3GPP TSG RAN WG1 #106bis-e R1-210xxxx

e-Meeting, October 11th – 19th, 2021

Source: Moderator (OPPO)

Title: Summary#2 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.~~ |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# 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. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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 . 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 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# 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 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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.