3GPP TSG RAN WG1 #106-e R1-2108274

e-Meeting, August 16th – 27th, 2021

Source: Moderator (OPPO)

Title: Summary#1 of email thread [106-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.

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

* 1st check point: August 19
* 2nd check point: August 25
* 3rd check point: August 27

# 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*

## Potential frameworks

From E/// Tdoc:



**Figure 1: Rel-17 A1 and A2 candidate frameworks for Intra-UE multiplexing of overlapping PUCCHs/PUSCHs**



**Figure 2: Rel-17 B1 and B2 candidate frameworks for simultaneous PUCCH/PUSCH transmission of overlapping PUCCHs/PUSCHs. In case of B1, B2 is discarded and vice-versa**.

Figure 3: Rel-17 A1-B1, A2-B1 and A2-B2 candidate frameworks for intra-UE multiplexing of overlapping PUCCH/PUSCH enabled with simultaneous PUCCH/PUSCH. In case of B1, B2 is discarded and vice-versa.



Figure 4: Examples of overlapping resolution of PUCCHs/PUSCHs in a PUCCH group with single carrier based on different candidate frameworks



Figure 5: Examples of overlapping resolution of PUCCHs/PUSCHs in a PUCCH group with inter-band carriers based on different candidate frameworks

From Apple Tdoc:

Diagram

Description automatically generated

Figure 2 Alt. 2 of Rel-17 UCI multiplexing flow

## Proposals from Tdocs

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| Company | Proposals/observations from Tdocs |
| Ericsson | [Observation 1 Without a common understanding on the overall framework of the expected procedures, detailed solutions are difficult to agree.](#_Toc79181275)  [Observation 2 The different candidate frameworks are A1, A2, B1, B2 and their combinations. B2 and A2-B2 seem most promising from a gain and complexity analysis,](#_Toc79181276)  [Observation 3 The complexity of potential features for multiplexing UCI with different priority in PUCCH/PUSCH is a large consideration.](#_Toc79181277)  [Proposal 1 When simultaneous PUCCH and PUSCH transmission is supported, perform UCI multiplexing on PUCCH and PUSCH per priority before considering simultaneous PUCCH and PUSCH transmission, i.e. A2-B2.](#_Toc79181278)   1. Resolve overlapping between PUCCH resources based on Rel-15 procedures where the overlapping is resolved starting from the first set of mutually overlapping PUCCH resources in a slot (a.k.a. set Q) until there are no overlapping PUCCH resources in the slot. 2. To determine a single PUCCH resource for a set of mutually overlapping PUCCH resources with different priority, drop SR and CSI of low priority, if any. Then, use sub-slot PUCCH resources if there is a sub-slot HARQ-ACK PUCCH in the set, starting from the earlier and smaller sub-slot. |
| HW | ***Proposal 22: Support flexible UE capability configuration on handling inter-priority multiplex/prioritization:***   * ***1) Rel-16 inter-priority prioritization and Rel-15 intra-priority multiplexing.*** * ***2) Rel-17 inter-priority multiplexing and Rel-15 intra-priority multiplexing.*** * ***3) Rel-17 inter-priority multiplexing, Rel-16 inter-priority prioritization and Rel-15 intra-priority multiplexing.***   ***Proposal 23: For Rel-17 inter-priority multiplexing order, support the second option, i.e. to handle the multiplexing of overlapped PUCCHs with intra-priority first, and then handle the multiplexing between inter-priority.***  ***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.*** |
| 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)?** |
| ZTE | ***Proposal 15:*** *For handling the scenarios with more than two overlapping PUCCHs of different priorities, 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.*  ***Proposal 16:*** *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.* |
| Samsung | **Proposal 10: The time unit for resolving a collision of PUCCHs with different L1 priority indexes is the HP PUCCH time unit.**   * **FFS an associated HP PUCCH time unit for LP HARQ-ACK PUCCH if it overlaps with multiple HP PUCCH time units.**   **Proposal 11: 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 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.**   **Proposal 13: Intra-UE multiplexing is performed in the following order**   * **Step1: Resolve overlapping PUCCH(s) and/or PUSCH(s) with same priority index.** * **Step2: Resolve overlapping PUCCH(s) and/or PUSCH(s) with different priority indexes.**   **Proposal 16: 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.** * **The LP PUSCH with (HP) HARQ-ACK should not be canceled by a HP PUSCH or a HP SR PUCCH.** |
| vivo | ***Proposal 20: To avoid the dropping of LP UCI, the multiplexing order may need be reconsidered.***  ***Proposal 21: 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 22: 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.*** |
| 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 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.*** |
| OPPO | ***Proposal 11: 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 12: 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;*** * ***Cancel the LP PUCCH does not satisfy the multiplexing timeline conditions (Rel-16 cancellation timeline should be satisfied).***   ***Proposal 13: 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 14: 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.*** |
| LGE | **Proposal #6: Consider the overall procedures for the inter-priority multiplexing of UCIs on PUCCH/PUSCH.**   * **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 #7: Consider the following approach as the procedure for the inter-priority multiplexing of UCIs on PUCCH/PUSCH, in order to avoid/reduce dropping of UCI (and loss of PUSCH code rate) and timeline checking complexity.**   * **The intra-priority multiplexing defined in Rel-16 is applied per each of LP PUCCH/PUSCH and HP PUCCH/PUSCH as the first step.** * **As the second step, the inter-priority multiplexing is performed for the outcomes of the first step, specifically between the (intra-priority) multiplexed LP PUCCH/PUSCH and the (intra-priority) multiplexed HP PUCCH/PUSCH.** |
| Intel | **Proposal 17: Instead of two-step approach, consider a single checking step among all channels for** **multiplexing of UCIs of different priorities into a PUCCH resource if UE supports intra-UE multiplexing across different priorities.**  **Proposal 18: When UCIs of different priorities overlap and if at least one is based on a DCI, UE may drop the low priority UCI and transmit the high priority UCI, when timeline conditions are not satisfied.**  **Proposal 19: If a PUSCH overlaps with two sub-slot based PUCCHs, multiplex the UCIs from the PUCCHs onto the PUSCH if timeline conditions are met. If timeline conditions are not met, drop the low priority channel and transmit the high priority channel.**   * **FFS: whether to apply Rel16 intra-UE prioritization in this case.**   **Proposal 20: If a PUCCH overlaps with two PUSCHs, following behaviors can be considered, assuming timeline conditions are met:**   * **If PUCCH is of high priority, PUCCH is multiplexed onto first PUSCH.** * **If first (second) PUSCH is of high (low) priority, UCI from PUCCH is multiplexed onto second PUSCH if the PUCCH is of low priority.**   **Proposal 21: If a PUSCH overlaps with a PUCCH repetition in a slot, multiplex the UCI onto the PUSCH and drop the PUCCH repetition.**   * **FFS whether this is only applicable if PUSCH is of high priority and/or PUCCH is of low priority.**   **Proposal 22: If UE is configured with both simultaneous PUSCH and PUCCH transmissions over different carriers and Rel16 or Rel17 intra-UE prioritization, option of simultaneous transmissions should take precedence over the intra-UE prioritization.** |
| Apple | **Proposal 2-1: Study alternatives with introducing an inter-L1 priority PUCCH multiplexing with PUCCH resources Z as inputs.** |
| Pana | **Proposal 8: For multiplexing a high-priority HARQ-ACK and a low-priority HARQ-ACK into a PUCCH, after resolving the overlapping for PUCCH transmissions of same priority index, UE procedure for multiplexing HARQ-ACK codebooks with different priority indexes should be performed.** |
| 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).*** |
| TCL | **Proposal 4: Regarding the scenario of multiplexing more than two overlapping channels, one checking/multiplexing step between channels of different priorities after multiplexing/prioritization (if any) between overlapping channels of the same priority is already done should be further studied.** |
| ETRI | **Proposal 2: Multiplex HP UCI, and check to multiplex each LP UCI at earliest order.** |
| NEC | ***Proposal 3:*** *Further study the order of prioritization or multiplexing for collision cases involving PUSCH and PUCCH with different priorities when simultaneous PUCCH/PUSCH transmission of different priorities over different cells is configured.* |
| DCM | **Proposal 13:**  For overlapping of more than two PUCCHs/PUSCHs with same and different priorities, two options should be considered for muliplexings:   * Option 1: Resolve overlapping among HP and LP PUCCHs first. Then resolve PUCCH and PUSCH overlapping. * Option 2: Resole overlapping among UL channels with the same priority (as in Rel-16) first. Then resolve overlapping among different priorities.   **Proposal 14:**  For the case when one PUCCH overlaps with multiple PUSCHs of the different priority, how to select the multiplexed PUSCH needs to be discussed.  **Proposal 15:**  For the case when one PUCCH including HP and LP UCI overlaps with multiple HP and LP PUSCHs , how to multiplex HP and LP UCI needs to be discussed.  **Proposal 16:**  For the case when one HP/LP PUCCH overlapping with a LP/HP PUCCH overlaps with LP/HP PUSCH(s) simultaneously, multiplexing behavior needs to be clarified.  **Proposal 17:**   * *Discuss processing order of intra-UE multiplexing with different priorities and cancellation due to dynamic SFI/UL CI/semi-static TDD and SSB.* |
| MTK | Proposal 3: Multiplexing allowed only if the resulted PUCCH is confined within the sub-slot of the HP-PUCCH sub-slot. |
| Moto/Leno | * **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. |

## 1st round discussion

Proposal for 1st round discussion:

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:

* The time unit of high priority PUCCH is used as the time unit for multiplexing of low-priority PUCCH and high-priority PUCCH. (assuming the time unit of HP PUCCH is equal to or smaller than that of LP PUCCH.)
* FFS: How 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. Options under consideration include:
  + Option 1: The low priority PUCCH performs multiplexing or dropping procedure in the first overlapping time unit that contains high priority PUCCH.

Proposal for 1st round discussion:

For R17 intra-UE multiplexing, the following order is performed:

* Step1: Resolve overlapping between channels with same priority.
* Step2: Resolve overlapping between channels with different priorities.

Proposal for 1st round discussion:

For handling the scenarios with more than two overlapping PUCCHs of different priorities, consider the following options:

* Option 1: Use R15 multiplexing as baseline, i.e. a single checking/multiplexing step among all channels.
* Option 2: 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.
* Other options are not excluded.
* Note: the candidate cases should be identified first.

Proposal for 1st round discussion:

If simultaneous PUCCH/PUSCH over different cells is configured, further study the following options:

* Option 1:
  + The PUCCH/PUSCH on different cells are transmitted simultaneously
  + The PUCCH/PUSCH on a same cell are multiplexed, following the same procedure with simultaneous PUCCH/PUSCH disabled.
* Option 2:
  + Perform PUCCH/PUSCH multiplexing per priority per PUCCH group
  + If an overlap still happens on the same cell or cells within the same band, the LP PUCCH/PUSCH is dropped.
  + Then perform simultaneous PUCCH/PUSCH over different cells.
* Option 3:
  + Performs PHY multiplexing decision for low priority channels – and determines the final LP UL transmission.
  + The UE determines the overlapping of the resulting LP channel with HP PUCCH/PUSCH before and/or after HP UL channel multiplexing across all serving cells.
  + Based on the overlapping determination, the UE cancels the resulting LP channel if overlapping with a HP channel across all serving cells of the same band.
* Other options are not excluded.

