3GPP TSG RAN WG1 #105-e R1-210xxxx

e-Meeting, May 12th – 20th, 2021

Source: Moderator (OPPO)

Title: Summary#1 of email thread [104b-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#105-e are summarized.

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

* 1st check point: 5/21
* 2nd check point: 5/25
* Final check: 5/27

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



Figure : 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 Alt. 1 of Rel-17 UCI multiplexing flow

Diagram

Description automatically generated

Figure Alt. 2 of Rel-17 UCI multiplexing flow

## Proposals from Tdocs

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| Company | Proposals/observations from Tdocs |
| Ericsson | 1. Prioritize work to stablish early on a common understanding on the overall framework of the expected procedures than detailed solutions. 2. Investigate the candidate frameworks A1, A2, B1, B2 and their combinations for gain and complexity analysis, starting with B2 and A2-B2. 3. Consider investigating the complexity of potential features for multiplexing UCI with different priority in PUCCH/PUSCH. |
| HW | ***Proposal 9: The discussion about multiplexing more than 2 PUCCHs should be postponed until the multiplexing rules for two colliding PUCCHs are agreed.***  ***Observation 2: 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 3.13: 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 3.14: 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.**   ***Observation 3.3: Multiplexing of more than one PUCCH carrying HARQ-ACK on a PUSCH of different priority should not be supported, as the multiplexing is also not supported for the same priority.***  ***Observation 3.4: 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 3.5: 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 3.22: 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 of high-priority UCI on low-priority PUSCH.** |
| ZTE | ***Proposal 12:*** *Determine the multiplexing rules for the UCI multiplexing rules of more than two overlapping PUCCHs with different priorities after the UCI multiplexing rules for two overlapping PUCCHs is clear.* |
| vivo | ***Proposal 21: To avoid the dropping of LP UCI, the overlapping handling order may need be reconsidered.***  ***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 14: For overlapping between PUCCH and multiple PUSCHs with different priorities, it is proposed that UCI of PUCCH is multiplexed on a PUSCH with different priority only when there is no PUSCH with same priority overlaps with the PUCCH.*** |
| CMCC | **Proposal 3: Support multiplexing in case a PUCCH overlaps with more than one PUCCH with principle of ensuring the performance of each HP PUCCH.**  **Proposal 4: The low priority PUCCH and the first high priority PUCCH satisfying the multiplexing conditions are multiplexed only if the PUCCH carrying multiplexed UCI(s) do not overlap with any other high priority PUCCH.**  **Proposal 8: Multiplexing in case a PUSCH/PUCCH overlaps with more than one PUCCH/PUSCH is supported with principle of ensuing the performance of each HP PUCCH/PUSCH.** |
| Intel | **Proposal 15: Instead of two-step approach, consider joint multiplexing of UCIs of different priorities into a PUCCH resource if UE supports intra-UE multiplexing across different priorities.**  **Proposal 17: 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 18: 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 19: 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 20: 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.** |
| TCL | **Proposal 4: The scenario of multiplexing more than two overlapping channels should be further studied.** |
| ETRI | **Proposal 2: Multiplex HP UCI, and check to multiplex each LP UCI at earliest order.** |
| NEC | ***Proposal 4:*** *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.* |
| Samsung | **Observation 2: For determination of the PUCCH time unit for handling PUCCH collisions with different PUCCH time units (i.e. slot and sub-slot PUCCH configuration) of different priorities, when A LP HARQ-ACK PUCCH overlaps with more than one HP sub-slot, at least following cases should be considered.**   * **Case 1) Each HP sub-slot contains zero or more HP SR PUCCH resource.** * **Case 2) Each HP sub-slot contains zero or one HP HARQ-ACK PUCCH resource.** * **Case 3) Each HP sub-slot contains zero or more HP SR PUCCH resource and zero or one HP HARQ-ACK PUCCH resource.** * **Note: Multiplexing of PUCCH with different priorities is performed within a PUCCH time unit (i.e. either within a slot or a sub-slot). E.g. for each PUCCH time unit, put all the associated PUCCHs (e.g. for a same priority, associated PUCCHs are the PUCCHs within the PUCCH time unit) in the corresponding set Q and then reuse Rel-15/Rel-16 rules.** * **Aiming to reuse Rel-15/16 pseudo code for PUCCH multiplexing with limited optimization.**   **Proposal 10: The time unit for solving the collision of PUCCHs with different L1 priority indexes should be the HP PUCCH time unit.**   * **If a LP HARQ-ACK PUCCH overlaps with multiple HP PUCCH time units, determine an associated HP PUCCH time unit for the LP HARQ-ACK PUCCH.**    + **FFS details.**   **Proposal 11: Down select from the following options for multiplexing/prioritizing LP HARQ-ACK PUCCH, HP HARQ-ACK PUCCH and HP SR PUCCH on a same PUCCH. FFS potential enhancements.**   * **Option 1) All PUCCHs are viewed with same priority – Rel-15 multiplexing applies.** * **Option 2) First, multiplex overlapping HP HARQ-ACK PUCCH and LP HARQ-ACK, then multiplex resulting PUCCH and SR PUCCH (if there is overlapping)**   **Proposal 12: Consider solutions to ensure the reliability of data in a HP PUSCH if a LP Type-2 HARQ-ACK codebook is multiplexed in the HP PUSCH.**  **Proposal 13: Determine order for resolving overlapping among HP/LP PUCCHs and HP/LP PUSCHs.**  **Observation 4: Support of simultaneous PUCCH and PUSCH transmissions need not have any RAN1 specification impact other than that a UE does multiplex UCI of an overlapping PUCCH in a PUSCH on an SCell (and instead transmits the PUCCH on the primary cell and the PUSCH on the SCell).**  **Proposal 15: 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.** * **FFS potential solutions to ensure the reliability of UCI on a LP PUSCH.** |
| LGE | **Proposal #4: Discuss and decide the overall multiplexing procedures/steps 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 #17: Consider the framework designed in Rel-10 LTE-A as the baseline for supporting simultaneous transmission of PUCCH and PUSCH in Rel-17 NR.** |
| Xiaomi | ***Proposal 3: When a LP PUCCH overlaps with multiple HP PUCCHs contained in multiple subslots, whether multiplexing timeline is met is only determined by the LP PUCCH and HP PUCCH(s) contained in one subslot, rather than by the LP PUCCH and HP PUCCH(s) in all the subslots.***  ***Proposal 11: The R16 agreement about multiplexing/cancelling order is not applicable in some cases and needs to be reconsidered. It is more nature for UE to operate in a“first come first process” manner.*** |
| DCM | **Proposal 12:**  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 13:**  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 14:**  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 15:**  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 16:**   * *Discuss processing order of intra-UE multiplexing with different priorities and cancellation due to dynamic SFI/UL CI/semi-static TDD and SSB.* |
| MTK | 1. 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. |

