. We think the purpose Beta-offset =0 can be achieved by an explicit indication for multiplexing enable/disable. |
|  |  |
|  |  |
|  |  |
|  |  |

## Separate configurations of alpha values?

#### Inputs from Tdocs

* Yes
  + QC, LGE, Quectel, Sony
  + Arguments:
    - To guarantee HP PUSCH reliability (with LP UCI piggybacking), similar to the reason for beta offset.
    - R16 has supported separate alpha values for HP PUSCH and LP PUSCH.
* No
  + Nokia
  + Arguments:
    - The same goal on controlling number of REs can be achieved with combination of alpha and different beta values

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Nokia | **Proposal 3.19: For the scenarios of multiplexing HARQ-ACK bits in a PUSCH of different priorities, do not support separate configurations of the scaling factor “alpha”.** |
| QC | ***Proposal 13*: In NR Rel-17, up to four sets of scaling factors alpha can be configured to the UE to indicate separate alpha values for the following cases:**   * **Multiplexing LP HARQ-ACK/UCI on LP PUSCH** * **Multiplexing LP HARQ-ACK/UCI on HP PUSCH** * **Multiplexing HP HARQ-ACK/UCI on LP PUSCH** * **Multiplexing HP HARQ-ACK/UCI on HP PUSCH** |
| LGE | **Proposal #15: Consider separate configuration of beta offset as well as alpha factor per each of UCI priority or per UCI priority combination (e.g. for LP and HP, or for LP only case and other cases) for each priority (e.g. LP, HP) of PUSCH, to ensure reliability/protection of HP PUSCH.** |
| Quectel | **Proposal 13**: Separate configuration of scaling factors (“alpha”) is supported for UCI-PUSCH multiplexing with different priority combinations. |
| Sony | **Proposal 9: For multiplexing of UCI into PUSCH of different L1 priorities, the gNB is able to configure separate ** offsets for different PUSCH L1 priorities.** |

## Multiplexing enable/disable mechanism

## Inputs from Tdocs

Multiplexing enable/disable mechanism

* Option 1: By beta\_offset (e.g. beta=0 or non-numerical value to disable mux)
  + CATT, IDC, DCM, Sony, ITRI
* Option 2: By DCI field
  + E///, ZTE (in HP DCI or RRC), IDC, Quectel, Intel, vivo, ETRI
* Option 3: Only RRC configuration
  + CATT, LGE, QC, IDC (for CG PUSCH and SPS), Intel, MTK, Spreadtrum, TCL, Xiaomi

The arguments are similar to that for Section 2.3.

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| E/// | [Proposal 9 Support dynamic enabling/disabling of multiplexing of different priorities both for PUCCH and PUSCH.](#_Toc84035009) |
| ZTE | ***Proposal 21****: The beta\_offset should not be used to disable the intra-UE multiplexing UCI with data*.  ***Proposal 22****: The indicator of intra-UE multiplexing UCI with data exists in the scheduling DCI or RRC parameter for the high priority transmission.* |
| CATT | ***Proposal 12: Semi-static RRC configuration to enable/disable the multiplexing between channels with different priorities is supported.***  ***Proposal 13: A value of zero for beta-offset in a DCI can be used to dynamically indicate that LP UCI is not multiplexed on the HP PUSCH scheduled by the DCI.*** |
| IDC | ***Proposal 16: DCI scheduling HP PUSCH indicates if UE multiplexes LP HARQ-ACK in HP PUSCH.***  ***Proposal 17: DCI indicating HP HARQ-ACK also indicates if UE multiplexes HP HARQ-ACK in LP PUSCH.***  ***Proposal 18: A beta\_offset indicator field set to 0 indicates that UE disables multiplexing of LP HARQ-ACK in HP PUSCH.***  ***Proposal 19: RRC configuration for each HP CG configuration includes an indication of whether the UE can multiplex LP HARQ-ACK in corresponding HP PUSCH.***  ***Proposal 20: RRC configuration of SPS with HP HARQ-ACK includes an indication of whether the UE can multiplex HP HARQ-ACK in LP PUSCH.*** |
| Intel | **Proposal 18: DCI indication can be provided to enable multiplexing of UCI into DG PUSCH.** |
| DOCOMO | **Proposal 9:**   * *Support beta-offset =0 or a value disabling the UCI multiplexing on PUSCH of different priorities* |
| Sony | **Proposal 11: The gNB dynamically indicates whether to enable/disable multiplexing of UCI bits into PUSCH of different L1 priorities.**  **Proposal 12: The “*beta\_offset indicator*” DCI field in the UL Grant scheduling the PUSCH is used to enable/disable multiplexing of UCI bits into PUSCH, where some of the indices have non-numerical values, i.e. “NOT MULTIPLEX”, to indicate that multiplexing is not used and that the UE performs prioritisation. That is:**   * **If *beta\_offset indicator* is numerical then:**   + **LP UCI is multiplexed into HP PUSCH using the indicated ** offset value**   + **HP UCI is multiplexed into LP PUSCH using the indicated ** offset value** * **If *beta\_offset indicator* = “NOT MULTIPLEX” or non-numerical then:**   + **For the case of LP UCI & HP PUSCH, the LP UCI is dropped and HP PUSCH is transmitted**   + **For HP UCI & LP PUSCH, the LP PUSCH is dropped and HP UCI is transmitted on PUCCH** |
| Spreadtrum | ***Support RRC configuration method for multiplexing enable/disable mechanism for UCI on PUSCH.*** |
| TCL | **Proposal 6: RRC configuration for enabling UCI multiplexing on PUSCH with different priorities should be supported.** |
| Xiaomi | ***Proposal 5: For enabling/disabling multiplexing of channels of different priorities, semi-static configuration is preferred.*** |
| ETRI | **Proposal 7: The scheduling UL-DCI has an additional field whether or not to allow multiplex HP UCI and LP UCI, or otherwise by the RRC signalling.** |
| ITRI | **Proposal 6:**  For PUCCH multiplexed in PUSCH, beta-offset configuration can be used to enable or disable the multiplexing. The multiplexing disabled if beta-offset=0; otherwise the UE should perform the multiplexing. |
|  |  |

## 1st round discussion

Proposal for 1st round discussion:

For multiplexing a HARQ-ACK into a PUSCH with different priorities in R17, at least support RRC configuration for gNB to enable/disable the multiplexing.