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| Company | Comments |
| Lenovo, Motorola Mobility | Fine with the first proposal.  For the second proposal, we think that a UE, first, should identify all overlapping PUCCHs of different priorities, and secondly, determine a PUCCH resource of a higher priority based on multiplexing/dropping rules for different types of UCI of different priorities (e.g. drop LP CSI, multiplex LP HARQ-ACK and LP SR).  For the third proposal, we support Option 1, “Use R15 multiplexing as baseline, i.e. a single checking/multiplexing step among all channels.”  For the fourth proposal, we support Option 1. |
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# 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.*

## 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, E///, Nokia, ZTE, vivo, QC, OPPO, Intel, DCM, Quectel
  + Option 2: Reuse R15 TS 38.212 Clause 5.3.3.3, i.e., padding to 3 bits and using RM coding.
    - Samsung, LGE, Spreadtrum, CATT
* **Rate matching** 
  + HP A/N reuses the rate matching equation of Rel-15 A/N+CSI-1. LP A/N reuses the rate matching equation of Rel-15 CSI-2.
    - HW, Nokia, ZTE, vivo, QC, Pana, CATT
  + Enhanced rate matching
    - OPPO, Quectel
* **RE mapping**
  + Reuse R15 TS 38.212 Sec. 6.3.1.6 for PUCCH format 3/4. 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.
    - Nokia, ZTE, Samsung, QC, CATT
  + Distributed RE mapping for HP UCI and LP UCI



* + - HW, LGE
* **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.
    - Nokia, ZTE,vivo, QC, Quectel, Sony, Apple (for LP CSI)
  + Option 2: Drop CSI part 2 if CSI would multiplex on a PUCCH which has HP A/N.
    - LGE, DCM
* **Separate code rate configurations:**
  + Option 1: An additional maxCodeRate for LP HARQ-ACK can be configured in the second PUCCH-Config.
    - Samsung, vivo, QC, Intel, Sony, Leno/Moto, Spreadtrum, Quectel
  + Option 2: Reuse maxCodeRate in the first PUCCH-Config for LP HARQ-ACK.
    - HW, Nokia, ZTE, LGE, DCM
* **Enhanced power control:**
  + HW: Further study BPRE calculation
  + QC: Two open-loop power control P0 values are configured for multiplexing LP and HP UCI
  + OPPO: Enhance the determination of 
  + Apple
  + IDC: UE utilizes a normalized UCI payload size for calculating payload-dependent factor of PUCCH transmission power.

|  |  |
| --- | --- |
| 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.***   * ***Support separate code rates 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***,   * ***HP HARQ-ACK can reuse the encoder and rate matching equation of Rel-15 HARQ-ACK+CSI part 1.*** * ***LP HARQ-ACK can reuse the encoder and rate matching equation of Rel-15 CSI part 2.*** * ***For the encoding method of HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support Option 1, i.e., 1 bit repetition code and 2 bits simplex code.***   ***Observation 1: It is feasible to consider 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.***  ***Proposal 6: The code rate configured in the first PUCCH-config should be reused for LP HARQ-ACK transmission under the case of HP HARQ-ACK and LP HARQ-ACK multiplexing.*** |
| E/// | [Proposal 9 For 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) |
| 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, adopt the following:**   * **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.**   **Proposal 3.7: Confirm the RAN1#104bis-e Working Assumption to not support multiplexing of CSI (include 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, reuse Rel-15 operation for two UCI parts to determine the rate matching output sequence length for each of the high-priority HARQ-ACK and low-priority HARQ-ACK.**  **Proposal 3.9: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK resulting from the overlap between high-priority PUCCH resource and low-priority PUCCH resource:**   * **the maxCodeRate configured for the selected high-priority PUCCH resource for multiplexing should be used as maxCodeRate for the high-priority HARQ-ACK; and** * **the maxCodeRate configured for the low-priority PUCCH resource could be used as maxCodeRate for low-priority HARQ-ACK.**   + **If the low-priority PUCCH resource is with Format 0/1, use the maxCodeRate (for low-priority HARQ-ACK) associated to the low-priority PUCCH resource corresponding to a low-priority HARQ-ACK payload size of 3 bits.**   **Proposal 3.10: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 3/4, adopt the Rel-15 operation of ‘multiplexing of coded UCI bits to PUCCH’ given in TS 38.212 Sec. 6.3.1.6.**  **Proposal 3.11: 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.** |
| 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.*  ***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:*** *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, confirm the RAN1#104b-e meeting working assumption as:*   * *Drop LP CSI (including part 1 and part2, if exist) if the CSI would multiplex on the PUCCH.*   ***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,*   * *Let HP A/N reuse the encoder, rate matching equation, and RE mapping rules in Rel-15 for A/N+CSI-1.* * *Let LP A/N reuse the encoder, rate matching equation, and mapping rules in Rel-15 for CSI-2.*   ***Proposal 5:*** *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,*   * *Rel-15 can be the baseline for rate matching and RE mapping rules for PF3/4.* * *Coded bits of HP HARQ-ACK and LP HARQ-ACK are continuously mapped in the time-frequency resources for PF2.*   ***Proposal 6:*** *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, R15 design is reused without power boosting.*  ***Proposal 7:*** *The maxCodeRate configuration in Rel-16 is reused for multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in Rel-17.* |
| 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: For PRB determination and RE mapping when multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH**   * **Reuse Rel-15 rules of separate coding in a PUCCH format 3/4.** * **Drop LP HARQ-ACK if the 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: When multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH:**   * **Reuse the *maxCodeRate* configured in the second *PUCCH-Config* for HP HARQ-ACK.** * **A separate *maxCodeRate* for LP HARQ-ACK is provided by the second *PUCCH-Config* per PUCCH format.** |
| vivo | ***Proposal 2: 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), option 1 is slightly 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: Confirm the working assumption that drop CSI (including part 1 and part2, if exist) if CSI would multiplex on a PUCCH which has HP A/N.***  ***Proposal 4: The following principle should be baseline for UCI multiplexing with different priorities***   * ***HP A/N reuse the encoder, rate matching equation, and RE mapping rules in Rel-15 for A/N+CSI-part 1.*** * ***LP A/N reuse the encoder, rate matching equation, and mapping rules in Rel-15 for CSI-part 2.***   ***Proposal 5: For both HP and LP A/N on PUCCH, two maximum code rates are configured for each PUCCH format corresponding to HP and LP HARQ-ACK, respectively.*** |
| 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.*** 2. ***For separate coding of the two HARQ-ACKs with HARQ-ACK bits being more than 2, the maxcoderate for HP and LP HARQ-ACK can be different.*** 3. ***The minimum PRB number for HP HARQ-ACK and LP HARQ-ACK can be separately determined based on Rel-15 rule by using the maxcoderate configured for HP HARQ-ACK and LP HARQ-ACK separately.*** |
| CATT | ***Proposal 3: 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 4: For separate coding of HP HARQ-ACK and LP HARQ-ACK when multiplexing on a PUCCH resource with PUCCH format 3 or PUCCH format 4:***   * ***Let HP HARQ-ACK reuse the rate matching equation, and RE mapping rules in Rel-15 for A/N+CSI part 1;*** * ***Let LP HARQ-ACK reuse the rate matching equation, and mapping rules in Rel-15 for CSI part 2.***   ***Proposal 5: 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 1*: Confirm the working assumption in the following.**  **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.**   ***Proposal 2*: 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,**   * **With >2 bits HP A/N payload, HP A/N reuse the encoder, rate matching equation, and RE mapping rules in Rel-15 for A/N+CSI part 1. With <=2 bits HP A/N, HP A/N use repetition encoding (for 1 bit) or simplex encoding (for 2 bits), reuse rate matching equation, and RE mapping rules in Rel-15 for A/N+CSI part 1.** * **With >2 bits LP payload, LP A/N reuse the encoder, rate matching equation, and RE mapping rules in Rel-15 for CSI part 2. With <= 2 LP payload, LP A/N use repetition encoding (for 1 bit) or simplex encoding (for 2 bits), reuse rate matching equation, and RE mapping rules in Rel-15 for CSI part 2.** * **FFS: rate matching and RE mapping for HP and LP HARQ-ACK multiplexed on PUCCH format 2**   ***Proposal 3*: 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**   * **Support gNB to configure coding rates separately for HP and LP HARQ-ACK.** * **For a given priority, support gNB to configure multiple coding rates for HARQ-ACK based on the payload size.**   ***Proposal 7*: 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** |
| 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.***  ***Proposal 5: The rate matching output sequence lengths for HP HARQ-ACK and LP HARQ-ACK should be determined as follows***  ***Proposal 6:*** ***Except the determination of the number of PRBs for PUCCH transmission and the rate matching output sequence lengths for HP HARQ-ACK and LP HARQ-ACK, other Rel-15 procedures for multiplexing HARQ-ACK and CSI should be reused.***  ***Proposal 7: When multiple code rates are supported for different priorities in a PUCCH, the determination of***  ***to calculate the PUCCH transmission power should be enhanced.*** |
| 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.**   **Proposal #10: Consider to reuse the existing maximum UCI coding rate (configured for LP UCI on LP PUCCH) for the LP UCI multiplexed on HP PUCCH.** |
| Intel | **Proposal 4: 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 5: A pair of *maxCodeRate* values per PUCCH format canbe configured to UE for UCI multiplexing of different priorities into PUCCH.**  **Proposal 6: At least PUCCH format 3 and 4 are supported for LP and HP HARQ-ACK multiplexing**   * **FFS: PUCCH format 2** |
| 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 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.** |
| Pana | **Proposal 1: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH, when the total number of LP and HP HARQ-ACK bits are more than 2 bits, rate matching equation in Rel.15/16 is baseline.**  **Proposal 3: A single *maxCodeRate* is configured per PUCCH format for HP + LP HARQ-ACK multiplexing.** |
| IDC | ***Proposal 8: The UE utilizes a normalized UCI payload size for calculating payload-dependent factor of PUCCH transmission power.*** |
| Sony | **Proposal 1: Confirm the following working assumption:**  **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.**   * **Drop CSI (including part 1 and part2, if present) if CSI would multiplex on a PUCCH which has HP A/N.**   **Proposal 2: Separate *maxCodeRate* is configured for HP and LP UCIs.**  **Proposal 3: Encoded UCI symbols for HP UCI are mapped to earlier OFDM symbols of the PUCCH whilst those for LP UCI are mapped to later OFDM symbols.** |
| Quectel | **Proposal 1**: 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 2**: Option 1 is supported, i.e., repetition coding or simplex coding is adopted for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s) when the total number of HP or LP HARQ-ACK bits multiplexed on the PUCCH is larger than 2.  **Proposal 3**: Placeholder bits “y” are introduced for the scrambling of PUCCH.  **Proposal 4**: Rate matching output sequence lengths respectively for HP HARQ-ACK and LP HARQ-ACK are computed based on a coding rate  configured by the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK when the total number of HP or LP HARQ-ACK bits multiplexed on the PUCCH is larger than 2.  **Proposal 5**: A set of candidate values dedicated for HP HARQ-ACK and LP HARQ-ACK rate matching is supported when HP and LP HARQ-ACK bits are multiplexed on a PUCCH and the total number of HP and LP HARQ-ACK bits is larger than 2. |
| 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.* |
| FGI/APT | Proposal 4 For multiplexing LP HARQ-ACK and HP HARQ-ACK on a PUCCH format 0, HARQ-ACK values to CS indices mapping with unequal distance between mapped CS indices should be supported. |
| 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.*   **Proposal 4:**   * *For separate coding, a scaling factor can be introduced for HP and LP UCI coding rate determination.* |
| Leno/Moto | * **Proposal 4:** Support indicating two values of *maxCodeRate*, a first value for HP UCI and a second value for LP UCI in a PUCCH configuration corresponding to a high priority index, in order to support different coding rates for HP UCI and LP UCI that are multiplexed in a PUCCH. |
| WILUS | * ***Proposal 1****. To determine a code rate for LP HARQ-ACK for multiplexing, consider the following two options.*   + *Option 1. Additional code rate for LP HARQ-ACK in a HP PUCCH format is configured by RRC.*   + *Option 2. Code rate configured in LP PUCCH format is reused.* * ***Proposal 2:*** *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 3:*** *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 4:*** *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 6:*** *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.