# 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.*

## 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 >2 bit(s):**
  + HP A/N reuse the encoder, rate matching equation, and RE mapping rules in Rel-15 for A/N+CSI-1.
  + LP A/N reuse the encoder, rate matching equation, and RE mapping rules in Rel-15 for CSI-2.
    - Nokia, ZTE, QC, vivo, Apple
  + Enhanced rate matching
    - OPPO, Quectel, DCM
  + Consider enhanced RE mapping
    - HW, Samsung
* **Encoder for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s):**
  + Option 1: Separate coding
    - DCM, vivo, Sony
    - Option 1a:
      * HP A/N reuse the Rel-15 1-2 bits UCI coding methods, i.e., repetition code/simplex code.
      * LP A/N reuse the Rel-15 1-2 bits UCI coding methods, i.e., repetition code/simplex code.
      * E///, HW, QC, CATT, Quectel
    - Option 1b: Reuse the Rel-15 less than 3 bits CSI part 2 coding method for UCI on PUCCH, where zero(s) are appended to the UCI bit sequence to expand it to 3 bits before performing the RM coding.
      * HW, Samsung, LGE
    - Option 1c: (3,2) coding scheme for HP or LP HARQ-ACK with 2 bits and then repeat; Repetition scheme for HP or LP HARQ-ACK with 1 bit.
      * ZTE (simulation)
    - Option 1d: use RM coding without appending CRC
      * Intel
  + Option 5: Joint coding
    - China Telecom, Sharp
* **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.
    - E///, HW, Nokia, QC, Quectel, Sony
  + Option 2: Drop CSI part 2 if CSI would multiplex on a PUCCH which has HP A/N. Drop CSI part 1 if resource is insufficient.
    - ZTE, LGE
* **Separate code rate configurations:**
  + Support gNB to configure coding rates separately for HP and LP HARQ-ACK.
    - QC (For a given priority, support gNB to configure multiple coding rates for HARQ-ACK based on the payload size), vivo, Spreadtrum, CMCC, Intel, Samsung, Sharp, WILUS
* **Separate power control configurations:**
  + Two open-loop power control P0 values are configured for multiplexing LP and HP UCI
    - QC

**When the total number of LP and HP HARQ-ACK bits is 2,**

* Option 1: Treat the two bits as HARQ-ACK bits with HP priority and following the existing mechanism.
  + HW, Nokia, ZTE, vivo, CATT, OPPO, China Telecom, Intel, Pana, NEC, Samsung, Sharp
* Option 2:
  + For multiplexing on a PUCCH format 0, support HARQ-ACK values to CS indices mapping with unequal distance between mapped CS indices.
  + For multiplexing on a PUCCH format 1, support transmit the 2-bits HARQ-ACK values via two orthogonal sequences S1 and S2.
    - S1 and S2 are generated based on the same base sequence S with different CS indices CS1 and CS2.
    - 1-bit is transmitted via sequence selection between S1 and S2, while the other bit is transmitted using the selected sequence following legacy Rel-15 PF1 with 1-bit payload.
    - gNB can signal either HP 1-bit or LP 1-bit is transmitted via sequence selection.
  + QC (simulation), WILUS (only support enhancement for PF0)