* FFS whether or not to additionally introduce dynamic mechanism, e.g. DCI indication, beta\_offset=0
* FFS: Interaction between the enable/disable mechanism and other multiplexing conditions
* FFS for other types of UCI.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Dynamic enabling/disabling does not even incur any additional DCI bits since one of the beta\_offset value can be mapped into a NON-NUMERICAL value to indicate “No Multiplexing”. Hence this cost nothing but offer significant benefit for gNB scheduling. |
| Lenovo/Motorola Mobility | Support the proposal. |
| InterDigital | Don’t support. We should decide on the dynamic mechanism and not leave FFS.  For the case of LP HARQ-ACK in HP PUSCH, the DCI indication can be beta\_offset=0 at no additional overhead cost.  For the case of HP HARQ-ACK in LP PUSCH, the indication needs to be in HP DCI for PDSCH. However, the same indication as for the case of multiplexing on PUCCH (if agreed) can be used. |
| Intel | It seems no company object RRC configuration. We think the key point is to resolve the FFS point, whether to allow additional DCI indication on top of RRC configuration.  In our view, it is beneficial to support dynamic indication, to better control the impact of LP on HP UL transmission. |
| QC | We support this proposal.  For DCI based enabling/disabling multiplexing, we can further discuss. But we have the following concern. It complicates UE implementation without justified benefit. Since for UCI multiplexing on PUSCH, the UL DCI has to arrive later than DL DCI. Therefore, gNB can always allocate enough REs in PUSCH to make sure multiplexing can be performed without hurting HP UCI performance. We don’t see the need to introduce dynamic switch between multiplexing/not multiplexing which will complicate UE implementation. |
| Ericsson | Do not support.  It’s important to have DCI indication. |
| DOCOMO | Support the proposal. |
| MediaTek | No need for DCI indication. RRC should be the only option. |
| Panasonic | Although the proposal is OK, as mentioned by other companies, resolve FFS on DCI indication would be necessary for the progress. In our view, dynamic enabling/disabling UCI multiplexing on PUCCH and PUSCH should considered as a unified principle. |
| LG | Support RRC only. |
| vivo | Do not support.  See comment in section 3.3.2. It’s important to have DCI indication. |
| Nokia, NSB | Not support.  Similar as commented in 3.3.2, RRC configuration only does not bring much benefit. As commented in previous meetings, gNB should be able to dynamically enable/disable multiplexing HARQ-ACK in PUSCH of different priorities especially considering beta\_offset is **already** part of the DCI, i.e. no additional overhead to support dynamic indication, especially if beta-offset =0 will be agreed in Section 4.3.1.2. Moreover, supporting dynamic indication can avoid introducing any complicated/additional conditions for multiplexing which will reduce the standardization efforts significantly. |
| ITRI | Don’t support. Share same view with Interdigital. |
| TCL | Support the proposal. |
| ZTE | Generally fine with the proposal. Not comfortable on the “beta\_offset=0” |
| Sharp | Support the proposal. |
| Huawei/Hisi | Support. |
| Samsung | Same comment as for 3.3.2. Both RRC and DCI support is needed. |
| Quectel | We support dynamic enabling/disabling. The UL DAI, i.e., could be reused to disable the multiplexing in case RRC has already enabled it. |
| OPPO | Support |
| CATT | We support the proposal. |
| NEC | Fine with the proposal. But we prefer to support DCI indication to enable/disable the multiplexing, it is simple and flexible. |
| FGI/APT | Do not support. We prefer to also support DCI indication. |
|  |  |

## If no enough resource for both HP and LP HARQ-ACK

## Inputs from Tdocs

* Option 1: The LP UCI is (partly or fully) dropped
  + LGE, Intel, Sony, TCL
* Option 2: The LP UCI is compressed/bundled.
  + ZTE, QC, LGE, Apple, OPPO, MTK, TCL

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| ZTE | ***Proposal 24:*** *LP UCI compression is slightly preferred in case there is no enough resource left for LP UCI.* |
| QC | ***Proposal 16:* In Rel-17 UCI multiplexing, support low priority HARQ-ACK compression.**   * **FFS conditions to trigger low priority HARQ-ACK compression** * **FFS details of compression scheme.** |
| LGE | **Proposal #16: Consider the bundling/dropping of LP UCI on PUSCH based on the maximum UCI coding rate as for the case of LP UCI on PUCCH.** |
| Intel | **Proposal 15: When sufficient resource is not available for accommodating LP HARQ-ACK on HP PUSCH, LP HARQ-ACK payload bits can be partially dropped.** |
| Apple | **Proposal 11-3: For a UCI part, UCI omission/compaction is applied to the right-most UCI first among UCIs in that UCI part as in Tables 11-1 and 11-2. Before all the later-placed UCIs are omitted, an early UCI is not omitted or compacted.**  Proposal 11-4: LP HARQ-ACK can be multiplexed to either CSI part 1 or CSI part 2, CSI part 2 is dropped by design due to the presence of LP HARQ-ACK on PUSCH. |
| OPPO | ***Proposal 18: LP HARQ-ACK transmitted on HP PUSCH should be compressed when the actual coding rate is higher than a threshold.*** |
| Sony | **Proposal 10: When multiplexing UCI bits into PUSCH of different L1 priorities, if there are insufficient REs in a PUSCH to carry the UCI bits, the LP UCI bits are dropped.** |
| TCL | **Proposal 7: For the multiplexing between low priority UCI and high priority PUSCH, if the resource is not sufficient for the multiplexing, considering bundling or partially drop the low priority UCI.** |
|  |  |

## Timeline and latency requirements

## Inputs from Tdocs

**Latency requirement:**

* Option 1: Multiplexing is only allowed when the ending symbol of the LP PUSCH is no later than the ending symbols of PUCCHs carrying HP HARQ-ACK
  + HW, ZTE, TCL, ITRI
* Option 3: Multiplexing is only allowed when the ending symbol used for UCI transmission in a LP PUSCH is not later than the ending of HP PUCCH.
  + OPPO

**For the case where the timeline requirements are not met,**

* Option 1: UE behavior fallbacks to Rel-16 prioritization.
  + Nokia, Intel, Sharp, ITRI
* Option 2:
  + If a UE doesn’t support Rel-16 prioritization, the UE doesn’t expect the multiplexing timeline conditions are not satisfied.
  + If the UE support Rel-16 prioritization, UE behavior fallbacks to Rel-16 prioritization.
  + OPPO

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 12: For HP HARQ-ACK overlapping with LP PUSCH, the multiplexing is only allowed when the ending symbol of the LP PUSCH is no later than the ending symbol of the PUCCH carrying HP HARQ-ACK.*** |
| LGE | Proposal #20: Consider to introduce new timeline or offset in case of PUSCH collision handling with different priority. |
| OPPO | ***Proposal 16: To support multiplexing UCI in one PUSCH with different priority, the ending symbol used for UCI transmission in a low-priority PUSCH is not later than the ending of high-priority PUCCH.***   * ***If the condition is not met, UE behavior fallbacks to Rel-16 prioritization.*** |
| TCL | **Proposal 8: Multiplexing for UCI and PUSCH with different priorities should only be allowed when the ending symbol of multiplexed PUSCH is no later than the ending symbol of high-priority UCI.** |
| Xiaomi | ***Proposal 4: The R15 multiplexing timeline can be reused for PUCCH/PUSCH with different priorities.*** |
| ITRI | **Proposal 2:**  The UE can multiplex HP UCI in a LP PUSCH only if the processing time of HP UCI is sufficient. Otherwise, the UE should not perform the multiplexing and the LP PUSCH should be dropped.  **Proposal 3:**  The HP UCI should only multiplexed on a set of LP PUSCH resource even if the LP PUSCH is configured with frequency hoping, and the set of PUSCH resource is selected from the first DMRS symbol of the LP PUSCH that can satisfy the timeline requirement.  **Proposal 4:**  To ensure the acknowledgement response validity, a UE should perform the multiplexing procedure only if the ending symbol of PUSCH/PUCCH resource for multiplexed UCI transmission is not later than the ending symbol of PUCCH for the higher priority UCI. |
|  |  |