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,

* 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.

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, an additional maxCodeRate for LP HARQ-ACK can be configured in the second PUCCH-Config per PUCCH format.

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| Company | Comments |
| CATT | 1. For repetition coding or simplex coding, placeholder bits are used and the placeholder bits are not scrambled by the scrambling bit sequence to maintain the maximized Euclidean distance. The scrambling design for PUCCH in current specification does not take the placeholder bits into account. Therefore, we prefer padding to 3 bits and using RM coding to avoid modification of the scrambling design for PUCCH. We would like to clarify whether the proponents of the 1st proposal propose to modify the scrambling design for PUCCH to take the placeholder bits into account as for PUSCH. 2. We support the 2nd proposal. 3. For the 3rd proposal, we would like to better understand the necessity and benefit of introducing new RRC configuration. |
| Quectel | 1st Proposal, support, for reasons: 1) Performance gains as shown by simulation results in R1-2104329; 2) lower overhead; 3) more flexible to control effective coding rate hence smaller specification impact (the scrambling for PUSCH could be directly reused for PUCCH).  2nd Proposal, support;  3rd Proposal, we are generally OK for this proposal, but we think this should be discussed in Section 3.4.2. In our understanding, the additional maxCodeRate is not used for HP and LP rate matching and RE mapping. The second Proposal effectively implies that a single code rate is used for HP and LP rate matching and RE mapping (that is the case in Rel-15). The single code rate should be the one configured for HP HARQ-ACK in the second PUCCH-Config.  We suggest to discuss this proposal in Section 3.4.2 and replace it with a new 3rd proposal as below:  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, a single maxCodeRate configured in the second PUCCH-Config is used to calculate rate matching output sequence lengths, i.e.,  for HP HARQ-ACK and  for LP HARQ-ACK   * FFS whether Rel-16  is reused. |
| Panasonic | We support the above three proposals.  On the third proposal, we think maxCodeRate will be used for PRB determination of PUCCH, and therefore it would be merit to have controllable parameter (i.e., additional maxCodeRate) for multiplexing case. |
| Lenovo, Motorola Mobility | Fine with the 1st proposal. |
| Apple | Fine with the first proposal. |
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## Multiplexing enable/disable mechanism

## Inputs from Tdocs

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

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|  | | 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. |

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| 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 4 In case of overlapping between PUCCH and/or PUSCH resources in a slot with different priorities, dynamically enabling or disabling UCI multiplexing on PUCCH or PUSCH is supported.](#_Toc79181281) |
| Nokia | **Proposal 3.1: The gNB dynamically indicates, via an explicit field in the DCI scheduling high-priority 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 high-priority HARQ-ACK does not have a corresponding PDCCH, the multiplexing is not supported.** |
| ZTE | ***Proposal 8****: 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 9****: 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.* |
| vivo | ***Proposal 16: Dynamic indication of intra-UE multiplexing and prioritization manner can be supported in Rel-17.***  ***Proposal 17: For dynamic indication, multiplexing or prioritization indication field can be included in DCI for HP or LP or both HP and LP service.*** |
| 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 on a PUCCH/PUSCH of a second priority are configurable by the network.** |
| Spreadtrum | 1. ***For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH, support RRC configuration to enable/disable the multiplexing as a baseline. RRC+DCI-based enabling/disabling method can be considered as an optional feature.*** |
| CATT | ***Proposal 11: Semi-static RRC configuration to enable/disable the multiplexing between channels with different priorities is supported.*** |
| QC | ***Proposal 20:* The Rel-17 intra-UE multiplexing feature is enabled/disabled via RRC configuration on per UE basis.** |
| LGE | **Proposal #8: Consider RRC configuration for the mechanism to enable/disable the multiplexing of HP HARQ-ACK and LP HARQ-ACK on PUCCH or the multiplexing of HARQ-ACK on PUSCH with different priority, with consideration of potential UE complexity and UCI/PUSCH reliability.** |
| Intel | **Proposal 9: DCI triggering HARQ-ACK may include an indication for enabling or disabling multiplexing.**   * **The indication may be applicable to both HARQ-ACK/HARQ-ACK and HARQ-ACK/SR multiplexing.** |
| FGI/APT | Proposal 3 Dynamic indication is supported for indicating whether to multiplex overlapping high priority PUCCH and low priority PUCCH. |
| China Telecom | **Proposal 1: For multiplexing UCI/PUSCH with different priorities on PUCCH or PUSCH in R17, support RRC configuration to enable/disable the multiplexing at least.** |
| Pana | **Proposal 7:**   * **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 7: The gNB dynamically enables/disables multiplexing in an HP PUCCH by an indication in the DL Grant scheduling the HP PUCCH.**  **Proposal 8: When a HP PUCCH scheduled by multiple DL Grants overlap with LP HARQ-ACKs, the decision to multiplex the HP & LP HARQ-ACKs is determined by the indicator in the last DL Grant scheduling the HP PUCCH.** |
| Quectel | **Proposal 9**: Dynamic enabling/disabling by DCI for HARQ-ACK multiplexing on PUCCH with different priorities is supported on top of RRC configuration. |
| TCL | **Proposal 1: Support explicit indication to enable multiplexing procedure between HP UCI and LP UCI via RRC configuration.** |
| 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.*** |
| Sharp | **Proposal 2: Multiplexing of UCI of different priorities on PUCCH, and different scenarios of UCI multiplexing on PUSCH can be separately enabled/disabled by RRC configuration.** |
| DOCOMO | **Proposal 7:**   * *RRC configuration should be baseline for enabling/disabling multiplexing of LP and HP PUCCH* |
| MTK | Proposal 1: Dynamic indication of the multiplexing activation/de-activation is not supported.   1. Guard gap timeline of the new multiplexed PUCCH is of the earliest PUCCH. |
| ETRI | **Proposal 1: 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.**  **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.** |

## 1st round discussion

Proposal for 2nd 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.

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| Company | Comments |
| CATT | Support the proposal. |
| Quectel | We can accept this proposal for the sake of progress, although our first preference is to agree the DCI indication together with RRC. |
| Panasonic | We are fine with the proposal. In addition, we prefer to introduce dynamic enabling/disabling the multiplexing via explicit indication. This can avoid additionally introducing mechanism for multiplexing such as reliability and/or latency requirement. |
| Lenovo, Motorola Mobility | Fine with the proposal. |
| Apple | Fine with the proposal. |
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## 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).
  + Nokia, ZTE, Intel, Pana, IDC, Leno/Moto, Quectel, Sharp, ETRI

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|  | | 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. |  |

**UCI payload size for PUCCH resource set selection**

* Option 1: UCI payload size = the number of HP UCI bits + the number of LP UCI bits
  + ZTE, Samsung, LGE, Intel, Sony, Quectel
* Option 2: UCI payload size = the number of HP UCI bits + the number of LP UCI bits \* scaling factor.
  + vivo, Apple, DCM, Pana, IDC, FGI/APT, ETRI, Quectel

**PRB number determination**

* HW: 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.
* QC: 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.
* Pana: Determination of the number of PRBs does not depend on the number of LP HARQ-ACK bits.
* CATT: 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 .*

**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, vivo, Pana
* 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, Intel (in combination with Option 4), Quectel
* 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), LGE, DCM, China Telecom, FGI/APT, CATT (FFS whether it is semi-static), Quectel
* 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), LGE, Intel (in combination with Option 3a), FGI/APT, CATT
* 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), China Telecom, FGI/APT

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| 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 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, TCL, MTK, WILUS
* Option 2: LP HARQ-ACK is dropped.
  + HW
* 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