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| Company | Proposals/observations from Tdocs |
| E/// | 1. Support separate coding for LP and HP HARQ-ACK for all payload sizes, using the channel codes for small block lengths defined in Rel-15. 2. Allow CSI consisting of one part to be encoded together with LP HARQ-ACK and be multiplexed with HP HARQ-ACK. |
| HW | ***Proposal 2: For multiplexing HP HARQ-ACK and LP HARQ-ACK on PUCCH in case that the total number of bits is 2 bits, the 1-bit HP HARQ-ACK and the 1-bit LP HARQ-ACK are concatenated and transmitted on PUCCH format 0 or PUCCH format 1 following the existing mechanism.***  ***Proposal 3: For the encoders* *of LP and HP HARQ-ACK bits with more than 2 bits total payload***,   * ***Confirm the working assumption, i.e., drop CSI (including part 1 and part2, if exist) if CSI would multiplex on a PUCCH which has HP A/N.*** * ***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.*** * ***Separate PUCCH coding rates should be adopted for HP HARQ-ACK and LP HARQ-ACK.***   ***Observation 1: It is feasible to consider enhanced RE mapping rule in Rel-17 as the changing on RE mapping would be less challenging in implementation.***  ***Proposal 4: For multiplexing of HP HARQ-ACK and LP HARQ-ACK with more than 2 bits total payload and 1-2 bit(s) HP or LP HARQ-ACK, one of the following two alternatives can be considered for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s):***   * ***Alt.1: Reuse the Rel-15 1-2 bits UCI coding methods for UCI on PUSCH, i.e., repetition code/simplex code.*** * ***Alt.2: Reuse the Rel-15 less than 3 bits CSI part 2 coding method for UCI on PUCCH, where zero(s) are appended to the UCI bit sequence to expand it to 3 bits before performing the RM coding.*** |
| 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, multiplexing can be done on the high-priority PUCCH resource by treating the two bits as high-priority HARQ-ACK bits and using existing rules of mapping two HARQ-ACK bits of the same priority. The order of the 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 separate encoding:**   * **In case HARQ-ACK is 1 bit: use the existing 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 2-bit information encoding scheme in TS 38.212 Sec. 5.3.3.2 to encode this HARQ-ACK.**   **Proposal 3.7: Confirm the Working Assumption to not support multiplexing of CSI (include part 1 and part 2, if any) and high-priority HARQ-ACK 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 on PUCCH, adopt the Rel-15 operation of ‘multiplexing of coded UCI bits to PUCCH’ given in TS 38.212 Sec. 6.3.1.6.** |
| ZTE | ***Proposal 1:*** *Adopt (3,2) coding scheme for HP or LP HARQ-ACK with 2 bits and then repeat when the total payload of the UCIs is more than 2 bits.*   * *Note: (3,2) coding means (A,B) encodes to (A,B, A XOR B)*   In the same way, it is beneficial to use repetition scheme for HP or LP HARQ-ACK with 1 bits.  Table 1 Coding schemes for 2 information bits.   |  |  | | --- | --- | | Case 1 | (3,2) + repetition | | Case 2 | 2bits RM | | Case 3 | 2bits + "0" padding, RM, 3bits Decode | | Case 4 | 2bits + "1" padding, RM, 3bits Decode | | Case 5 | 2bits + "1" padding, RM, 2bits Decode |   Theoretically, the coding scheme with the largest minimum Hamming distance has the best performance.  The minimum Hamming distance of case 1 scheme is the largest among the 5 coding alternatives. Therefore, the performance is expected to be the best, which is verified in simulations. Here (3,2) coding means (A,B) encodes to (A,B, A XOR B).    Figure 1: Comparison of average performance of 2 bits among different coding schemes  ***Proposal 2:*** *Adopt repetition scheme for HP or LP HARQ-ACK with 1 bits when the total payload of the UCIs is more than 2 bits.*  ***Proposal 3:*** *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 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 2, treat the two bits as HARQ-ACK bits with HP priority, R15 design is reused without power boosting.*  ***Proposal 9:*** *Modify the working assumption:*  *Drop CSI part 2 if CSI would multiplex on a PUCCH which has HP A/N.*   * *HP A/N occupies one encoder chain.* * *LP A/N + CSI part 1(drop CSI part 1 if resource is insufficient) occupies the other encoder chain.* * *Intend to reuse the rate matching equation, and RE mapping principles in Rel-15.* |
| vivo | ***Proposal 3: For HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), separate coding is suggested.***  ***Proposal 4: 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 5: 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 6: 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.***  ***Proposal 11:*** ***For multiplexing a HP HARQ-ACK and a LP HARQ-ACK, when the total number of LP and HP HARQ-ACK bits is 2 bits.***   * ***On PUCCH format 0: HP HARQ-ACK bit and LP HARQ-ACK bit are mapped into a cyclic shift as in R15/R16.*** * ***On PUCCH format 1: HP HARQ-ACK bit and LP HARQ-ACK bit are modulated into a QPSK symbol as in R15/R16.*** |
| Spreadtrum | 1. ***For separate coding of the two HARQ-ACKs with HARQ-ACK bits being more than 2, the max coderates for HP and LP HARQ-ACK can be different.*** 2. ***Support separate coding if HP HARQ-ACK or LP HARQ-ACK is of 1-2 bit.*** |
| CATT | ***Proposal 3: For multiplexing of HP HARQ-ACK and LP HARQ-ACK when total number of bits is 2, 1 bit HP HARQ-ACK and 1 bit LP HARQ-ACK are treated as two HP HARQ-ACK bits and transmitted on the time-frequency resource for the HP HARQ-ACK transmission.***  ***Proposal 7: For multiplexing of HP HARQ-ACK and LP HARQ-ACK on PUCCH when total number of bits is more than 2 and when HP HARQ-ACK or LP HARQ-ACK includes only 1 or 2 bits, reuse the 1/2 bits coding scheme used for UCI on PUSCH.***  ***Proposal 8: For separate coding of HP HARQ-ACK and LP HARQ-ACK when multiplexing on PUCCH:***   * ***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.*** |
| CMCC | **Proposal 5: For determining the code rates for HP UCI and LP UCI when multiplexing, two maxCodeRates can be configured for PUCCH resource used for multiplexing, one is used for LP UCI and the other is used for HP UCI.** |
| QC | ***Proposal 1*: For 1-bit high priority HARQ-ACK and 1-bit low priority HARQ-ACK transmitted in a PUCCH format 0 resource, support HARQ-ACK values to CS indices mapping with unequal distance between mapped CS indices.**   * **FFS: Solution for 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK multiplexing with 1-bit HP or LP SR on PUCCH format 0**   ***Proposal 2*: For 1-bit high priority HARQ-ACK and 1-bit low priority HARQ-ACK transmitted in a PUCCH format 1 resource, support transmit the 2-bits HARQ-ACK values via two orthogonal sequences S1 and S2.**   * **S1 and S2 are generated based on the same base sequence S with different CS indices CS1 and CS2.** * **1-bit is transmitted via sequence selection between S1 and S2, while the other bit is transmitted using the selected sequence following legacy Rel-15 PF1 with 1-bit payload.** * **gNB can signal either HP 1-bit or LP 1-bit is transmitted via sequence selection.**   **FFS: Solution for 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK multiplexing with 1-bit HP or LP SR on PUCCH format 1**  ***Proposal 3*: 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 4*: 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 5*: 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 6*: 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 8*: For HP UCI and LP UCI multiplexing on PUCCH format 2, support mapping encoded HP UCI bits first with a distributed RE mapping in frequency domain, followed by mapping encoded LP UCI bits onto remaining REs.**   * **FFS: how to determine distance d between adjacent REs in frequency domain for HP UCI.**   ***Proposal 9*: 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 3: The rate matching output sequence lengths for HP HARQ-ACK and LP HARQ-ACK should be determined as follows***  ***Proposal 4:*** ***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 5: No enhancement is supported for multiplexing of 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK on a PUCCH format 0/1.***  ***Proposal 14: 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.*** |