## Other enhancements

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 14: For multiplexing LP HARQ-ACK with type 1 HARQ-ACK codebook on HP PUSCH, LP HARQ-ACK is not transmitted if DAI\_UL is 0.*** |
| Samsung | **Proposal 20: A UE does not expect to multiplex a HP HARQ-ACK in a LP PUSCH which would be canceled by UL CI.** |
| LGE | **Proposal #17: Consider how to determine the priority of CG-UCI and how to encode the CG-UCI payload in case of UCI multiplexing on NR-U CG PUSCH with different priority.**  Proposal #21: Consider enhanced collision handling between HP PUSCH and LP PUSCH with UCI piggybacking. |
| Intel | **Proposal 16: CG-UCI is regarded as high priority and can be multiplexed in a similar manner as HP HARQ-ACK into PUSCH.**  **Proposal 17: If both HP and LP HARQ-ACK are to be multiplexed into CG-PUSCH that includes CG-UCI, CG-UCI is jointly encoded with HP HARQ-ACK with same beta offset.** |
| DCM | **Proposal 10:**  Regarding prioritization for transmission power reduction, any PUSCH including HP HARQ-ACK has the same priority for power allocation as HP PUCCH including HARQ-ACK and/or SR, or HP PUSCH including HARQ-ACK. |
| ETRI | **Proposal 8: UCI into a PUSCH with different priorities can be applied to any type.**  **Proposal 9: The CG-UCI has an additional field whether or not to multiplex HP UCI and LP UCI.**  **Proposal 10: For HARQ-ACK codebook construction, sub-slot based HARQ-ACK codebooks are concatenated, and may be transmitted for PUSCH repetition.**  **Proposal 11: Further discuss how to adjust the power of PUSCH for payload from the other priority.** |
| WILUS | ***Proposal 9:*** *In case of HP-PUSCH or LP-PUSCH contains LP HARQ-ACK and HP HARQ-ACK, it should be discussed how to indicate the presence of LP HARQ-ACK and/or HP HARQ-ACK to be multiplexed.* |
|  |  |

# PHY prioritization between DG and CG PUSCHs with different priorities

## Agreements and discussion status in previous meetings

In Rel-16, it was agreed in the RAN1 #98b meeting that the HP PUSCH can puncture the LP PUSCH. However, this agreement was re-discussed in the RAN1 101-e meeting, and only the prioritization of two CG PUSCHs with different priorities was agreed while there was no consensus on the prioritization of DG PUSCH and CG PUSCH with different priorities. In the RAN1 #101-e meeting, the following proposals are provided.

|  |
| --- |
| **Proposal from Feature Lead**   * For collision handling between high priority CG and low priority DG, down-select following options.   + Option 1: define a UE capability for collision handling between the CG and DG with different priorities in PHY layer.     - If UE supports the capability, PHY layer can make the prioritization so that the UE is expected to transmit the PUSCH corresponding to the configured grant, and cancel the PUSCH transmission scheduled by the PDCCH at latest starting at the first symbol of the PUSCH corresponding to the configured grant.     - Otherwise, MAC layer should make the prioritization so that only one MAC PDU is delivered to PHY layer.   + Option 2: re-use Rel.15 timeline, MAC layer should make the prioritization so that only one MAC PDU (e.g. the one with higher priority) is delivered to PHY layer.     - Supported by QC, Intel, LG, Apple   + Option 3: PHY layer can make the prioritization so that the UE is expected to transmit the PUSCH corresponding to the configured grant, and cancel the overlapping low priority PUSCH scheduled by the PDCCH at latest starting at the first symbol of the PUSCH corresponding to the configured grant.     - Supported by Nokia, NSB, Huawei/HiSilicon, CATT, NEC, MTK, ZTE * No PHY collision handling necessary if MAC does not generate a PDU for the CG. * PHY does not expect MAC to generate a PDU for a later, lower-priority, CG PUSCH, which overlaps with an earlier, higher-priority, DG PUSCH.   **Proposal from Feature Lead**   * For collision handling between high priority DG and low priority CG, down-select following options:   + Option 1: Define a UE capability for collision handling between the CG and DG with different priorities in PHY layer.     - If a UE supports the capability, the UE is expected to cancel the overlapping low priority CG by the first overlapping symbol at the latest. Further, a UE expects that the first [overlapping] symbol of the high priority DG is not earlier than Tproc,2+d1 after the last symbol of the PDCCH with the DCI format scheduling the high priority DG.     - Otherwise, the UE can only cancel the entire PUSCH transmission corresponding to the configured grant starting in a symbol 𝑗, if the end of symbol 𝑖 for PDCCH scheduling the PUSCH is at least 𝑁2 symbols before the beginning of symbol 𝑗.   + Option 2: Rel.15 timeline is reused to support cancellation of the low priority CG PUSCH.     - A UE is not expected to be scheduled by a PDCCH ending in symbol *i* to transmit a high priority DG PUSCH on a given serving cell overlapping in time with a transmission occasion, where the UE is allowed to transmit a CG PUSCH with low priority, starting in a symbol *j* on the same serving cell if the end of symbol *i* is not at least *N2* symbols before the beginning of symbol *j*.   + Option 3: PHY layer can make the prioritization so that the UE is expected to cancel the overlapping low priority CG PUSCH by the first overlapping symbol at the latest. Further, a UE expects that the first [overlapping] symbol of the high priority DG PUSCH is not earlier than *T*proc,2+d1 after the last symbol of the PDCCH with the DCI format scheduling the high priority channel. * No PHY collision handling necessary if MAC does not generate a PDU for the CG. |

In the RAN1 #102-e and #103-e meetings, the following agreement was achieved.