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 7: 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 8: Support a group of dedicated PUCCH sets in the second PUCCH-Configuration to carry the multiplexed HP HARQ-ACK and LP HARQ-ACK.*** |
| 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 3.4: 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 3.5: For the scenario where a PUCCH carrying high-priority HARQ-ACK overlaps with another PUCCH carrying low-priority HARQ-ACK: If the high-priority HARQ-ACK does not have a corresponding PDCCH, the multiplexing is not supported.**  **Proposal 3.12: Further discuss the selection of PUCCH resource set and the number of RBs for the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK.**  ***Observation 3.1: Errors in low-priority HARQ-ACK codebook size determination may cause selection of different PUCCH resource set or use of smaller number of RBs for the multiplexed high-priority and low-priority HARQ-ACKs feedback than what gNB would expect.***  **Proposal 3.13: To avoid discrepancy between the UE and the gNB on the determination of PUCCH resource set and number of RBs 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.** * **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 included in the high-priority DL assignment.**   ***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.*** |
| ZTE | ***Proposal 10****: 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 11****: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, UCI payload size for PUCCH resource determination is determined as the total number of HP UCI bits + LP UCI bits*  ***Proposal 12：****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.* |
| Samsung | **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).** |
| vivo | ***Proposal 6: A scaling factor to determine a target reference UCI payload size should be considered for PUCCH resource set selection due to the different code rates for HP and LP UCI. The scaling factor can be a function of code rate for HP and LP UCI.***  ***Proposal 11：For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, option 1 are preferred***   * ***Option 1: Configure a dedicated PUCCH resource for HP+LP in the second PUCCH-Config*** |
| CATT | ***Proposal 10: 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 4*: 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.**  ***Proposal 5*: For HP HARQ-ACK and LP HARQ-ACK multiplexing on a PUCCH, the PUCCH resource set is determined based on a weighted sum of the LP and HP HARQ-ACK payload size**  **where**   * **is the payload size of the HP HARQ-ACK** * **is a reference payload size for the LP HARQ-ACK, which is obtained by round up the LP HARQ-ACK size to a nearest reference size as in Proposal 6** * **is a weight factor** * **FFS: how to signal/determine the weigh factor .**   ***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.** |
| 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 8: If a PUCCH carrying HP dynamic HARQ-ACK overlaps with a PUCCH carrying LP HARQ-ACK, a PUCCH resource in the PUCCH resource set configured for HP dynamic HARQ-ACK is used to transmit HP dynamic HARQ-ACK and LP HARQ-ACK.***  ***Proposal 9: 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 16: 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.*** |
| LGE | **Proposal #11: Consider to determine HP PUCCH resource set based on the total UCI payload size of HP UCI and LP UCI as done so far.**  **Proposal #12: 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 #13: 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 #18: 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.** |
| Intel | **Proposal 3: 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 7: 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:**  **UCI payload size = the number of HP UCI bits + the number of LP UCI bits** |
| Apple | **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.** |
| China Telecom | **Proposal 3: Support option 3b configuring by RRC semi-static size reservation for LP HARQ-ACK payload or option 5 indicating the PUCCH resource set index by DCI for PUCCH resource set determination.**  **Proposal 4: To deal with ambiguity on LP HARQ-ACK existence,**   * **for 1-bit LP HARQ-ACK and 1-bit HP HARQ-ACK multiplexed in PF0, CS=0, 3, 6, 9 is mapped to (HP HARQ-ACK, LP HARQ-ACK)=(NACK, NACK), (NACK, ACK), (ACK, NACK), (ACK,ACK);** * **for 1-bit LP HARQ-ACK and 1-bit HP HARQ-ACK multiplexed in PF1, (HP HARQ-ACK, LP HARQ-ACK) is QPSK modulated using .** * **for the multiplexing of LP HARQ-ACK and HP HARQ-ACK with larger than 2 total bits, reserved PUCCH resource for HP LP multiplexing in the second PUCCH-Config is considered.** |
| Sony | **Proposal 4: The UCI payload size used for PUCCH Resource Set selection is the number of HP UCI bits + the number of LP UCI bits (i.e. Option 1).**  **Proposal 5: Do not consider options that increases PUCCH resources or introduce additional PUCCH resources to solve the CB size misalignment between gNB and UE for multiplexing HARQ-ACKs of different L1 priorities into Type 2 HARQ-ACK CB.**  **Proposal 6: For multiplexing HARQ-ACKs of different L1 priorities into a Type 2 HARQ-ACK CB, the gNB indicates the DAI value of the last DL Grant associated with the LP HARQ-ACKs in a HP DL Grant when multiplexing these HARQ-ACKs of different L1 priorities into the Type 2 HARQ-ACK CB.** |
| Pana | **Proposal 2: Determination of the number of PRBs does not depend on the number of LP HARQ-ACK bits.**  **Proposal 4: 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 5: In case the total number of LP and HP HARQ-ACK bits is more than 2, dedicated PUCCH resource is configured for multiplexing of HP HARQ-ACK and LP HARQ-ACK.**  **Proposal 6: UCI payload size for PUCCH resource determination is the number of HP UCI bits + the number of LP UCI bits \* scaling factor.** |
| Quectel | **Proposal 6**: 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. FFS enhancements to ensure the reliability of HP HARQ-ACK.  **Proposal 7**: **Alt 1** (i.e., LP HARQ-ACK is used as HP UCI) or **Alt 2** (i.e., an equivalent UCI bit size for HP HARQ-ACK and LP HARQ-ACK) is considered for the PUCCH resource determination in case the total number of LP and HP HARQ-ACK bits multiplexed on a PUCCH is larger than 2.  **Proposal 8**: A reference LP type 2 HARQ-ACK codebook size is used for PUCCH resource set determination and/or PUCCH resource determination. How to determine the reference size is FFS. |
| TCL | **Proposal 2: If the total UCI bits exceed the payload of the multiplexed PUCCH resource, partially dropped low priority UCI and/or compressed/bundled low-priority HARQ-ACK should be supported.** |
| ETRI | **Proposal 2: The LP DCI determines the final PUCCH resource in at least for the HP SPS case.**  **Proposal 3: Multiplex HP UCI, and check to multiplex each LP UCI at earliest order.**  **Proposal 4: Further study how to adjust the power of PUCCH for payload from the other priority.** |
| FGI/APT | **Proposal 2 Further consider the following options to resolve the issue of DCI miss detection.**  **- 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.**  **- 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.**  **- 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.** |
| LGE | **Proposal #7: Consider the partial dropping for LP HARQ-ACK according to HARQ-ACK codebook type for the case of exceeding the maximum UCI coding rate on PUCCH.**  **Proposal #8: Discuss and decide at least the following details for PUCCH resource determination based on the agreed HP PUCCH configuration.**   * **How to select one of multiple HP PUCCH resource sets** * **How to determine a PUCCH resource in the selected HP PUCCH resource set**   **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).** |
| 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: The UE determines PUCCH resource set based on a normalized UCI payload size calculated as the sum of the number of high priority bits and the scaled number of low priority bits.***  ***Proposal 9: DCI indicating HP HARQ-ACK includes an indication of the DAI of LP HARQ-ACK.*** |
| ETRI | **Proposal 5: The Option 1 (resource in the second PUCCH-Config) is preferred.**  **Proposal 6: The Option2 (considering a scaling factor for UCI size) is considered.** |
| Sharp | **Proposal 3: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH with separate coding,**   * **Code rate for HARQ-ACK with different priorities are determined based on existing or additional maxCoderate parameters, or separate scaling factor configurations.** * **A HP PUCCH resource is selected based on a derived effective payload.** |
| DOCOMO | **Proposal 3:**   * *For the problem of ambiguity on LP HARQ-ACK existence or LP HARQ-ACK type 2 codebook size due to DCI miss-detection, support Option 3b.*   + *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.*   **Proposal 5:**   * *For separate coding, an effective UCI payload size is introduced for PUCCH resource selection and PRB determination procedure, where is determined by HP UCI payload size, LP UCI payload size, HP UCI coding rate for multiplexing, LP UCI coding rate for multiplexing, and also additional CRC bits introduced by separate coding.*   **Proposal 6:**   * *For PRB determination for separate coding, introduce the following procedure:*   + *If ,*      - *PRB number is determined as the minimum number of , satisfying ;*   + *Otherwise,*      - *PRB number is determined as .* |
| MTK | Group-bundling is supported when multiplexing and when the resulted UCI payload is large. |
| 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 5:** 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. |
| WILUS | ***Proposal 5:*** *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 multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, on how to determine UCI payload size for PUCCH resource determination:

* UCI payload size = the number of HP UCI bits + the number of LP UCI bits

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| Company | Comments |
| CATT | Given that we have already agreed that the 2 bits are treated as HP HARQ-ACK, is the first proposal still needed?  We support the 2nd proposal. |
| Quectel | 1st Proposal: support  2nd Proposal: We are generally fine with this proposal. We want to clarify that “PUCCH resource determination” includes both PUCCH resource set determination and PUCCH PRB determination. |
| Panasonic | We support the 1st proposal.  On 2nd proposal, we are fine with the proposal assuming *maxCodeRate* is separately configured for HP and LP HARQ-ACK. |
| Lenovo, Motorola Mobility | Fine with both proposals. |
| Apple | We don’t support Proposal 2: as LP HARQ-ACK and HP HARQ-ACK are protected with different coding rates as agreed this morning, it is reasonable to reflect that in PUCCH resource determination. |
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## 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, China Telecom, TCL

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

* Option 1: UE behavior fallbacks to Rel-16 prioritization.
  + Intel, Sharp
* 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

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 9: 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 HP HARQ-ACK.*** |
| QC | ***Proposal 18:* 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.**  ***Proposal 19:* Confirm the working assumption made in #104-e to reuse Rel-15 intra-UE PUCCH/PUSCH multiplexing timeline requirements for Rel-17 intra-UE PUCCH/PUSCH multiplexing with different priorities.** |
| OPPO | ***Proposal 15: 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.*** |
| LGE | **Proposal #5: Consider additional condition for the processing of inter-priority multiplexing and the latency requirement for HP UCI.** |
| China Telecom | **Proposal 2: Multiplexing for channels with different priorities is allowed only when the ending symbol of PUCCH or PUSCH resource carrying the multiplexed UCI is no later than the ending symbol of channel carrying HP traffic.** |
| Intel | **Proposal 16: When UCIs of different priorities overlap and if at least one is based on a DCI, UE may drop the low priority UCI and transmit the high priority UCI, when timeline conditions are not satisfied.** |
| TCL | **Proposal 3: 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.** |
| Sharp | **Proposal 1: Reusing Rel-15 intra-UE PUCCH/PUSCH multiplexing timeline for Rel-17 intra-UE PUCCH/PUSCH multiplexing with different priorities.**  **The Rel-16 dropping rule is reused if the multiplexing timeline requirements are not met.** |
| MTK | 1. Guard gap timeline of the new multiplexed PUCCH is of the earliest PUCCH. |
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## 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.
    - Nokia, ZTE, CATT, China Telecom, Quectel, Sharp, DCM, WILUS
  + Opt.1c: For negative SR, the UE transmits SR and HARQ-ACK on the SR resource
    - Nokia
  + 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.
    - E///, LGE
  + 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, vivo, Intel, 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.
    - Nokia, CATT, China Telecom, Sony, Sharp, DCM
  + Opt.1c: For negative SR, the UE transmits SR and HARQ-ACK on the SR resource
    - Nokia
* 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.
    - E///
  + 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.
    - LGE, 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, 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, vivo, OPPO, Intel, Pana, Spreadtrum, Quectel, 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.
    - 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.
    - LGE
  + 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, vivo, Intel, 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, QC, China Telecom, Quectel, Sharp, DCM, CATT
* Opt.4: No enhancement over Rel-16.
  + Samsung, OPPO, Pana,