| China Telecom | **Proposal 3: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH when the total number of bits is 2,**   * **Use R15 mapping rules for 2 bits HARQ-ACK as a baseline.** * **Use a PUCCH resource in the second *PUCCH-Config* (the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK).**   **Proposal 4: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH when the total number of bits is more than 2, and the number of HP HARQ-ACK or LP HARQ-ACK bits is 1-2, support joint coding for the two HARQ-ACKs.** |
| Intel | **Proposal 3: When combined payload is 2 bits, multiplexing LP and HP HARQ-ACK bits follow Rel-15 approach assuming both bits are HP.**  **Proposal 4: Separate encoding of HARQ-ACK, SR, CSI Part1 and CSI Part 2 and the multiplexing procedure defined in Rel-15 can be used as a starting point for LP and HP HARQ-ACK multiplexing into a PUCCH in Rel-17.**  **Proposal 5: A set of *maxCodeRate* values canbe configured to UE for UCI multiplexing into PUCCH.**   * **FFS: Identification of applicable *maxCodeRate* value for PUCCH transmission**   **Proposal 6: At least PUCCH format 3 and 4 are supported for LP and HP HARQ-ACK multiplexing**   * **FFS: PUCCH format 2**   **Proposal 7: When LP or HP HARQ-ACK payload is less than 3 bits, use RM coding without appending CRC.** |
| 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.**  Text  Description automatically generated  Figure 9-6(a) UCI mapping for separate encoding of HP/LP HARQ-ACK (1),  Text  Description automatically generated  Figure 9-6(b) UCI mapping for separate encoding of HP/LP HARQ-ACK (2),  **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.** |
| 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 exist) if CSI would multiplex on a PUCCH which has HP A/N.**   **Proposal 2: 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**: The working assumption is confirmed with clarification: Drop CSI (including part 1 and part2, if exist) if CSI would multiplex on a PUCCH which has HP A/N if CSI is for a report quantity as defined in Rel-15/16.  **Proposal 2**: Repetition coding or simplex coding is supported 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 single coding rate  configured for 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 configuration dedicated for HP HARQ-ACK and LP HARQ-ACK rate matching is supported when the total number of HP or LP HARQ-ACK bits multiplexed on the PUCCH is larger than 2. |
| NEC | ***Observation 1****: The straightforward method for multiplexing two Type-1 HARQ-ACK codebooks on a PUCCH by constructing two Type-1 HARQ-ACK codebooks separately as Rel-16 and pasting them together as a multiplexed HARQ-ACK codebook may lead to unnecessary redundancy.*  ***Proposal 1:***  *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, support joint coding when the total number of LP and HP HARQ-ACK bits is 2.*  ***Proposal 2:***  *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.* |
| Samsung | **Proposal 3: Reuse Rel-16 for the case where a PUCCH with 1 bit LP HARQ-ACK overlaps with a PUCCH with 1 bit HP HARQ-ACK in the time domain.**  **Proposal 4: Zeros should be appended to the LP/HP HARQ-ACK information bits if the payload of LP/HP HARQ-ACK is less than 3 bits when multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH.**  **Proposal 6: When multiplexing a HP HARQ-ACK and a LP HARQ-ACK in a PUCCH format,**   * **Reuse the maxCodeRate configured in the second PUCCH-Config for HP HARQ-ACK.** * **Consider following two options to determine the maxCodeRate for LP HARQ-ACK.**   + **Option 1) Reuse the maxCodeRate configured in the first PUCCH-Config of the same PUCCH format.**   + **Option 2) RRC configures a separate maxCodeRate for LP HARQ-ACK per PUCCH format in the second PUCCH-Config.**   **Observation 1: Multiplexing of LP HARQ-ACK codebook and HP HARQ-ACK codebook with same and/or different HARQ-ACK codebook types can be enabled via the configuration for HP/LP multiplexing.**  **Proposal 7: Consider solutions to ensure the reliability of multiplexing of LP Type-2 HARQ-ACK codebook and HP HARQ-ACK codebook and/or HP data.** |
| LGE | **Proposal #1: Consider the following aspects related to the support of separate coding for HP HARQ-ACK and LP HARQ-ACK multiplexed on a PUCCH.**   * **Bit-padding for HP/LP HARQ-ACK of up to 2 bits (to make 3-bit payload) in order to reuse current coding chains/procedures for UCI on PUCCH** * **Multiplexing of (separate encoding for) HP HARQ-ACK and CSI part 1 on at least PUCCH format 3/4 (by dropping CSI part 2)** * **Multiplexing of HP HARQ-ACK and LP HARQ-ACK by separate encoding for the two HARQ-ACKs on PUCCH format 2**   **Proposal #2: Decide UCI bit mapping used for cyclic shift or QPSK modulation for multiplexing of LP UCI and HP UCI 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.** |
| Sharp | **Proposal 5: When the total number of LP and HP HARQ-ACK bits is 2 bits, the LP-HARQ-ACK is appended to HP HARQ-ACK, and the concatenated HARQ-ACK bits are reported on the original PUCCH resource for the HP HARQ-ACK.**  **Proposal 6: For UCI multiplexing on PUCCH, apply joint coding method at least to the cases when both HP HARQ-ACK and LP HARQ-ACK is up to 2 bits.**   * **FFS optimization on reporting joint HARQ-ACK bits on PUCCH format 0/1.**   **Proposal 7: 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.** |
| DCM | **Proposal 1:**   * *It is preferred to support separate coding for the case where either of HP HARQ-ACK or LP HARQ-ACK is 1-2 bit(s) when the combined UCI bits are more than 2 bits, while we are open to discuss introduction of joint coding for the cases.*   **Proposal 2:**   * *Agree the working assumption for CSI dropping with small modification for rate-matching output sequence equation for separate coding of HP and LP HARQ-ACKs when the combined UCI bits are more than 2 bits.*   **Proposal 3:**   * *For separate coding, a scaling factor can be introduced for HP and LP UCI coding rate determination.* |
| Leno/Moto | * **Proposal 2:** 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 with 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 with 1-bit LP HARQ-ACK and 1-bit HP HARQ-ACK in PF0, use the new CS mapping.*     - *CS=0, 3, 6, 9 for (HP HARQ-ACK, LP HARQ-ACK)=(NACK, NACK), (NACK, ACK), (ACK, NACK), (ACK,ACK) respectively*   + *To multiplex with 1-bit LP HARQ-ACK in PF1 and 1-bit HP HARQ-ACK in PF1, reuse Rel-15 multiplexing rules without any modification.* |