Agreements:

*Support PHY prioritization for the case where low-priority DG-PUSCH collides with high-priority CG-PUSCH in R17.*

* *FFS details*
* *Clarify R16 baseline if needed.*

Agreements:

*Support PHY prioritization of overlapping high-priority dynamic grant PUSCH and low-priority configured grant PUSCH on a BWP of a serving cell in R17.*

* *FFS the related cancelation behavior for the PUSCH of lower PHY priority and other details.*
  + *First clarify what is the scope of this feature, e.g. if overlapping between more than 2 channels is considered.*
* *FFS the timeline requirements.*
  + *First clarify what is the behavior of Rel-16 UE in case of DG/CG/UCI overlapping, with and without uplink skipping enabled.*
* *FFS UE capability for this feature.*
* *Note: The main bullet has been agreed in the WID by RAN Plenary.*
* *FFS details*
* *Clarify R16 baseline if needed.*

## Collision handling between LP DG-PUSCH and HP CG-PUSCH

## Inputs from Tdocs

* Option 1: For collision between HP CG PUSCH and LP DG PUSCH, PHY layer can make the prioritization so that the UE is expected to transmit the CG PUSCH and cancel the overlapping DG PUSCH at latest from the first symbol that is overlapping with the CG PUSCH.
  + HW, ZTE, Nokia, Samsung, Intel, MTK, vivo
* Option 2: Handled by UE implementation.
  + Xiaomi

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 21: For collision between HP CG PUSCH and LP DG PUSCH, PHY layer can make the prioritization so that the UE is expected to transmit the CG PUSCH and cancel the overlapping DG PUSCH at latest from the first symbol that is overlapping with the CG PUSCH.*** |
| E/// | [Proposal 12 MAC may send two PDUs to two overlapping grants only if the later grant has higher PHY priority than the earlier grant.](#_Toc84035012)  [Proposal 15 When *lch-basedPrioritization* is configured, Rel-16 UL skipping related procedure is not enabled in Rel-17.](#_Toc84035015)  [Proposal 16 For the scenario of HP DG vs LP CG, reuse Rel-15 timeline.](#_Toc84035016)  [Proposal 17 For the scenario of LP DG vs HP CG, it is up to UE implementation to perform the DG/CG prioritization.](#_Toc84035017) |
| ZTE | ***Proposal 27:*** *For the overlapping between HP CG and LP DG, PHY layer can make the prioritization so that the UE is expected to transmit the PUSCH corresponding to the configured grant, and cancel the overlapping low priority PUSCH scheduled by the PDCCH at latest starting at the first symbol of the PUSCH corresponding to the configured grant.* |
| Nokia | **Proposal 2.1: RAN1 to resume the discussions on the WI objective on ‘overlapping CG & DG PUSCH of different priorities’ in RAN1#106bis-e to guarantee the completion of this WI objective in Rel-17.**  ***Observation 2.1: For the scenarios CG PUSCH vs. DG PUSCH of different PHY priorities, the aspects related to handling the cases where a PUCCH overlaps with at least one of the overlapping PUSCHs and the impact of uplink skipping can be discussed after reaching a conclusion on the related Rel-16 discussions***  **Proposal 2.2: For the scenario high-priority CG PUSCH vs. low-priority DG PUSCH, it is up to UE implementation to ensure that the low-priority DG PUSCH is cancelled, at the latest, from the first symbol that is overlapping with the high-priority CG PUSCH.** |
| Samsung | **Proposal 26: If transmission of a CG-PUSCH with priority 1 starts after a transmission of a DG-PUSCH with priority 0 from a UE on a same serving cell and the two PUSCHs overlap, the UE is expected to cancel the DG-PUSCH before the first overlapping symbol.** |
| Intel | **Proposal 1: UE is expected to transmit the CG PUSCH and cancel the overlapping DG PUSCH at the latest from the first symbol that is overlapping with the CG PUSCH when collision between HP CG PUSCH and LP DG PUSCH occurs.**  **Sufficient to capture the above in RAN1 specification.**  **Proposal 19: Further discuss whether to support LP and HP PUSCH multiplexing into a HP CG PUSCH.** |
| Apple | **Proposal 14-1: Clarify the Rel-16 UE behavior concerning DG/CG transmission.** |
| MTK | The UE is expected to transmit the HP-CG PUSCH and cancel the overlapping LP-DG PUSCH scheduled by the PDCCH starting at latest at the first symbol of the CG PUSCH. |
| vivo | ***Proposal 16: For collision handling between high priority CG and low priority DG, the UE is expected to transmit the PUSCH corresponding to the configured grant, and cancel the overlapping low priority PUSCH scheduled by the PDCCH at the first overlapping symbol of the PUSCH corresponding to the configured grant at the latest.*** |
| DOCOMO | **Proposal 16:**   * *Wait for Rel-16 discussion outcome on DG PUSCH/CG PUSCH/UCI collision handling*   + *If only one MAC PDU is delivered to PHY for all the collision cases, no need to further discuss PHY prioritization between DG PUSCH and CG PUSCH with different priorities.* |
| Xiaomi | ***Proposal 7:*** ***The case of HP CG-PUSCH overlapping with LP DG-PUSCH should be handled by UE implementation.*** |
|  |  |

## 1st round discussion

Proposal for 1st round discussion:

For collision between HP CG PUSCH and LP DG PUSCH, PHY layer can make the prioritization so that the UE is expected to transmit the CG PUSCH and cancel the overlapping DG PUSCH at latest from the first symbol that is overlapping with the CG PUSCH.

|  |  |
| --- | --- |
| Company | Comments |
| Lenovo/Motorola Mobility | Fine with the proposal. |
| QC | We are fine with this proposal.  For the other case where HP DG overlap with LP CG, additional UE processing time is needed on top of Rel-16 cancellation timeline. |
| Ericsson | Support. |
| DOCOMO | Not support.  Based on the Rel-16 discussions, there is no conclusion that two MAC PDUs are transferred to PHY layer for the collision between HP CG PUSCH and LP DG PUSCH. For example, the following scenario has been discussed; where the MAC entity is configured with *lch-basedPrioritization*, and there is collision between CG and DG with the same/different L1 priority, and there is also collision between PUCCH and the CG or DG with the same L1 priority. For this scenario, it was discussed whether the RAN 2 WAs that the MAC entity does not generate a MAC PDU for a deprioritized uplink grant even when its associated PUSCH is overlapping with PUCCH is confirmed in RAN1. However, no conclusion has been made. More details can be found in R1-2102151, R1-2106025 and R1-2108461.  As a result of the discussion, if only one MAC PDU is transferred to PHY in the case, the proposal is not needed. |
| Nokia/NSB | Support. |
| ITRI | Fine with the proposal. |
| ZTE | Fine with the proposal. |
| Sharp | Support the proposal. |
| Huawei/Hisi | Support |
| Samsung | Support |
| Quectel | Support |
| InterDigital | Support |
| Xiaomi | We can compromise to this proposal. But still has the understanding that the HP CG-PUSCH may in fact has nothing to transmit in the CG-PUSCH, and at this case cancelling LP-PUSCH is a loss. |
| CATT | We support the proposal. |
| NEC | Support. |
|  |  |

## 2nd round discussion

Proposal for 2nd round discussion (for email approval):

For collision between HP CG PUSCH and LP DG PUSCH, PHY layer can make the prioritization so that the UE is expected to transmit the CG PUSCH and cancel the overlapping DG PUSCH at latest from the first symbol that is overlapping with the CG PUSCH.