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| Company | Proposals/observations from Tdocs |
| E/// | [Proposal 5 When PUCCH with HP SR overlaps with PUCCH with LP HARQ-ACK:](#_Toc79181282)  [ For 1-2 LP HARQ-ACK bits: The PUCCH resource for HARQ-ACK is used for multiplexing of the HP SR and LP HARQ-ACK. If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the HARQ-ACK PUCCH resource (i.e. Opt. 2a).](#_Toc79181283)  [ For more than 2 LP HARQ-ACK bits: Rel-15 rules are used for multiplexing HARQ-ACK and SR in a PUCCH resource. If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the PUCCH resource (i.e. Opt. 2a).](#_Toc79181284)  [Proposal 6 When PUCCH with HP HARQ-ACK/SR overlaps with PUCCH with LP HARQ-ACK:](#_Toc79181285)  [ First, a PUCCH resource set associated to HP HARQ-ACK based on the total number of HP HARQ-ACK/SR and LP HARQ-ACK is determined. Then, a PUCCH resource in the PUCCH resource set to carry both HP and LP HARQ-ACK based on the last DCI corresponding to the HP HARQ-ACK is determined.](#_Toc79181286) |
| HW | ***Proposal 10: 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 11: For multiplexing HP SR and LP HARQ-ACK with PUCCH format 2/3/4,***   * ***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.***   ***Proposal 12: When*** ***a PUCCH format 0 or 1 carrying HP/LP HARQ-ACK overlaps with both a HP SR and a LP SR, drop the LP SR, and multiplex the HP SR and the HP/LP HARQ-ACK.*** |
| Nokia | **Proposal 3.14: 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.** |
| ZTE | ***Proposal 13:*** *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 14:*** *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.* | |
| Samsung | **Proposal 8: Drop LP HARQ-ACK PUCCH when a LP HARQ-ACK PUCCH with PF0/1 overlaps with a HP SR PUCCH.**  **Proposal 9: 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.** |
| vivo | ***Proposal 1: Support multiplexing a high-priority HARQ-ACK and a low-priority SR into a PUCCH in Rel-17.***  ***Proposal 7: 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 8: 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 9: 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 10: Define UCIs of different priorities multiplexing rule at least for the following cases***   * + ***LP HARQ-ACK using PF 1 and HP HARQ-ACK and LP SR using PF 0.***   + ***HP HARQ-ACK using PF 1 and LP HARQ-ACK and HP SR using PF 0.*** |
| 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 or transmitted on the SR resource. 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.*** |
| CATT | ***Proposal 7: 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 8: 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 9: 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 8*: 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 9*: 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 6 and Fig 7.**  ***Proposal 10*: 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.** |
| OPPO | ***Proposal 10: Multiplexing of HP SR and LP HARQ-ACK with more than 2 bits are not supported in Rel-17.***  ***Proposal 17: 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 18: 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 | |
| LGE | **Proposal #15: Consider to support Opt 2b for the combinations of {SR PF0 + HARQ-ACK PF0} and {SR PF0 + HARQ-ACK PF1} and {SR PF1 + HARQ-ACK PF0}, to ensure HP SR reliability as well as to keep PUCCH resource overhead.**  **Proposal #16: Consider to support Opt 2a for the combinations of {SR PF0 + HARQ-ACK PF0} and {SR PF0 + HARQ-ACK PF1} and {SR PF1 + HARQ-ACK PF0}, to guarantee LP HARQ-ACK performance on top of HP SR reliability.** |
| Intel | **Proposal 16:**  **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.   **Collision handling LP SR and HP HARQ-ACKs**   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | **HARQ-ACK with PF0** | **HARQ-ACK with**  **PF1** | **HARQ-ACK with PF2** | **HARQ-ACK with**  **PF3 or PF4** | | SR with PF0 | Multiplexed UCI is transmitted using PF0 on HARQ-ACK resource | Drop SR and transmit HARQ-ACK on HARQ-ACK resource | Multiplexed UCI is transmitted using PF 2 on HARQ-ACK resource if SR is with PF 0. SR is dropped if it is PF 1 | Multiplex HARQ-ACK and SR according to Rel-15 procedure. | | SR with PF1 | SR is dropped | Multiplexed UCI is transmitted using PF 1 on HARQ-ACK resource | |
| China Telecom | **Proposal 5: Resource selection is adopted in Rel-17 when a PUCCH carrying HP SR overlaps with a PUCCH carrying LP HARQ-ACK:**   * **When HP SR is positive, SR resource is used for the transmission.**   + **If SR resource corresponds to PF0, positive HP SR and LP HARQ-ACK are multiplexed using the cyclic shift values the same as in Rel-15.**   + **If SR resource corresponds to PF1, HARQ-ACK is transmitted on the SR resource to indicate the positive SR.** * **When HP SR is negative, the UE transmits only LP HARQ-ACK on the HARQ-ACK resource.** |
| Pana | **Proposal 9: When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, the SR and HARQ-ACK are multiplexed and transmitted on the HARQ-ACK resource.**  **Proposal 10:**   * **When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, 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 11: When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, no enhancement is necessary over Rel.16.**  **Proposal 12:**   * **When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, 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 13:**   * **When a PUCCH carrying HP SR with PF0 or PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF2, 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.**   **Proposal 14:**   * **For multiplexing a LP HARQ-ACK, a HP HARQ-ACK and HP SR into a PUCCH, following two procedures are studied.**   + **Option 1: UE first resolve the overlapping for PUCCH transmission of HP HARQ-ACK and HP SR. After resolving the overlapping, multiplexing of LP HARQ-ACK is handled.**   + **Option 2: How UCIs are concatenated up to certain size is handled as one step procedure, e.g., with the priority of HP HARQ-ACK > HP SR > LP HARQ-ACK.** |
| Sony | **Proposal 9: 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 10: 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 11: 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.** |
| Quectel | **Proposal 17**: 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 18**: 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 19**: 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. |
| Leno/Moto | * **Proposal 2**: For multiplexing a HP SR, 1-bit HP HARQ-ACK, and 1-bit LP HARQ-ACK into a PUCCH, first, determine a PUCCH resource for multiplexing the 1-bit LP HARQ-ACK and the 1-bit HP HARQ-ACK and secondly, multiplex the HP SR (i.e. a positive SR) and HARQ-ACK of mixed priorities according to Rel-15 SR/HARQ-ACK multiplexing rules. * **Proposal 3**: For multiplexing a HP SR and 1- or 2-bit LP HARQ-ACK into a PUCCH, treat the LP HARQ-ACK as HARQ-ACK bits with high priority, determine a HP PUCCH resource for the LP HARQ-ACK, and apply Rel-15 SR/HARQ-ACK multiplexing rules based on the determined HP PUCCH resource. |
| IDC | ***Proposal 10: 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 11: 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 12: 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.*** |
| Sharp | **Proposal 4: When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0,**   * **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 5: 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 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 6: 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, positive HP SR and LP HARQ-ACK multiplexing on the HP SR PUCCH with PF0 can be considered if the HP SR PUCCH PF0 resource is configured with multiple reserved CS values.**   **Proposal 7: 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 if LP SR bits should also be included.**   **Proposal 8: For multiplexing of HP HARQ-ACK, LP HARQ-ACK and SR, the multiplexing order and SR bit generation methods should be further clarified.** |
| DOCOMO | **Proposal 8:**   * *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 9:**   * *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.* |
| WILUS | * ***Proposal 6:*** *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 .* * ***Proposal 7:*** *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 8:*** *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 overlaps with a PUCCH carrying LP HARQ-ACK,

* 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.

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| Company | Comments |
| CATT | It is not clear how the proposal is drawn based on companies’ input. It seems that more companies prefer to multiplex HP positive SR and LP HARQ-ACK on SR resource instead of HARQ-ACK resource. In addition, the proposal is for PF0/1 only according to summary in section 3.6.1. Therefore, We would like to update the proposal as follows.  ~~When a PUCCH carrying~~ For multiplexing of HP SR ~~overlaps with a PUCCH carrying~~ and LP HARQ-ACK with PF0/1,   * If SR is positive, SR is multiplexed on ~~HARQ-ACK~~SR resource ~~in the same way as Rel-15~~. * If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource. |
| Quectel | Similar views as CATT. |
| Panasonic | We would like to clarify whether the proposal is applied to all PUCCH format combinations.  We are fine with the proposal for the following cases:  - PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0  - PUCCH carrying HP SR with PF0 or PF1 overlaps with a PUCCH carrying LP HARQ-ACK with FP2, 3, or 4  For the case when a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, to transmit HP SR and LP HARQ-ACK on the HARQ-ACK resource would increase the latency of SR transmission. Therefore, if the proposal is applied, latency requirement should be introduced.  For the case when a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, the proposal means Rel.15/16 multiplexing behavior for the same priority. However, to transmit HP SR and LP HARQ-ACK on the HARQ-ACK resource would cause the performance degradation since the HP SR is originally to be transmitted on PUCCH format 1. In our view, this case (HP SR is long PUCCH while LP HARQ-ACK is short PUCCH) might be a corner case. Therefore, no enhancement (i.e., drop LP-HARQ-ACK) could be sufficient. |
| Lenovo, Motorola Mobility | For multiplexing a HP SR and 1- or 2-bit LP HARQ-ACK into a PUCCH, we suggest treating the LP HARQ-ACK as HARQ-ACK bits with high priority, determine a HP PUCCH resource for the LP HARQ-ACK, and apply Rel-15 SR/HARQ-ACK multiplexing rules based on the determined HP PUCCH resource. |
| Apple | Please see our comment in Section 4.2.2. If in the end, the LP HARQ-ACK is transmitted (e.g. multiplexed over PUSCH) and is not discarded, the discussion here is meaningful. Otherwise, the discussion is less important. |
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## Other enhancements

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| 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. |
| ETRI | Proposal 3: Further study how to adjust the power of PUCCH for payload from the other priority. |
| DOCOMO | **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.* |
| 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. |
| Ericsson | Rather than spending time to reduce the options for the 3 combinations, it’s more efficient if framework type of issues are addressed first. If we go one by one for each specific combination, it’s time consuming and inefficient.  For example, just for the question of HP SR + LP X, there are still many combinations to go through:   * HP SR + LP HARQ-ACK:   + What to do for HP SR on PF1 and LP HARQ-ACK on PF1?   + What to do for SR on PF0 or PF1, HP HARQ-ACK on PF 2/3/4? * HP SR + HP HARQ-ACK + LP HARQ-ACK: this is agreed to be supported in Rel-17   + If we follow the way the 3 proposals were handled, then all the PF combinations have to be listed, each with possible options, then down-select. * HP SR + LP SR? * HP SR + LP CSI? * HP + LP PUSCH?   Thus, for the HP SR + LP HARQ-ACK, the 3 proposals are preferably combined into one:   * For positive SR, transmit HARQ-ACK on the SR resource. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource. |
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# 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.*

## 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, OPPO, Apple, DCM
* 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, Samsung, vivo, CATT, QC, OPPO, Quectel
* 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, Spreadtrum
* 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),
  + 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,
  + LP HARQ-ACK is jointly encoded with CSI part 1 or CSI part 2.
    - vivo, Apple, DCM

**Rate matching and RE mapping:**

* Reuse Rel-15 rate matching and RE mapping as the baseline.
  + Nokia, HW
* 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.
  + 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