## 1st round discussion

Proposal for 1st round discussion:

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.

* For HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding and reuse the Rel-15 1-2 bits UCI coding methods, i.e., repetition code/simplex code.
* For HP HARQ-ACK or LP HARQ-ACK >2 bit(s),
  + For HP A/N, Reuse the Rel-15 encoder for A/N+CSI-1.
    - FFS rate matching equation and RE mapping rules but treat Rel-15 as baseline.
  + For LP A/N, Reuse the Rel-15 encoder for CSI-2.
    - FFS rate matching equation and RE mapping rules but treat Rel-15 as baseline.
* Drop CSI (including part 1 and part2, if exist) if CSI would multiplex on a PUCCH which has HP A/N.

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 2, the baseline is to treat the two bits as HARQ-ACK bits with HP priority ~~and use R15 mapping rules~~.

* + FFS details, e.g. reuse R16 design for the two bits, or reuse R15 design with power boost for the two bits.

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| Company | Comments |
| Sony | Agree to both proposals. |
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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, vivo, Spreadtrum, Intel, Pana, Sony, Quectel, Samsung, IDC
  + Not support: MTK
* Option 2: RRC configuration
  + HW, ZTE, QC, Spreadtrum, CATT CMCC, China Telecom, Pana, Quectel, TCL, Samsung, LGE, IDC (for SPS), Xiaomi, Sharp, DCM, MTK

|  |  |  |  |
| --- | --- | --- | --- |
|  | | 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. |  |
| 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. |  |

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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. |
| 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.*** |
| 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 5****: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, support DCI+RRC configuration for gNB to enable/disable the multiplexing when DCI is applied.*   * *For SPS HARQ-ACK, the enable/disable scheme falls back to RRC configuration.*   ***Proposal 6****: The indicator of intra-UE multiplexing UCI with different priorities should be carried on the scheduling DCI or RRC parameter for the high priority transmission.* |
| 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.*** |
| 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 can be considered as an optional feature.*** |
| CATT | ***Proposal 10: Semi-static RRC configuration to enable/disable the multiplexing between channels with different priorities is supported.*** |
| CMCC | **Proposal 6: For multiplexing HP HARQ-ACK and LP HARQ-ACK into one PUCCH in R17, RRC signaling is used for gNB to enable/disable the multiplexing.** |
| QC | ***Proposal 22:* The Rel-17 intra-UE multiplexing feature is enabled/disabled via RRC configuration on per UE basis.** |
| 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 as a base line.** |
| 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.** |
| Pana | **Proposal 5:**   * **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 3: The gNB dynamically enables/disables multiplexing in an HP PUCCH by an indication in the DL Grant scheduling the HP PUCCH.**  **Proposal 4: 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 7**: 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.** |
| 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.** |
| 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 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.*** |
| Xiaomi | ***Proposal 9: For enabling/disabling multiplexing of channels of different priorities, semi-static configuration is preferred.*** |
| Sharp | **Proposal 2: RRC configuration is used as the mechanism to enable/disable the multiplexing of HP HARQ-ACK and a LP HARQ-ACK on PUCCH.** |
| DOCOMO | **Proposal 7:**   * *RRC configuration should be baseline for enabling/disabling multiplexing of LP and HP PUCCH* |
| MTK | 1. Dynamic indication of the multiplexing activation/de-activation is not supported. |
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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 PUCCH in R17, support RRC configuration and DCI indication for gNB to enable/disable the multiplexing at least for HARQ-ACK with DCI.

* FFS for HARQ-ACK for SPS PDSCH.
* FFS: Interaction between the enable/disable mechanism and other multiplexing conditions
* FFS for other types of UCI.

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| Company | Comments |
| Sony | Agree. We assume that in this proposal, the RRC configuration is a to configure the new Enable/Disable field in the DCI. |
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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: Select the PUCCH resource from the second *PUCCH-Config*.
  + HW, Nokia, ZTE, Spreadtrum, CATT, China Telecom, IDC, Xiaomi, Sharp, DCM

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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: the number of HP UCI bits + the number of LP UCI bits
* Option 2: the number of HP UCI bits + the number of LP UCI bits \* scaling factor. The scaling factor can be a function of code rate for HP UCI and LP UCI.
  + vivo, Apple, DCM

**Consider enhanced PRB number determination**

* + OPPO, Samsung, DCM

**Handling incorrect LP HARQ-ACK codebook size determination (due to DCI mis-detection)**

* Option 1: Configure a dedicated PUCCH resource for HP+LP
  + HW, Pana, Quectel, ETRI
* Option 2: PRI+x in the HP DCI is used to implicitly determine an extended PUCCH resource
  + ZTE, OPPO
* Option 3: the PUCCH resource set is determined based on a reference number (e.g. a weighted sum) of the LP and HP HARQ-ACK payload size
  + QC, CATT
* Option 4: Additional DCI field in DCI corresponding HP HARQ-ACK for determining the number of LP HARQ-ACK bits
  + CATT

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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

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

* Option 1: LP HARQ-ACK is compressed/bundled/compaction.
  + ZTE, QC, OPPO, TCL, MTK, WILUS
* Option 2: LP HARQ-ACK is dropped.
  + LGE, Sony
* Option 3: LP HARQ-ACK is partially dropped.
  + Intel, TCL