|  |  |
| --- | --- |
| Supporting companies: | Samsung, InterDigital, CATT, Quectel, NEC, vivo, Huawei/Hisi, Nokia/NSB, ZTE, Sharp |
| Objecting companies: | QC (not objecting, but request a clarification), DOCOMO (not strongly objecting but request a modification), LG (not objecting but would like to ask the necessity and use cases) |
| Company | Reason for objection |
| QC | The wording on “cancel the overlapping DG PUSCH” may lead to a wrong interpretation that UE has to transmit the non-overlapping DG PUSCH, which is very problematic.  To clarify, we suggest the following editorial change:  For collision between HP CG PUSCH and LP DG PUSCH, PHY layer can make the prioritization so that the UE is expected to transmit the CG PUSCH and cancel the ~~overlapping~~ DG PUSCH at latest ~~from~~ on the first symbol that is overlapping with the CG PUSCH. |
| DOCOMO | We can compromise to this proposal if the following modification is applied.  Proposal for 2nd round discussion (for email approval):  For collision between HP CG PUSCH and LP DG PUSCH, if MAC delivers two MAC PDUs to PHY, PHY layer can make the prioritization so that the UE is expected to transmit the CG PUSCH and cancel the overlapping DG PUSCH at latest from the first symbol that is overlapping with the CG PUSCH.  As we commented in the 1st round, cases that two MAC PDUs is delivered to PHY have not been agreed. The overlapping cases that have been discussed in Rel-16 can be categorized into two cases; 1) CG PUSCH and DG PUSCH are overlapping and no collision with PUCCH, and 2) CG PUSCH and DG PUSCH are overlapping and either of them or both of them overlap(s) with PUCCH. For the 1st case, the following agreement was made in RAN1#103-e to agree the understanding of RAN2 in R2-2008599, which is also cited below:  RAN1#103-e   |  | | --- | | **Agreement**  Send an LS to RAN2 to convey the following:   * For the collision scenario between CG and DG with same/different PHY-priority index, if there is no collision between PUCCH and the CG and there is no collision between PUCCH and the DG , the behavior mentioned in the LS is consistent with RAN1’s understanding if taking into account the TP to Rel-16 TS 38.214, i.e., revision CR in [R1-2008655](file:///C:/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008655.zip). * When the MAC entity is configured with lch-basedPrioritization, for the collision scenario between CG and DG with same/different PHY-priority index, and when there is collision between PUCCH and the CG with the same priority and/or there is collision between PUCCH and the DG with the same priority, RAN1 is still discussing the related PHY layer behavior.   LS is endorsed in [R1-2009680](file:///C:/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2009680.zip). |   RAN2 LS, R2-2008599   |  | | --- | | RAN2 would like to thank RAN1 for the LS R1-2005078 in which the supported scenarios for intra-UE prioritization in PHY are further clarified.  RAN2 has agreed in RAN2#107 that  For the case when no PDU has been generated at all yet, and there are two grants where one will be de-prioritized (and there is data available for both grants), one PDU is generated by MAC.  This agreement means that in the collision scenario between CG and DG with same/different PHY-priority index, and only one transport block is delivered to PHY, PHY transmit on the grant for which a transport block is delivered and skip the transmission on the other grant.  It is not clear from the wording in the LS R1-2005078 if the PHY behavior described above is consistent with RAN1 understanding. |   According to the RAN1 agreement and the RAN2 agreement above, it is understood that only one MAC PDU (i.e. transport block) is delivered to PHY when CG PUSCH and DG PUSCH of different priorities are overlapping without PUCCH collision. Therefore, the FL proposal that we are discussing here is not needed for the 1st case because PHY prioritization is meaningless as only one PDU is delivered to PHY. On the other hand, there has been no conclusion/agreement whether more than one PDUs are delivered to PHY in the 2nd case.  The reason why we have objected the proposal is uncertainty of the actual use cases supported in the spec, but if there would be such a case, we are fine with the UE behavior on the FL proposal. Therefore, if the modification is reflected, we can accept the proposal. |
| LG | Now it is clarified that UE always (regardless of L2/3 behavior) prioritizes HP CG PUSCH when HP CG PUSCH is overlapping with the first symbol of DG PUSCH based on the proposal above. Then, we are wondering why gNB schedules such DG PUSCH which to be cancelled eventually. In our view, gNB should avoid such scheduling since it is clearly a waste of PDCCH resources unless partial PUSCH transmission is supported. (if LP DG PUSCH is followed by HP CG PUSCH, DG PUSCH resource can be shortened not to overlap. If HP CG PUSCH is followed by LP DG PUSCH, gNB should not schedule such LP PUSCH meaningless)  Otherwise, as DoCoMo mentioned, if the proposal is preparing the case of two MAC PDU scenario, we are fine the proposal. |
| Ericsson | To avoid the confusion pointed out by QC, the following is suggested:  “…cancel the ~~overlapping~~ DG PUSCH at latest starting from the first symbol that is overlapping with the CG PUSCH”  This also means that DG PUSCH is not resumed even if the later part of DG PUSCH does not overlap with CG PUSCH. |
|  |  |
|  |  |

## 3rd round discussion

Proposal for 3rd round discussion:

For collision between HP CG PUSCH and LP DG PUSCH, if MAC delivers two MAC PDUs to PHY, PHY layer can make the prioritization so that the UE is expected to transmit the CG PUSCH and cancel the ~~overlapping~~ DG PUSCH at latest ~~from~~ on the first symbol that is overlapping with the CG PUSCH.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support the proposal with minor update.  We prefer to change back to “from” or as Ericsson had proposed ‘starting from’, i.e.  “For collision between HP CG PUSCH and LP DG PUSCH, if MAC delivers two MAC PDUs to PHY, PHY layer can make the prioritization so that the UE is expected to transmit the CG PUSCH and cancel the ~~overlapping~~ DG PUSCH at latest from ~~on~~ the first symbol that is overlapping with the CG PUSCH.” |
| Intel | We’re fine with the proposal. Suggested modification by Nokia/NSB is also fine. |
| InterDigital | Fine with proposal. Prefer modification by Nokia/NSB. |
| Apple | Given the complicated discussion, we don’t want to agree on something on a hypothetical situation |
| Huawei/Hisi R3 | Support Nokia’s version |
| Ericsson | Support with editorial change. Either Nokia edits, or “starting from” |
| QC | We are fine with the spirit of the proposal. If go with Nokia’s revision, we can revert back to original FL proposal in the irst round and add a note to clarify what does UE do the the non-overlapping part of the DG PUSCH.  For collision between HP CG PUSCH and LP DG PUSCH, if MAC delivers two MAC PDUs to PHY, PHY layer can make the prioritization so that the UE is expected to transmit the CG PUSCH and cancel the overlapping DG PUSCH at latest from the first symbol that is overlapping with the CG PUSCH.  Note: For the DG PUSCH, it is up to UE implementation to handle the OFDM symbols which are nonoverlapping with the HP CG PUSCH. |
| Samsung | Support. |
| Sharp | Support with Nokia’s changes. |
| ZTE | Support with Nokia’s changes. |
| Quectel | Support Nokia’s version |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Collision handling between HP DG-PUSCH and LP CG-PUSCH