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 18: 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 19: 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, 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 20: If HP HARQ-ACK, LP HARQ-ACK, and A-CSI would be transmitted on HP PUSCH, the LP HARQ-ACK should be dropped.***  ***Proposal 21: 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.*** |
| 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.** |
| ZTE | ***Proposal 17:*** *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 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 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 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 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 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 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 21:*** *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.* |
| Samsung | **Proposal 14: 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.** |
| vivo | ***Proposal 14: 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 15: 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.*** |
| 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.*** |
| Spreadtrum | 1. ***For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH, Option 4 is supported, i.e., no CSI is dropped.*** |
| QC | ***Proposal 11*: 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 14*: 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)** |
| OPPO | ***Proposal 20: 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.*** |
| LGE | **Proposal #17: 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.** |
| Intel | **Proposal 10: Separate encoding is used for multiplexing LP and HP HARQ-ACK bits onto the PUSCH.**   * **Separate beta offset configuration can be used depending on the combination of PUSCH and HARQ-ACK to be multiplexed** * **LP HARQ-ACK payload bits can be partially dropped if needed.** |
| Apple | **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 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.** |
| Leno/Moto | * **Proposal 7:** 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 8:** 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 9:** 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 10:** 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. * **Proposal 11:** Further study encoding and rate-matching when multiplexing semi-persistent/aperiodic CSI of a PUSCH with mixed priority UCI of a PUCCH in the PUSCH. |
| Quectel | **Proposal 10**: LP CSI part 2 (if exists) is dropped when HP HARQ-ACK and LP HARQ-ACK are multiplexed on a LP PUSCH.  **Proposal 11**: Multiplexing of LP HARQ-ACK in a HP PUSCH is supported only when HP A/N and HP CSI part 2 do not simultaneously exist on the HP PUSCH.  **Proposal 14**: LP HARQ-ACK is multiplexed on a number of last symbols occupied by the HP PUSCH when multiplexing of LP HARQ-ACK in HP PUSCH occurs.  **Proposal 16**: 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 on the LP PUSCH; * The multiplexing is expected to be applied only when certain timeline criterion are met. |
| ETRI | **Proposal 8: For HARQ-ACK codebook construction, sub-slot based HARQ-ACK codebooks are concatenated, and may be transmitted for PUSCH repetition.**  **Proposal 9: Further study how to adjust the power of PUSCH for payload from the other priority.**  **Proposal 10: Further study the SR multiplexing onto PUSCH** |
| NEC | ***Proposal 2:*** *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 HP HARQ-ACK with or without LP HARQ-ACK on LP PUSCH, details should be further studied on**   * **Multiplexing location, e.g. starting/ending symbol** * **Detailed multiplexing methods, etc.**   **Proposal 11: HP SR multiplexing on LP PUSCH can be supported, and enhanced channel dropping rule should be defined based on whether HP UCI is multiplexed on LP PUSCH.** |
| WILUS | * ***Proposal 9:*** *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.* |
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## 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 for LP HARQ-ACK.
* Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK.
* Reuse R15 Part 1 CSI rate matching and RE mapping for LP HARQ-ACK.

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. LP HARQ-ACK is coded separately from HP HARQ-ACK and CSI part 1.
* 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.
* FFS for LP CSI consisting of single part.
* FFS for HP/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. 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.
* FFS for LP CSI consisting of single part.
* FFS for HP/LP PUSCH not conveying UL-SCH.

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| Company | Comments |
| CATT | 1. For the 1st proposal, “for LP HARQ-ACK” at the end of the first sub-bullet should be removed. 2. For all the three proposals, for LP HARQ-ACK, our prefer is to reuse rate matching and RE mapping for HARQ-ACK, i.e. LP HARQ-ACK may puncture HP PUSCH when LP HARQ-ACK includes 1-2 bits. The benefit is that missing LP DCI corresponding LP HARQ-ACK would not impact the coding rate of HP PUSCH. 3. For the 2nd proposal, we would like to propose to modify the second sub-bullet to avoid potential confusion as follows. In addition, it seems that the proposal can be applied to both LP PUSCH and HP PUSCH so that “LP” in “LP PUSCH conveying UL-SCH” in the main bullet can be removed.    * LP HARQ-ACK and CSI part 1 ~~can be multiplexed by reusing~~ reuse the encoder chain, rate matching and RE mapping for Rel-15 CSI part 1 and part 2 respectively. 4. For the 3rd proposal, we would like to propose to modify the first sub-bullet to avoid potential confusion.    * LP HARQ-ACK is dropped. CSI part 1 and CSI part 2 ~~can be multiplexed by reusing~~ reuse the encoder chain, rate matching and RE mapping for Rel-15 CSI part 1 and part 2 respectively. |
| Quectel | 1st Proposal: Not support for the third sub-bullet. We are fine for the first two sub-bullets. For the third sub-bullet, we think the cases for HP HARQ-ACK in LP PUSCH and LP HARQ-ACK in HP PUSCH should be separately discussed. For the case of HP HARQ-ACK in LP PUSCH, R15 Part 1 CSI rate matching and RE mapping is reused for LP HARQ-ACK. For the case of LP HARQ-ACK in HP PUSCH, we think R15 UL-SCH (if exists) rate matching and RE mapping should be reused for LP HARQ-ACK. The reason is that LP HARQ-ACK should not be prioritized over HP UL-SCH.  2nd Proposal: Not support for the second sub-bullet. For same priority multiplexing of HARQ-ACK in PUSCH, RE reservation is supported when the number of HARQ-ACK bits is not larger than 2. No RE reservation for CSI. We are unclear what the second sub-bullet means for RE reservation. Is RE reservation still supported or not?  3rd Proposal: We generally support the idea. We think the first sub-bullet means Rel-16 behavior is reused. |
| Panasonic | We are fine with three proposals. |
| Lenovo, Motorola Mobility | For the 1st proposal, we propose the following modification (in red):  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 ~~for LP HARQ-ACK~~. * In principle, Reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK. * In principle, Reuse R15 Part 1 CSI rate matching and RE mapping for LP HARQ-ACK. * FFS: impact of separate beta offset values and separate alpha values   Regarding the 2nd proposal, we support first encoding with HP HARQ-ACK, second encoding jointly with LP HARQ-ACK/LP CSI-part1, and third encoding with LP CSI-part2, which correspond to Rel-15 HARQ-ACK, CSI-part1, and CSI-part2 encoding/rate matching/RE mapping, respectively. We think whether to drop LP CSI-part2 should be dependent on available REs.  Regarding the 3rd proposal, we support first encoding with HP HARQ-ACK, second encoding with HP CSI-part1, and third encoding jointly with HP CSI-part2/LP HARQ-ACK, which correspond to Rel-15 HARQ-ACK, CSI-part1, and CSI-part2 encoding/rate matching/RE mapping, respectively. In this way, LP HARQ-ACK of a small payload size can still be transmitted. |
| Apple | Proposal 1 is not very clear, we support Motorola’s modification on Proposal 1.  As for Proposal 3, we have several comments 1) How to reconcile Proposal 3 with the previous agreement (copied below in italics)?  *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.*   2) what is the enhancement over Rel-16? ☺ 3) Note for UCI multiplexing over PUCCH as in Section 3, we are discussing UCI multiplexing for 1 HP bit and 1 LP bit (apparently that is found to be worthy discussion), it would be very strange if in the end the LP-HARQ ARK would be dropped if the UCI would be multiplexed over PUSCH. We should be more consistent than that. Hence we support motorola’s modification on Proposal 3 (copied below also):  Proposal 3’:  First encoding with HP HARQ-ACK, second encoding with HP CSI-part1, and third encoding jointly with HP CSI-part2/LP HARQ-ACK, which correspond to Rel-15 HARQ-ACK, CSI-part1, and CSI-part2 encoding/rate matching/RE mapping, respectively. In this way, LP HARQ-ACK of a small payload size can still be transmitted.  Then for Proposal 2, we also support Motorola’s modification, with that, the treatment for HARQ/CSI multiplexing over PUSCH is unified:  Proposal 2’:  support first encoding with HP HARQ-ACK, second encoding jointly with LP HARQ-ACK/LP CSI-part1, and third encoding with LP CSI-part2, which correspond to Rel-15 HARQ-ACK, CSI-part1, and CSI-part2 encoding/rate matching/RE mapping, respectively.  In our contribution, we also discuss the pros and cons of mapping LP HARQ-ACK to CSI-part2, interested companies please also check our discussion on that (Section 11.1 of R1-2107735) |
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## Enhancements for multiplexing parameters

## Beta-offset value and configuration

#### Inputs from Tdocs

**Support Beta-offset =0?**

* Yes
  + E///, HW, Nokia, DCM, CATT, China Telecom, Pana, ITRI
* No
  + ZTE, Sharp

**Other Beta-offset values**

* Non-numerical
  + Pana

**Separate configurations of Beta-offset values for different priorities.**

* + E///, HW, OPPO, LGE, DCM
  + Option 1: 3 sets of beta-offset values
    - Multiplexing HARQ-ACK on the PUSCH with same priority
    - Multiplexing LP HARQ-ACK on HP PUSCH
    - Multiplexing HP HARQ-ACK on LP PUSCH
    - Nokia, Samsung, vivo, ZTE, ITRI
    - Argument:
      * In Rel-16, the same beta offsets are used for “HP HARQ-ACK on HP-PUSCH” and “LP-HARQ-ACK on LP PUSCH”. The same rule can be applied in Rel-17.
      * Given the BER/BLER curves, the beta offset required to achieve 1% (LP HARQ-ACK) from 10% (LP-PUSCH), can be different from 10^-6 (HP HARQ-ACK) to 10^-5 (HP PUSCH) as an example. The offsets may be close enough so that one value can be applied to both cases.
  + Option 2: 4 sets of beta-offset values
    - Multiplexing LP HARQ-ACK/UCI on LP PUSCH
    - Multiplexing LP HARQ-ACK/UCI on HP PUSCH
    - Multiplexing LP HARQ-ACK on HP PUSCH
    - Multiplexing HP HARQ-ACK on LP PUSCH
    - QC, Intel, IDC, Sharp, Sony, China Telecom, Potevio, FGI/APT, CATT
    - Argument: A HP HARQ-ACK should have higher protection than a LP HARQ-ACK. Consequently, a LP HARQ-ACK shouldn’t occupy more REs in a HP PUSCH compared to those occupied by a HP HARQ-ACK in a HP PUSCH.
* Option 3: Up to 4 groups of beta offset set can be configured to the UE to indicate separate beta\_offset values for the following cases:
  + Group 1: beta Offsets sets for LP UCIs (all UCIs are at LP) over LP PUSCH as in the Rel-16 legacy design
  + Group 2: beta Offsets sets for HP UCIs (all UCIs are at HP) over HP PUSCH as in the Rel-16 legacy design
  + Group 3: beta Offsets sets for UCI(s) with at least one UCI at HP over LP PUSCH
  + Group 4: beta Offsets sets for UCI(s) with at least one UCI at LP over HP PUSCH
    - Apple
* Option 4: 2 sets of beta-offset values, i.e. one for HP, one for LP
  + - MTK