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| Company | Proposals/observations from Tdocs |
| E/// | 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. |
| Huawei | ***Proposal 5: 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, multiplexing can be done on the high-priority PUCCH resource by treating the two bits as high-priority HARQ-ACK bits and using existing rules of mapping two HARQ-ACK bits of the same priority. The order of the 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 3.10: 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 3.11: RAN1 to define how 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.**  ***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 7****: 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 8****: 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 PUCCH set in the PUCCH-config with high priority for the multiplexed UCI.*  *- x is predefined, e.g., x=1.*  ***Proposal 16:*** *LP UCI compression is slightly preferred in case there is no enough resource left for LP UCI.* |
| vivo | ***Proposal 7: 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.*** |
| Spreadtrum | 1. ***Support to multiplex on the HP PUCCH resources if a 1 bit LP HARQ-ACK overlaps with a 1 bit HP*** |
| CATT | ***Proposal 9: 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 13: An additional UL DAI bit field can be considered to be added in the UL DCI for multiplexing PUCCH and PUSCH with different priorities.*** |
| QC | ***Proposal 7*: For HP 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 18:* In Rel-17 UCI multiplexing, support low priority HARQ-ACK compression.**   * **FFS conditions to trigger low priority HARQ-ACK compression** * **FFS details of compression scheme.** |
| OPPO | ***Proposal 1: The number of PRBs used to transmit HP HARQ-ACK and LP HARQ-ACK should result to:***  , and  ***Proposal 2: If , the UE transmits the PUCCH over  PRBs. LP HARQ-ACK should be compressed into bits that satisfy:***  , and  ***Proposal 6: A PUCCH resource in the PUCCH resource set configured for HP HARQ-ACK is used to transmit HP HARQ-ACK and LP HARQ-ACK.***  ***Proposal 7: The PUCCH resource for multiplexing HP 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 7: The PUCCH resource for multiplexing HP 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 8: 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.***   ***Proposal 10: 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.*** |
| China Telecom | **Proposal 3: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH when the total number of bits is 2,**   * **Use R15 mapping rules for 2 bits HARQ-ACK as a baseline.** * **Use a PUCCH resource in the second *PUCCH-Config* (the *PUCCH-config* containing the PUCCH resource of the HP HARQ-ACK).** |
| Intel | **Proposal 8: LP HARQ-ACK payload bits can be partially dropped**   * **FFS: How to partition LP HARQ-ACK payload bits** |
| Apple | **Proposal 4-1: is used for PUCCH resource set selection.**  **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.** |
| Pana | **Proposal 6: 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.** |
| Quectel | **Proposal 6**: Optional configuration of a set or subset of PUCCH resources dedicated for multiplexing of UCIs with different priorities is supported. |
| 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 3: Further study how to adjust the power of PUCCH for payload from the other priority.**  **Proposal 5: The LP DCI determines the final PUCCH resource in at least for the HP SPS case.** |
| Samsung | **Proposal 5: For PRB determination and RE mapping when multiplexing a HP HARQ-ACK and a LP HARQ-ACK in a PUCCH, consider following two options.**  **Option 1) Reuse Rel-15 rules of separate coding in a PUCCH.**  **Option 2) PRB determination and RE mapping are performed separately for HP HARQ-ACK and LP HARQ-ACK for PF2/3.**  **FFS: How to ensure the reliability of HP HARQ-ACK.** |
| 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: DCI indicating HP HARQ-ACK includes an indication of the DAI of LP HARQ-ACK.*** |
| Xiaomi | ***Proposal 4: Configuring dedicated resources for multiplexing of HP HARQ-ACK and LP HARQ-ACK is not necessary.***  ***Proposal 5: When the total number of LP and HP HARQ-ACK bits is 2, PUCCH resource of the HP HARQ-ACK should be adopted as the resource for multiplexing.*** |
| Sharp | **Proposal 4: A HP PUCCH resource configured for HP HARQ-ACK should be used for HP HARQ-ACK and LP HARQ-ACK multiplexing on PUCCH for all case.** |
| DOCOMO | **Proposal 4:**   * *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 5:**   * *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*   **Proposal 6:**   * *PUCCH resource for HP HARQ-ACK is used for multiplexing LP HARQ-ACK and HP HARQ-ACK when total UCI bit size is 2bits.* |
| MTK | Group-bundling is supported when multiplexing and when the resulted UCI payload is large. |
| Leno/Moto | * **Proposal 1:** A PUCCH resource configured by the second *PUCCH-Config*for multiplexing UCI of mixed priorities including up to 2bit HARQ-ACK information with/without a positive HP SR is determined 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 up to 2 HARQ-ACK bits with a positive SR, when there is no corresponding DCI format. * **Proposal 3:** UE determines whether to multiplex LP HARQ-ACK with HP UCI in a PUCCH resource of PUCCH format 2, 3, or 4 of higher priority index, based on the total UCI payload size and configured max. code rate/max PRB parameters. |
| 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,

* 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 for 1st round discussion:

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 set selection is determined by (the number of HP UCI bits + the number of LP UCI bits \* scaling factor).

* The scaling factor can be a function of code rate for HP UCI and LP UCI.

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, to avoid the incorrect LP HARQ-ACK codebook size determination due to DCI mis-detection, further study the following options:

* Option 1: Configure a dedicated PUCCH resource for HP+LP
* Option 2: PRI+x in the HP DCI is used to implicitly determine an extended PUCCH resource
* Option 3: the PUCCH resource set is determined based on a reference number (e.g. a weighted sum) of the LP and HP HARQ-ACK payload size
* Option 4: Additional DCI field in DCI corresponding HP HARQ-ACK for determining the number of LP HARQ-ACK bits
* Other solutions are not precluded.