## Inputs from Tdocs

* Option 1: For the overlapping between LP CG and HP DG, PHY layer can make the prioritization so that the UE is expected to cancel the overlapping low priority CG PUSCH by the first overlapping symbol at the latest.
  + Option 1a:The UE expects that the first [overlapping] symbol of the high priority DG PUSCH is not earlier than Tproc,2+d1 after the last symbol of the PDCCH scheduling the DG PUSCH.
    - ZTE, Samsung, MTK, vivo
  + Option 1b: The UE expects to transmit the DG PUSCH no earlier than Tproc,2+d2 after the last symbol of the PDCCH scheduling the DG PUSCH.
    - HW
* Option 2: The Rel-16 handling of the scenarios where a dynamically scheduled high-priority channel overlaps with a low-priority channel is adopted.
  + Nokia, Xiaomi
* Option 3: On top of Rel-16 cancellation time (N2+d1) for PUCCH/PUCCH or PUCCH/PUSCH collision, additional time d2 is needed (which results N2+d1+d2 in total cancellation time) for LP CG-PUSCH and HP DG-PUSCH collision resolution.
  + QC
* Option 4: Per UE capability.
  + Intel

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 22: For collision between HP DG PUSCH and LP CG PUSCH, PHY layer can make the prioritization so that the UE is expected to transmit the DG PUSCH and cancel the CG PUSCH by the first overlapping symbol at the latest.***   * ***The UE expects to transmit the DG PUSCH no earlier than Tproc,2+d1 after the last symbol of the PDCCH scheduling the DG PUSCH.*** * ***The processing time of d2 should be expanded to 3/4 symbols since the cancellation between PUSCHs need more time to prepare.*** |
| ZTE | ***Proposal 28:*** *For the overlapping between LP CG and HP DG, PHY layer can make the prioritization so that the UE is expected to cancel the overlapping low priority CG PUSCH by the first overlapping symbol at the latest. Further, a UE expects that the first [overlapping] symbol of the high priority DG PUSCH is not earlier than Tproc,2+d1 after the last symbol of the PDCCH with the DCI format scheduling the high priority channel.* |
| Nokia | **Proposal 2.1: RAN1 to resume the discussions on the WI objective on ‘overlapping CG & DG PUSCH of different priorities’ in RAN1#106bis-e to guarantee the completion of this WI objective in Rel-17.**  ***Observation 2.1: For the scenarios CG PUSCH vs. DG PUSCH of different PHY priorities, the aspects related to handling the cases where a PUCCH overlaps with at least one of the overlapping PUSCHs and the impact of uplink skipping can be discussed after reaching a conclusion on the related Rel-16 discussions***  **Proposal 2.3: The Rel-16 handling of the scenarios where a dynamically scheduled high-priority channel overlaps with a low-priority channel is adopted for the scenario of overlapping between high-priority DG PUSCH and low-priority CG PUSCH.** |
| QC | ***Proposal 19:* On top of Rel-16 cancellation time (N2+d1) for PUCCH/PUCCH or PUCCH/PUSCH collision, additional time d2 is needed (which results N2+d1+d2 in total cancellation time) for LP CG-PUSCH and HP DG-PUSCH collision resolution. The additional number of OFDM symbols (d2) needed is listed in following table**  Table 3. d2 for LP CG-PUSCH and HP DG-PUSCH collision resolution   |  |  | | --- | --- | |  | d2 [symbols] | | **0** | **1** | | **1** | **2** | | **2** | **4** | | **3** | **8** | |
| Samsung | **Proposal 27: If transmission of a DG-PUSCH with priority 1 starts after a transmission of a CG-PUSCH with priority 0 from a UE on a same serving cell and the two PUSCHs overlap, a UE is expected to cancel the CG-PUSCH before the first overlapping symbol.** |
| LGE | Proposal #19: Consider to apply Rel-15 timeline requirements between dynamic grant and configured grant, for PHY prioritization for the case where low-priority CG-PUSCH collides with high-priority DG-PUSCH. |
| Intel | **Proposal 2. Define a new UE capability for collision handling between the LP CG and HP DG PUSCH in PHY layer.**   * **If UE supports the capability, the UE is expected to cancel the overlapping low priority CG PUSCH by the first overlapping symbol at the latest. Further, the UE expects that the first symbol of the high priority DG PUSCH is not earlier than Tproc,2+min(d1,d2) after the last symbol of the PDCCH with the DCI format scheduling the high priority DG PUSCH, where d1 and d2 can be from {0, 1, 2} symbols, and correspond to the additional margins for cancelation and preparation times respectively in case of intra-UE prioritization and reported as UE capability.** * **Otherwise, the UE can only cancel the entire PUSCH transmission corresponding to the configured grant starting in a symbol 𝑗, if the end of symbol 𝑖 for PDCCH scheduling the PUSCH is at least Tproc,2 before the beginning of symbol 𝑗.** |
| MTK | 1. Support PHY prioritization for the case where high-priority DG-PUSCH collides with low-priority CG-PUSCH. 2. The UE is expected to transmit the HP-DG PUSCH and cancel the overlapping LP-CG PUSCH. Further, the UE expects that the first overlapping symbol of the high priority DG is not earlier than Tproc,2+d1 after the last symbol of the PDCCH scheduling the HP-DG PUSCH. |
| vivo | ***Proposal 17: For collision handling between high priority DG and low priority CG, the UE is expected to cancel the overlapping low priority CG PUSCH by the first overlapping symbol at the latest. Further, a UE expects that the first overlapping symbol of the high priority DG PUSCH is not earlier than Tproc,2+d1 after the last symbol of the PDCCH with the DCI format scheduling the high priority channel, where d1 is determined by a reported UE capability.*** |
| DOCOMO | **Proposal 16:**   * *Wait for Rel-16 discussion outcome on DG PUSCH/CG PUSCH/UCI collision handling*   + *If only one MAC PDU is delivered to PHY for all the collision cases, no need to further discuss PHY prioritization between DG PUSCH and CG PUSCH with different priorities.* |
| Xiaomi | ***Proposal 8:*** ***For LP CG-PUSCH overlaps with HP DG-PUSCH, related cancelation behaviour for LP CG-PUSCH defined in R16 can be reused.*** |
|  |  |

## 1st round discussion

Proposal for 1st round discussion:

For the overlapping between LP CG and HP DG, PHY layer can make the prioritization so that the UE is expected to cancel the overlapping low priority CG PUSCH by the first overlapping symbol at the latest.