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| Company | Proposals/observations from Tdocs |
| E/// | 1. For UCI multiplexing on PUSCH, one or more PUCCH can overlap with PUSCH where the corresponding UCI can be multiplexed in the PUSCH. 2. For UCI multiplexing on PUSCH, a different target code rate and beta factor is considered for high priority HARQ-ACK. 3. Support dynamically enable/disable multiplexing by beta factor (e.g. beta=0 to disable mux) |
| HW | ***Proposal 13: For multiplexing LP HARQ-ACK on HP PUSCH scheduled dynamically by UL grant, support beta-offset = 0 to disable the multiplexing.***  ***Proposal 15: For multiplexing HP HARQ-ACK/CSI and LP HARQ-ACK/CSI on one PUSCH, support different beta-offsets for these two UCIs.***  ***Proposal 16: 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.*** |
| 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.** |
| ZTE | ***Proposal 13****: The beta-offset should not be used to disable the intra-UE multiplexing UCI with data*.  ***Proposal 14****: The indicator of intra-UE multiplexing UCI with data exists in the scheduling DCI or RRC parameter for the high priority transmission.*  ***Proposal 15****: In NR Rel-17, up to three 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* |
| Samsung | **Proposal 15: A scaling factor for limiting a maximum number of REs of HP HARQ-ACK in a LP PUSCH is not defined. A separate is provided for HP HARQ-ACK multiplexing in a LP PUSCH.** |
| vivo | ***Proposal 12: For HP and LP UCI on PUSCH with UL-SCH, UE can be configured with 3 beta-offset sets including***   * + ***beta-offset set 1 for UCI multiplexing with a single priority***   + ***beta-offset set 2 for HP UCI multiplexing on LP PUSCH***   + ***beta-offset set 3 for LP UCI multiplexing on HP PUSCH***   ***Proposal 13: UE determines beta-offset set based on the priority of scheduled target PUSCH and the priority of multiplexed target UCI.*** |
| CATT | ***Proposal 12: For a UE supporting multiplexing between different priorities, consider enhancements to UCI multiplexed on PUSCH based on independent beta offsets for different priority combinations of UCI and PUSCH.*** |
| QC | ***Proposal 12*: In NR Rel-17, up to four sets of beta offset values can be configured to the UE to indicate separate beta offset 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** |
| OPPO | ***Proposal 21: Beta-offset values should be separately configured for different priority combinations.*** |
| LGE | **Proposal #19: 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.** |
| Intel | **Proposal 11: Separate encoding is used for multiplexing LP and HP HARQ-ACK bits onto the PUSCH.**   * **Separate beta offset configuration can be used depending on the combination of PUSCH and HARQ-ACK to be multiplexed** * **LP HARQ-ACK payload bits can be partially dropped if needed.**   **Proposal 12:**   * **Support 4 sets of beta-offset configuration for the following scenarios**   + - **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** * **FFS: whether and how to apply the above beta offset configurations for the following multiplexing scenario**   + - **Multiplexing LP HARQ-ACK/UCI, HP HARQ-ACK/UCI on LP PUSCH**     - **Multiplexing HP HARQ-ACK/UCI, LP HARQ-ACK/UCI on HP PUSCH** |
| China Telecom | **Proposal 6: In addition to beta offset configuration for each priority in Rel-16, two additional sets of beta offset values can be configured to the UE in Rel-17 for multiplexing a LP HARQ-ACK in a HP PUSCH, multiplexing a HP HARQ-ACK in a LP PUSCH.**   * **Beta-offset =0 can be configured in the value set for multiplexing a LP HARQ-ACK in a HP PUSCH.** |
| 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.** |
| Pana | **Proposal 15:**   * **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.** |
| Sony | **Proposal 12: For multiplexing of UCI into PUSCH of different L1 priorities, the gNB is able to configure four different sets of ** offsets.** |
| IDC | ***Proposal 13: Support separate configuration of beta\_offset parameters for the following cases:***   * ***LP HARQ-ACK multiplexed in LP PUSCH*** * ***LP HARQ-ACK multiplexed in HP PUSCH*** * ***HP HARQ-ACK multiplexed in LP PUSCH*** * ***HP HARQ-ACK multiplexed in HP PUSCH***   ***Proposal 14: 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.*** |
| Sharp | **Proposal 9: Support up to 4 different beta-offsets for different UCI and PUSCH priority combinations, and do not support beta offset = 0 for UCI disabling signalling.** |
| DOCOMO | **Proposal 11:**   * *Support beta-offset =0 or a value disabling the UCI multiplexing on PUSCH of different priorities*   **Proposal 12:**   * *Introduce new RRC parameter for the new beta-offset range (i.e. 0 < beta-offset < 1) in order to let UE to use different beta-offset values for different multiplexing scenario.* |
| Potevio | ***Proposal 1: Three sets of beta-offset values should be configured to the UE for the following cases:***   * ***Multiplexing HARQ-ACK on PUSCH with same priority.*** * ***Multiplexing low-priority HARQ-ACK on high-priority PUSCH.*** * ***Multiplexing high-priority HARQ-ACK on low-priority PUSCH.***   ***Proposal 2: DCI should be configured with two beta-offset indicator fields, one for each of low-priority and high-priority HARQ-ACK.*** |
| FGI/APT | Proposal 5 Separate beta offsets and scalings can be configured for low priority UCI multiplexed in low priority PUSCH, for low priority UCI multiplexed in high priority PUSCH, for high priority UCI multiplexed in low priority PUSCH, and for high priority UCI multiplexed in high priority PUSCH. |
| MTK | Proposal 5: Two sets of beta-offset could be defined one for high priority UCI and one for low priority UCI multiplexing. |
| ITRI | **Proposal 5:**  For HP and LP UCI on PUSCH, UE can be configured with 3 beta-offset sets and 2 alpha sets for UCI multiplexing, including:   * A first beta-offset set for UCI multiplexing on PUSCH with the same priority * A second beta-offset set for HP UCI multiplexing on LP PUSCH * A third beta-offset set for LP UCI multiplexing on HP PUSCH * A first alpha set for LP PUSCH * A second alpha set for HP PUSCH   **Proposal 6:**  When UCIs corresponding to different priorities are decided to multiplex in a PUSCH:   * The beta-offset of UCI with the same priority as PUSCH is determined by RRC; while the beta-offset of UCI with different priority from the PUSCH is determined by the UL grant DCI.   **Proposal 7:**  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. |
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#### 1st round discussion

Proposal for 1st round discussion:

In NR Rel-17, up to 4 sets of beta offset values can be configured to the UE to indicate separate beta\_offset values for the following cases:

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

Proposal for 1st round discussion:

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

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| Company | Comments |
| CATT | 1. We agree with the first proposal in principle. But HARQ-ACK is one type of UCI so that HARQ-ACK in the first two bullets can be removed. 2. We support the 2nd proposal. |
| Quectel | 1st Proposal: support;  2nd Proposal: This proposal is not clear for us. Does Beta-offset=0 mean that HP and LP HARQ-ACK multiplexing is disabled? Is Beta-offset=0 supported for both of multiplexing LP HARQ-ACK/UCI on HP PUSCH and multiplexing HP HARQ-ACK on LP PUSCH? |
| Panasonic | We support the above two proposals. |
| Lenovo, Motorola Mobility | We support the first proposal.  For the second proposal, disabling/enabling of multiplexing can be used instead of beta\_offset = 0. |
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## Separate configurations of alpha values?

#### Inputs from Tdocs

* Yes
  + QC, Sony, Quectel, ITRI
  + 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, China Telecom
  + Arguments:
    - The same goal on controlling number of REs can be achieved with combination of alpha and different beta values

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| 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** |
| China Telecom | **Proposal 7: For multiplexing HARQ-ACK and PUSCH with different priority combinations, there is no need for further extension to configure more separate alpha values.** |
| Sony | **Proposal 13: For multiplexing of UCI into PUSCH of different L1 priorities, the gNB is able to configure separate ** offsets for different PUSCH L1 priorities.** |
| Quectel | **Proposal 12**: Separate configuration of scaling factors (“alpha”) is supported for UCI-PUSCH multiplexing with different priority combinations. |
| ITRI | **Proposal 4:**  Support separate configuration of alpha for multiplexing with different priority combinations of HARQ-ACK and PUSCH. |
| Leno/Moto | **Proposal 9:** Support configuring more than one scaling value for the variable , to allocate different maximum numbers of resource elements to UCI with different 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)
  + Sony, IDC, DCM
* Option 2: By DCI field
  + E///, ZTE (in HP DCI or RRC), Intel, vivo, Quectel, ETRI, IDC, Potevio, FGI/APT
* Option 3: By RRC configuration
  + ZTE (in HP DCI or RRC), QC, Intel, CATT, China Telecom, TCL, ETRI (when no DCI indication), LGE, IDC (for CG PUSCH and SPS), Potevio (for CG PUSCH), MTK

The arguments are similar to that for Section 2.3.

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| Company | Proposals/observations from Tdocs |
| E/// | Proposal 6 In case of overlapping between PUCCH and/or PUSCH resources in a slot with different priorities, dynamically enabling or disabling UCI multiplexing on PUCCH or PUSCH is supported. |
| ZTE | ***Proposal 22****: The beta\_offset should not be used to disable the intra-UE multiplexing UCI with data*.  ***Proposal 23****: The indicator of intra-UE multiplexing UCI with data exists in the scheduling DCI or RRC parameter for the high priority transmission.* |
| Vivo | ***Proposal 17: Dynamic indication of intra-UE multiplexing and prioritization manner can be supported in Rel-17.***  ***Proposal 18: For dynamic indication, multiplexing or prioritization indication field can be included in DCI for HP or LP or both HP and LP service.*** |
| CATT | ***Proposal 10: Semi-static RRC configuration to enable/disable the multiplexing between channels with different priorities is supported.***  ***Proposal 11: 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.*** |
| QC | ***Proposal 20:* The Rel-17 intra-UE multiplexing feature is enabled/disabled via RRC configuration on per UE basis.** |
| Intel | **Proposal 15: DCI and higher layer indication can be provided to enable multiplexing of UCI onto DG PUSCH and CG PUSCH, respectively.** |
| China Telecom | **Proposal 1: For multiplexing UCI/PUSCH with different priorities on PUCCH or PUSCH in R17, support RRC configuration to enable/disable the multiplexing at least.** |
| Sony | **Proposal 15: The gNB dynamically indicates whether to enable/disable multiplexing of UCI bits into PUSCH of different L1 priorities.**  **Proposal 16: 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** |
| Quectel | **Proposal 15**: Dynamic enabling/disabling by DCI for UCI-PUSCH multiplexing with different priorities is supported. FFS whether existing fields (e.g., the fields for UL DAI and/or beta\_offset) could be reused or re-interpreted. |
| Potevio | ***Proposal 3: gNB should dynamically indicate whether to enable/disable multiplexing of UCI bits into PUSCH of different priorities.***  ***Proposal 4: For CG, RRC configuration should include an indication of whether UE can multiplex low-priority HARQ-ACK on high-priority PUSCH.*** |
| TCL | **Proposal 5: RRC configuration for enabling UCI multiplexing on PUSCH with different priorities should be supported.** |
| 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.** |
| LGE | **Proposal #5: Prefer RRC configuration for the mechanism to enable/disable the multiplexing of HP HARQ-ACK and LP HARQ-ACK on PUCCH or the multiplexing of HARQ-ACK on PUSCH with different priority, with consideration of potential UE complexity and UCI/PUSCH reliability.** |
| IDC | ***Proposal 15: DCI scheduling HP PUSCH indicates if UE multiplexes LP HARQ-ACK in HP PUSCH.***  ***Proposal 16: DCI indicating HP HARQ-ACK also indicates if UE multiplexes HP HARQ-ACK in LP PUSCH.***  ***Proposal 17: A beta\_offset indicator field set to 0 indicates that UE disables multiplexing of LP HARQ-ACK in HP PUSCH.***  ***Proposal 18: RRC configuration for each HP CG configuration includes an indication of whether the UE can multiplex LP HARQ-ACK in corresponding HP PUSCH.***  ***Proposal 19: RRC configuration of SPS with HP HARQ-ACK includes an indication of whether the UE can multiplex HP HARQ-ACK in LP PUSCH.***  ***Proposal 20: 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.*** |
| MTK | 1. Dynamic indication of the multiplexing activation/de-activation is not supported. |
| FGI/APT | Proposal 6 Dynamic indication is supported for indicating whether to multiplex overlapping high priority PUSCH and low priority PUCCH. FFS the indication method when semi-static beta offsets are configured. |
| DOCOMO | **Proposal 8:**   * *Support beta-offset =0 or a value disabling the UCI multiplexing on PUSCH of different priorities* |
| ITRI | **Proposal 7:**  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. |
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## 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.