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| Company | Comments |
| Sony | **1st Proposal: Agree**  **2nd Proposal: Not Agree:**   * Why is the scaling done at the info bits level? The Code Rate is applied during the encoding stage and we can have different Code Rat for HP UCI and LP UCI. This seemed to apply code rate BEFORE the UCI info bits are encoded.   **3rd Proposal: Not Agree**   * Is there even an issue with miss detection of LP DCI? One of the benefits of separate encoding is to handle missed detection. The LP UCI and HP UCI are separately encoded and so if the LP UCI has missed bits, it won’t affect the HP UCI. Hence, it isn’t clear we need yet another mechanism to handle this or at least we should discuss whether there is even a problem to begin with. |
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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
    - Option 1b: X>0.
      * CMCC

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

* Option 1: UE behavior fallbacks to Rel-16 prioritization.
  + Intel, Xiaomi, 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 6: 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 19:* On top of Rel-16 cancellation time (N2+d1) for PUCCH/PUCCH or PUCCH/PUSCH collision, additional time d2 is needed (which results N2+d1+d2 in total cancellation time) for LP CG-PUSCH and HP DG-PUSCH collision resolution. The additional number of OFDM symbols (d2) needed is listed in following table**  Table 3. d2 for LP CG-PUSCH and HP DG-PUSCH collision resolution   |  |  | | --- | --- | |  | d2 [symbols] | | **0** | **1** | | **1** | **2** | | **2** | **4** | | **3** | **8** |   ***Proposal 20:* For d1 defined for PUCCH vs PUCCH or PUCCH vs PUSCH cancellation with different priorities, support subcarrier spacing dependent d1 values. FFS exact d1 values for each subcarrier spacing.**  ***Proposal 21:* 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.** |
| CMCC | **Proposal 2: The following conditions can be considered for multiplexing of LP HARQ-ACK and HP HARQ-ACK/HP SR on top of reusing Rel-15 intra-UE PUCCH multiplexing timeline requirements:**   * **Latency check, i.e. the last symbol of PUCCH resource carrying multiplexed LP UCI and HP UCI is not X symbol(s) later than the original PUCCH resource for HP UCI;**   **Reliability check, i.e. the code rate or the total REs of the HP UCI after multiplexing is not larger than the code rate or less than the total REs before multiplexing** |
| OPPO | ***Proposal 9: Reuse Rel-15 intra-UE PUCCH/PUSCH multiplexing timeline conditions for Rel-17 intra-UE multiplexing with different priorities:***   * ***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, when the timeline conditions are 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.** |
| 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.** |
| LGE | **Proposal #3: Consider additional condition for the processing of inter-priority multiplexing and the latency requirement for HP UCI.** |
| Xiaomi | ***Proposal 1: Confirm the working assumption to reuse Rel-15 intra-UE PUCCH/PUSCH multiplexing timeline requirements for Rel-17 intra-UE PUCCH/PUSCH multiplexing with different priorities.***  ***Proposal 2:*** ***When the multiplexing timeline is not met, HP channels can be transmitted and LP channels is dropped.*** |
| 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. |
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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.
    - DCM
  + 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, Xiaomi
  + 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, Spreadtrum, Intel, Pana, Sony
* Opt.3: No enhancement over Rel-16.
  + OPPO (R15 or R16 according to the number of PUCCH symbols.), Samsung

**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.
    - DCM
  + Opt.1b: For negative SR, the UE transmit only HARQ-ACK on the HARQ-ACK resource.
    - Nokia, ZTE, CATT, China Telecom, Sony, Sharp
  + Opt.1c: For negative SR, the UE transmits SR and HARQ-ACK on the SR resource
    - Nokia, Xiaomi, DCM
* 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.
  + 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, OPPO, vivo, Spreadtrum, Intel, Pana, Quectel, Samsung, 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, ZTE, vivo, Spreadtrum, Intel, 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.
  + Nokia, QC, China Telecom, Quectel, Xiaomi, Sharp, DCM
* Opt.4: No enhancement over Rel-16.
  + OPPO, Pana, Samsung