* The UE expects that the first [overlapping] symbol of the high priority DG PUSCH is not earlier than Tproc,2+d1 after the last symbol of the PDCCH scheduling the DG PUSCH.

|  |  |
| --- | --- |
| Company | Comments |
| Lenovo/Motorola Mobility | Support the proposal. |
| QC | We object this proposal. Like we commented in multiple meetings, for UE to support this feature, additional processing time on top of Tproc,2+d1 is needed. The reason UE needs additional time is very straightforward: cancelling an ongoing PUSCH transmission is more complicated than cancelling a PUCCH. The timeline Tproc,2+d1 was budgeted only for cancelling a PUCCH, which is not sufficient for UE to cancel a PUSCH.  We have the following proposal in our submitted Tdoc R1-2110181. Without additional processing time, we cannot accept this proposal.  ***Proposal 19:* On top of Rel-16 cancellation time (N2+d1) for PUCCH/PUCCH or PUCCH/PUSCH collision, additional time d2 is needed (which results N2+d1+d2 in total cancellation time) for LP CG-PUSCH and HP DG-PUSCH collision resolution. The additional number of OFDM symbols (d2) needed is listed in following table**  Table 2. d2 for LP CG-PUSCH and HP DG-PUSCH collision resolution   |  |  | | --- | --- | |  | d2 [symbols] | | **0** | **1** | | **1** | **2** | | **2** | **4** | | **3** | **8** | |
| Ericsson | Support.  We are also OK to make agreement on the main proposal, and leave the bullet (processing time related issue) as FFS |
| DOCOMO | Not support. Same comment as 5.2.2. Based on the Rel-15/16 discussions, there is no conclusion that two MAC PDUs are transferred to PHY layer for the collision between LP CG PUSCH and HP DG PUSCH. If only MAC PDU is transferred to PHY in the case, the proposal is not needed. |
| Nokia/NSB | Support the proposal in principle, and we are OK to further discuss whether different/additional timeline extension would be needed on top of Rel-16’s. |
| ITRI | Support the proposal. |
| ZTE | Fine with the proposal. |
| Sharp | Support the proposal. |
| Huawei/Hisi | Do not support. The current value of *d*2 is designed for PUCCH and PUSCH cancelation, and has to be expanded into 0/1/2/3/4 symbols to fit the timeline for PUSCH and PUSCH cancelation. |
| Samsung | Support |
| Quectel | Support |
| InterDigital | Support |
| Xiaomi | Support the proposal. |
| CATT | We support the proposal. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# Simultaneous x-CC PUCCH/PUSCH transmissions for inter-band CA

## Agreements in previous meetings

Agreements:

*Support simultaneous PUCCH/PUSCH transmissions on different cells at least for inter-band CA.*

* *FFS how to trigger this function.*
* *FFS for intra-band CA.*

Agreements:

*Per UE with the capability of inter-band CA, simultaneous PUCCH/PUSCH transmission of different PHY priorities over different cells can be RRC configured within the same PUCCH group*

* *FFS: dynamic indication*

## How to trigger this function?

## Inputs from Tdocs

Support dynamic indication?

* Yes:
  + E/// (RRC + dynamic disable)
* No
  + Nokia, CATT, QC, LGE, Spreadtrum, TCL

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| E/// | [Proposal 2 Support simultaneous PUCCH/PUSCH transmission of same PHY priorities over different cells can be RRC configured within the same PUCCH group](#_Toc79181279)  [Proposal 3 When simultaneous PUCCH/PUSCH transmissions is enabled by RRC configuration, simultaneous PUCCH/PUSCH transmissions can be dynamically disabled.](#_Toc79181280) |
| Nokia | **Proposal 4.5: For UE with the capability of inter-band CA, simultaneous PUCCH/PUSCH transmission over different cells can be triggered via higher layer signalling (e.g. RRC signalling).** |
| CATT | ***Proposal 19: Dynamic indication of simultaneous PUCCH/PUSCH transmission is not supported.*** |
| MTK | 1. Simultaneous PUCCH/PUSCH transmissions is enabled based on specific conditions. E.g. LP-PUCCH carrying HARQ feedback. |
| Spreadtrum | 1. ***Support RRC configuration for simultaneous PUCCH/PUSCH transmission.*** |
| TCL | **Proposal 9: Dynamic indication for simultaneous PUCCH/PUSCH should not be supported.** |
|  |  |

## Use cases for simultaneous PUCCH/PUSCH transmission

## Support simultaneous PUCCH/PUSCH transmission of same PHY priority?

#### Inputs from Tdocs

* Yes:
  + CATT, QC, MTK
* No:
* Nokia, Intel, DCM

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Nokia | **Proposal 4.3: The simultaneous transmission of PUCCH and PUSCH on different serving cells is applicable only for the case when PUCCH and PUSCH are of different PHY priority.** |
| CATT | ***Proposal 20: Simultaneous PUCCH/PUSCH transmission of same PHY priority over different cells for inter-band CA can be supported*** |
| QC | ***Proposal 2:* Clarify the agreement made in RAN1 102e “Support simultaneous PUCCH/PUSCH transmissions on different cells at least for inter-band CA” applies to PUCCH/PUSCH with same or different priorities.**  ***Proposal 22:* Update the description of the RRC parameter of “simultaneousPUCCH-PUSCH” as the following.**   * **Parameter indicates whether simultaneous PUCCH and PUSCH transmissions with different priorities is configured.** * **~~Note: Still FFS whether the feature is supported for same priority.~~** * **Note: Still FFS whether the same or a separate RRC parameter is used to configure simultaneous PUCCH/PUSCH transmissions with a same priority** * **Note: Still FFS whether the feature is supported for intra-band CA.** |
| Intel | **Proposal 21: Discussion on support of simultaneous transmission of PUSCH and PUCCH over different carriers for intra-band CA and simultaneous transmission of PUSCH and PUCCH for the same priority is deprioritized.** |
| MTK | 1. Per UE with the capability of inter-band CA, simultaneous PUCCH/PUSCH transmission of the same PHY priority over different cells can be RRC configured within the same PUCCH group. |
| DCM | **Proposal 17:**   * *Not to introduce the simultaneous PUCCH and PUSCH transmission for same priority case.* |
|  |  |

## Support simultaneous PUSCH/PUCCH transmission for intra-band CA or not?

#### Inputs from Tdocs

* Support with conditions
  + E///, CATT, Apple (introducing PTRS for PUCCH to handle phase discontinuity problem), MTK (for some cases),
  + Arguments:
    - In NR Rel-15, multiple PUSCHs transmission on different carries and one among them with the piggy-backed UCI has been already supported for both inter band CA and intra band CA.
* Not support.
  + Nokia, Intel
  + Arguments:
    - Considering the most efficient implementation with a single PA (most likely case of intra-band CA), e.g. Tx discontinuity, Large Tx power back-off.