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| Company | Comments |
| CATT | Support the proposal. |
| Quectel | Not support. In our understanding, dynamic enabling/disabling has already been supported based on UL DAI for HARQ-ACK multiplexing in PUSCH for a same priority. We don’t see any reason to preclude this in case of different priority multiplexing. Otherwise, the UL DAI should be re-interpreted for the multiplexing of different priorities. |
| Panasonic | We are fine with the proposal. In addition, we prefer to introduce dynamic enabling/disabling mechanism via explicit indication. Dynamic indication can avoid additionally introducing mechanism for multiplexing such as reliability and/or latency requirement. For explicit indication, beta-offset=0 can be used for disabling the multiplexing for multiplexing a LP HARQ-ACK and a HP PUSCH. For multiplexing a HP HARQ-ACK and a LP PUSCH, non-numerical value of beta-offset can be used for disabling the multiplexing. |
| Lenovo, Motorola Mobility | Fine with the proposal. |
| Apple | Fine with the proposal. |
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## 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.
  + QC, OPPO, LGE, Apple, TCL, MTK

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| Company | Proposals/observations from Tdocs |
| 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.** |
| OPPO | ***Proposal 22: LP HARQ-ACK transmitted on HP PUSCH should be compressed when the actual coding rate is higher than a threshold.*** |
| LGE | **Proposal #20: 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.** |
| 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.** |
| TCL | **Proposal 6: 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.** |
| Sony | **Proposal 14: 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.** |
| MTK | Group-bundling is supported when multiplexing and when the resulted UCI payload is large. |
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## 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, China Telecom, 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

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 14: 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.*** |
| Nokia | **Proposal 3.20: For the scenario of the multiplexing between HARQ-ACK and PUSCH with different priorities,**   * **RAN1 should confirm the working assumption of reusing Rel-15 timeline conditions for multiplexing HARQ-ACK and PUSCH.** * **If multiplexing timeline conditions are not met or no multiplexing is indicated from gNB, Rel-16 prioritization rule should be applied (i.e. the transmission of the low-priority channel(s) is cancelled)**. |
| ZTE | ***Proposal 17:*** *For the overlapping between high priority HARQ-ACK and low priority PUSCH, if the gNB allows a UE to multiplex the HARQ-ACK on PUSCH, the UE maps this HARQ-ACK to PUSCH resource elements no later than the last symbol of PUCCH resource for HARQ-ACK.* |
| QC | ***Proposal 18:* 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.**  ***Proposal 19:* Confirm the working assumption made in #104-e to reuse Rel-15 intra-UE PUCCH/PUSCH multiplexing timeline requirements for Rel-17 intra-UE PUCCH/PUSCH multiplexing with different priorities.** |
| OPPO | ***Proposal 19: 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.*** |
| China Telecom | **Proposal 2: Multiplexing for channels with different priorities is allowed only when the ending symbol of PUCCH or PUSCH resource carrying the multiplexed UCI is no later than the ending symbol of channel carrying HP traffic.** |
| TCL | **Proposal 7: 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.** |
| LGE | Proposal #19: Consider to introduce new timeline or offset in case of PUSCH collision handling with different priority. |
| Sharp | **Proposal 1: Confirm the working assumption of reusing Rel-15 intra-UE PUCCH/PUSCH multiplexing timeline requirements for Rel-17 intra-UE PUCCH/PUSCH multiplexing with different priorities.**  **The Rel-16 dropping rule is reused if the multiplexing timeline requirements are not met.** |
| MTK | 1. Guard gap timeline of the new multiplexed PUCCH is of the earliest PUCCH.   Multiplexing allowed only if the resulted PUCCH is confined within the sub-slot of the HP-PUCCH sub-slot. |
| ITRI | **Proposal 1:**  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 2:**  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 3:**  To ensure the acknowledgement response validity, a UE should perform the multiplexing procedure only if the latest symbol for multiplexing the HP UCI is not later than the latest symbol of the PUCCH. Otherwise, the UE should not perform the multiplexing. |
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## Other enhancements

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| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 17: 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.*** |
| Nokia | **Proposal 3.25: For the scenario where multiplexing high-priority HARQ-ACK bits on a low-priority PUSCH, RAN1 to investigate UL power control aspects to guarantee the required reliability of high-priority HARQ-ACK bits.**  **Proposal 3.26: Multiplexing high-priority SR in low-priority PUSCH is supported. FFS detailed ways of carrying high-priority SR information.** |
| LGE | **Proposal #21: 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 #24: Consider to introduce new timeline or offset in case of PUSCH collision handling with different priority.  Proposal #25: Consider enhanced collision handling between HP PUSCH and LP PUSCH with UCI piggybacking. |
| Intel | **Proposal 13: CG-UCI is regarded as high priority and can be multiplexed in a similar manner as HP HARQ-ACK onto PUSCH.**  **Proposal 14: If both HP and LP HARQ-ACK are to be multiplexed onto CG-PUSCH that includes CG-UCI, CG-UCI is jointly encoded with HP HARQ-ACK with same beta offset.** |
| Pana | **Proposal 16: 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).** |
| FGI/APT | Proposal 7 CG-UCI multiplexed in a high priority CG PUSCH is treated as high priority HARQ-ACK and jointly encoded with high priority HARQ-ACK, if there is high priority HARQ-ACK to be multiplexed in the CG PUSCH. |
| WILUS | ***Proposal 10:*** *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 and “beta offset” for LP HARQ-ACK and/or HP HARQ-ACK.* |

# 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.

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| **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, Nokia, Samsung, vivo, ZTE, Intel, MTK

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 24: 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/// | 1. MAC may send two PDUs to two overlapping grants only if the later grant has higher PHY priority than the earlier grant. 2. When *lch-basedPrioritization* is configured, Rel-16 UL skipping is not enabled in Rel-17. 3. Identification of PUSCH for UCI multiplexing is performed after CG-vs-DG prioritization. |
| Nokia | ***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 2.1: 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.** |
| ZTE | ***Proposal 18:*** *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.* |
| Samsung | **Proposal 17: 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.** |
| vivo | ***Proposal 18: 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.*** |
| 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.** |
| Apple | **Proposal 14-1: Clarify the Rel-16 UE behavior concerning DG/CG transmission.** |
| DOCOMO | **Proposal 18:**   * *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.* |
| MTK | Proposal 12: 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. |

## 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.
    - Samsung, vivo, ZTE, MTK
  + 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
* 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

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 25: 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 later than Tproc,2+d1 after the last symbol of the PDCCH scheduling the DG PUSCH.*** |
| Nokia | **Proposal 2.2: 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.** |
| ZTE | ***Proposal 19:*** *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.* |
| Samsung | **Proposal 18: 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.** |
| vivo | ***Proposal 19: 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.*** |
| QC | ***Proposal 17:* 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** | |
| 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.** |
| LGE | Proposal #23: 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. |
| DOCOMO | **Proposal 17:**   * *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.* |
| MTK | Proposal 11: Support PHY prioritization for the case where high-priority DG-PUSCH collides with low-priority CG-PUSCH.  Proposal 13: 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. |

# 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, TCL

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| 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).** |
| QC | ***Proposal 21:* The enabling/disabling of the feature of simultaneous PUCCH/PUSCH transmission for inter-band CA is via RRC configuration on per CC basis. For a CC where RRC enables simultaneous PUCCH/PUSCH transmission, this CC is dedicated to PUSCH transmission and UCI is not multiplexed on this CC.** |
| CATT | ***Proposal 19: Dynamic indication of simultaneous PUCCH/PUSCH transmission is not supported.*** |
| LGE | **Proposal #22: Consider the framework designed in Rel-10 LTE-A as the baseline for supporting simultaneous transmission of PUCCH and PUSCH in Rel-17 NR.**   * **The simultaneous PUCCH+PUSCH transmission should be applied for any priority combinations (enabled by single RRC parameter) by taking potential UE complexity and gNB/UE ambiguity into account.** |
| TCL | **Proposal 8: Dynamic indication for simultaneous PUCCH/PUSCH should not be supported.** |
| MTK | Proposal 10: Simultaneous PUCCH/PUSCH transmissions is enabled based on specific conditions. E.g. LP-PUCCH carrying HARQ feedback. |

## Use cases for simultaneous PUCCH/PUSCH transmission

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| Company | Proposals/observations from Tdocs |
| Nokia | * **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 of the same PHY priority will increase low-priority information and channel dropping when taking the PHY prioritization into account.*** * **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)?** |

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

#### Inputs from Tdocs

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

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| 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.*** |
| DCM | **Proposal 19:**  *Not to introduce the simultaneous PUCCH and PUSCH transmission for same priority case.* |
| MTK | Proposal 9: 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. |

#### 1st round discussion

Proposal for 1st round discussion:

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.

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| Company | Comments |
| CATT | Support the proposal. |
| Quectel | Support |
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## Support simultaneous PUSCH/PUCCH transmission for intra-band CA or not?

#### Inputs from Tdocs

* Support with conditions
  + 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.

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| Company | Proposals/observations from Tdocs |
| 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 23: Discussion on support of simultaneous transmission of PUSCH and PUCCH over different carriers for intra-band CA 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 | Proposal 6: Support simultaneous PUCCH/PUSCH transmissions on different cells for intra-band CA for the same numerology both with aligned and non-aligned channel case.  Proposal 7: 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.   Proposal 8: The UE is to be configured separately for inter-band and intra-band simultaneous PUCCH/PUSCH transmissions. |
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## Support simultaneous PUSCH/PUCCH transmission on a same cell?

#### Inputs from Tdocs

* No:
  + Apple, DCM

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| Company | Proposals/observations from Tdocs |
| Apple | **Proposal 15-3: Simultaneous PUCCH/PUSCH transmission on the same CC is not supported.** |
| DOCOMO | **Proposal 13:**   * *Not to introduce the simultaneous PUCCH and PUSCH transmission for same priority case.* |
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## Other enhancements

## Inputs from Tdocs

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| Company | Proposals/observations from Tdocs |
| Qualcomm | ***Proposal 22:* 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 20:**   * *Support PHR for simultaneous PUCCH and PUSCH transmission on different carriers.*   **Proposal 21:**   * *Discuss the interaction between capabilities for two PUCCH groups and the new capability for simultaneous PUCCH/PUSCH transmission on different carriers.* |
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