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| E/// | [Proposal 19 Support intra-band simultaneous PUCCH and PUSCH transmission with UE capability signalling.](#_Toc84035019) |
| Nokia | **Proposal 4.4: For intra-band CA, simultaneous transmission of PUCCH and PUSCH on different cells is not supported.** |
| CATT | ***Proposal 21: Simultaneous PUCCH/PUSCH transmission for intra-band CA can be supported.*** |
| Intel | **Proposal 21: Discussion on support of simultaneous transmission of PUSCH and PUCCH over different carriers for intra-band CA and simultaneous transmission of PUSCH and PUCCH for the same priority is deprioritized.** |
| Apple | **Proposal 15-1: Simultaneous PUCCH/PUSCH transmission for intra-band CA is not supported if phase discontinuity problem cannot be addressed.**  **Proposal 15-2: consider the feasibility of introducing PTRS for PUCCH to handle phase discontinuity problem in simultaneous PUCCH/PUSCH transmissions for intra-band CA.** |
| MTK | 1. Support simultaneous PUCCH/PUSCH transmissions on different cells for intra-band CA for the same numerology both with aligned and non-aligned channel case. 2. Support simultaneous PUCCH/PUSCH transmissions on different cells for intra-band CA for different numerology if the transmissions are aligned on symbol-level (with the symbol of the lowest SCS as a reference).  * i.e. Allocation on the carrier with higher numerology doesn’t start during an ongoing symbol on the other carrier with the smaller numerology.  1. The UE is to be configured separately for inter-band and intra-band simultaneous PUCCH/PUSCH transmissions. |
|  |  |

## Support simultaneous PUSCH/PUCCH transmission on a same cell?

#### Inputs from Tdocs

* No:
  + Apple

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Apple | **Proposal 15-3: Simultaneous PUCCH/PUSCH transmission on the same CC is not supported.** |
|  |  |

#### 1st round discussion

Proposal for 1st round discussion:

Simultaneous PUCCH/PUSCH transmission on the same cell is not supported in Rel-17.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Agree |
| Lenovo/Motorola Mobility | Support the proposal. |
| Intel | Is the intention of the proposal to change conclusion in last meeting to the agreement?  In last meeting, we had the conclusion as below.  **Conclusion**  Simultaneous PUCCH/PUSCH transmission on the same cell is not supported in Rel-17. |
| QC | Since we already have conclusion in last meeting, the proposal is not needed. |
| DOCOMO | Share the same view as Intel. The proposal is not needed since we already have the conclusion. |
| vivo | Share the same view as Intel and DOCOMO. |
| Nokia, NSB | Share the same view with other companies, no need to discuss as the conclusion was already made last meeting. |
| ITRI | Share the same view with Intel, this proposal is not needed. |
| ZTE | We have achieved this conclusion in last meeting. No need to discuss again. |
| Sharp | Support the proposal. |
| Samsung | We share similar view as QC. |
| Quectel | Share the same view as companies above. |
| OPPO | Share view as QC |
| CATT | As commented by Intel and QC, the same conclusion was agreed in the last meeting. |
| NEC | Share the same view with other companies, the proposal is not needed. |
|  |  |

## Other enhancements

## Inputs from Tdocs

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Qualcomm | ***Proposal 1:* Support the PHR for simultaneous PUCCH/PUSCH for inter-band CA with either of the following two options.**   * **Option 1: reuse LTE type 2 PHR for PUCCH transmission on PCC with a virtual/reference PUSCH** * **Option 2: define a type 4 PHR for PUCCH transmission on a component carrier** |
| DOCOMO | **Proposal 18:**   * *Support PHR for simultaneous PUCCH and PUSCH transmission on different carriers.*   **Proposal 19:**   * *Discuss the interaction between capabilities for two PUCCH groups and the new capability for simultaneous PUCCH/PUSCH transmission on different carriers.* |
| TCL | **Proposal 10: PHR for simultaneous PUCCH and PUSCH transmission should be further studied.** |

# References

1. [R1-2108628](file:///C:/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2007567.zip) Summary#5 of email thread [106-e-NR-R17-IIoT\_URLLC-04] OPPO
2. [R1-2108728](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2108728.zip) Intra-UE multiplexing enhancements Huawei, HiSilicon
3. R1-2108832 Intra-UE Multiplexing/Prioritization Enhancements for IIoT/URLLC Ericsson
4. [R1-2108843](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2108843.zip) Discussion on enhanced intra-UE multiplexing ZTE
5. [R1-2108908](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2108908.zip) Discussion on intra-UE multiplexing/prioritization Spreadtrum Communications
6. [R1-2108969](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2108969.zip) Intra-UE Multiplexing/Prioritization for Rel-17 URLLC vivo
7. [R1-2109096](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109096.zip) Enhancements on intra-UE multiplexing/prioritization OPPO
8. [R1-2109132](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109132.zip) Discussion on Intra-UE prioritization and multiplexing NEC
9. [R1-2109160](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109160.zip) On UL intra-UE prioritization and multiplexing enhancements Nokia, Nokia Shanghai Bell
10. [R1-2109218](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109218.zip) Intra-UE multiplexing and prioritization CATT
11. [R1-2109260](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109260.zip) Discussion on Intra-UE Multiplexing/Prioritization Quectel, Langbo
12. [R1-2109355](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109355.zip) Intra-UE multiplexing and prioritization TCL Communication Ltd.
13. [R1-2109408](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109408.zip) Intra-UE multiplexing prioritization for URLLC IIoT Xiaomi
14. [R1-2109454](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109454.zip) Discussion on Intra-UE multiplexing of different priority Panasonic Corporation
15. [R1-2109484](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109484.zip) Uplink intra-UE multiplexing and prioritization Samsung
16. [R1-2109577](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109577.zip) Methods for intra-UE multiplexing and prioritization MediaTek Inc.
17. [R1-2109607](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109607.zip) Further details of intra-UE uplink channel multiplexing and prioritization Intel Corporation
18. [R1-2109674](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109674.zip) Discussion on intra-UE multiplexing/prioritization for Rel.17 URLLC NTT DOCOMO, INC.
19. [R1-2109730](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109730.zip) Intra-UE multiplexing and prioritization InterDigital, Inc.
20. [R1-2109785](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109785.zip) Considerations on intra-UE UL multiplexing Sony
21. [R1-2109811](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109811.zip) Intra-UE Multiplexing/Prioritization ETRI
22. [R1-2109943](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109943.zip) Intra-UE multiplexing enhancement for IIoT/URLLC Lenovo, Motorola Mobility
23. [R1-2109973](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109973.zip) Discussion on Intra-UE multiplexing/prioritization LG Electronics
24. [R1-2109995](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2109995.zip) Enhancements of channel collision resolution and intra-UE UCI multiplexing on PUCCH and PUSCH Sharp
25. [R1-2110030](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2110030.zip) Rel-17 URLLC intra-UE multiplexing/prioritization Apple
26. [R1-2110181](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2110181.zip) Intra-UE multiplexing and prioritization for IOT and URLLC Qualcomm Incorporated
27. [R1-2110245](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2110245.zip) Discussion on intra-UE multiplexing and prioritization ITRI
28. [R1-2110324](file:///D:/Documents/3GPP%20documents/RAN1/TSGR1_106b-e/Docs/R1-2110324.zip) Discussion on intra-UE multiplexing/prioritization for URLLC/IIoT WILUS Inc.