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| E/// | [Proposal 7 When PUCCH with HP SR overlaps with PUCCH with LP HARQ-ACK:](#_Toc68676144)  [ 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).](#_Toc68676145)  [ 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).](#_Toc68676146)  [Proposal 8 When PUCCH with HP HARQ-ACK/SR overlaps with PUCCH with LP HARQ-ACK:](#_Toc68676147)  [ 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.](#_Toc68676148) |
| HW | ***Proposal 7: 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 8: For multiplexing HP SR and LP HARQ-ACK with format2/3/4,***   * ***Adopt separate coding to HP SR and LP HARQ-ACK on one PUCCH resource*** * ***The PUCCH resource is selected from dedicated PUCCH resource sets in the second PUCCH-Config for multiplexing HP HARQ-ACK and LP HARQ-ACK*** * ***The multiplexing is only allowed if the ending symbol of the PUCCH resource carrying multiplexed SR and HARQ-ACK is no later than the ending symbol of the PUCCH resource carrying SR.*** |
| Nokia | **Proposal 3.12: 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 10:*** *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 11:*** *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.* | |
| vivo | ***Proposal 1: Support multiplexing a high-priority HARQ-ACK and a low-priority SR into a PUCCH in Rel-17.***  ***Proposal 2: The priorities of investigation scenarios bases on Table 1.***  **Table 1 UCI multiplexing scenarios**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | **HP SR** | **HP HARQ-ACK** | **HP HARQ-ACK+SR** | **HP PUSCH (UL-SCH only)** | **HP PUSCH + HP HARQ-ACK and/or CSI** | | **LP HARQ-ACK** | agreed | agreed | agreed | agreed | agreed | | **LP PUSCH (UL-SCH only)** | Medium | agreed | agreed | \* | \* | | **LP PUSCH + LP HARQ-ACK and/or CSI** | Medium | agreed | agreed | \* | \* | | **LP SR** | Medium | High | Medium | Medium | Medium | | **CSI** | low | low | low | low | low |   ***Proposal 8: When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, option 2c is adapted.***   * ***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 9: When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, option 4 is adapted.***   * ***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 10: When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, option 2c is adapted.***   * ***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 12: 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 4: 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 5: 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 6: 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 10*: 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 2 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 11*: 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 12 and Fig 13.**  ***Proposal 12*: 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 11: Rel-15 or Rel-16 mechanism should be reused to support multiplexing of HARQ-ACK and SR with different priorities.***  ***Proposal 12: 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 | |
| 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.** |
| Intel | **Proposal 14:**  **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 | |
| Pana | **Proposal 8: 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 9:**   * **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 10: 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 11:**   * **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 12:**   * **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 13:**   * **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 5: 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 6: 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 transmit only HARQ-ACK on the HARQ-ACK resource.**   **Proposal 7: 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 12**: 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 13**: 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 14**: 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. |
| Samsung | **P Proposal 8: Drop LP HARQ-ACK PUCCH when a LP HARQ-ACK PF0/1 overlaps with a HP SR PUCCH.**  **Proposal 9: Support multiplexing of LP HARQ-ACK and HP SR when HARQ-ACK is transmitted on PUCCH format 2/3/4**   * **Use Rel-15 mechanism as a baseline assuming HARQ-ACK and SR have the same priority.** * **FFS: how to ensure the latency and reliability of HP SR.** |
| LGE | **Proposal #10: 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 #11: 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.** |
| IDC | ***Proposal 1: Support multiplexing for following additional scenarios:***   * ***High-priority SR in a low-priority PUSCH (UL-SCH only)*** * ***High-priority SR and HARQ-ACK in a low-priority PUSCH (UL-SCH only)*** * ***High-priority SR in a low-priority PUSCH (UL-SCH + low-priority HARQ-ACK and/or CSI)*** * ***High-priority SR and HARQ-ACK in a low-priority PUSCH (UL-SCH + low-priority HARQ-ACK/CSI)***   ***Proposal 8: 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 9: 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 10: 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.*** |
| Xiaomi | ***Proposal 6:*** ***When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/PF1, support Opt1 and Opt 1c.***  ***Proposal 7:*** ***Power boosting is not needed to transmit multiplexed payload for*** ***HP SR and LP HARQ-ACK.***  ***Proposal 8:*** ***when a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0,*** ***support Opt 3, that is, for positive SR, transmit HARQ-ACK on the SR resource. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.***  ***Proposal 10: Solutions such as direct puncture or treating HP SR as HARQ-ACK/CSI bit in multiplexing can be considered for HP SR on LP PUSCH.*** |
| Sharp | **Proposal 8: 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 9: 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, esp. if different CS or transmit power is applied to differentiate a HP positive SR from a LP positive SR.** * **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 10: 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 11: 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 12: 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 7:*** *To multiplex with 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 8:*** *We propose to support Option 2b for multiplexing with HP-SR with PF0 and LP HARQ-ACK with PF1.*   + *To multiplex with 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 9:*** *To multiplex with HP-SR with PF1 and LP HARQ-ACK with PF0, reuse multiplexing rule for HP-SR with PF0 and LP HARQ-ACK with PF0.* |

## 1st round discussion

Proposal for 1st round discussion:

When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, down-select the following options:

* Opt.1b: The positive SR and HARQ-ACK are multiplexed and transmitted on the SR resource. For negative SR, the UE transmit only HARQ-ACK on the HARQ-ACK resource.
* 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.
* FFS: Whether/How to differentiate HP SR and LP SR when multiplexed with LP HARQ-ACK?

Proposal for 1st round discussion:

When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, down-select the following options:

* Opt.1b: The positive SR and HARQ-ACK are multiplexed and transmitted on the SR resource. For negative SR, the UE transmit only 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 (i.e. No enhancement over Rel-16).
* FFS: Whether/How to differentiate HP SR and LP SR when multiplexed with LP HARQ-ACK?

Proposal for 1st round discussion:

When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, down-select the following options:

* 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.
* FFS: Whether/How to differentiate HP SR and LP SR when multiplexed with LP HARQ-ACK?

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| Company | Comments |
| Sony | Agree with all 3 proposals. |
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## Other enhancements

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| Company | Proposals/observations from Tdocs |
| ETRI | **Proposal 3: Further study how to adjust the power of PUCCH for payload from the other priority.** |
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| 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. |
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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,
  + the LP HARQ-ACK can be multiplexed by reusing the encoder chain for legacy CSI part 1.
    - HW, OPPO, Nokia, Apple
* 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 for legacy CSI part 1.
    - Nokia, vivo
  + Option 2: Only the CSI part 2 is dropped, consider following sub-options:
    - Option 2a: LP HARQ-ACK reuses the encoder chain for legacy CSI part 2.
    - Option 2b: LP HARQ-ACK reuses the encoder chain for legacy CSI part 1, and CSI part 1 reuses the encoder chain for legacy CSI part 2.)
    - Option 2c: 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.
    - HW, QC, OPPO, vivo, Quectel
* If HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI would be transmitted on HP PUSCH,
  + Drop LP HARQ-ACK, and
    - 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
    - QC, HW
  + LP HARQ-ACK is jointly encoded with CSI part 1 or CSI part 2.
    - vivo

**Rate matching:**

* 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.
  + HW

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 14: 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 encoder chain for legacy CSI part 1 or CSI part 2.***  ***Proposal 15: 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 encoder chain for legacy HARQ-ACK, and LP HARQ-ACK reuses the encoder chain for legacy CSI part 2.*** * ***Candidate 2: HP HARQ-ACK reuses the encoder chain for legacy HARQ-ACK, LP HARQ-ACK reuses the encoder chain for legacy CSI part 1, and CSI part 1 reuses the encoder chain for legacy CSI part 2.***   ***Proposal 16: If HP HARQ-ACK, LP HARQ-ACK, and A-CSI would be transmitted on HP PUSCH, the LP HARQ-ACK should be dropped.***  ***Proposal 17: 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 3.19: For the scenario where multiplexing both high-priority HARQ-ACK bits and low-priority HARQ-ACK bits into a low-priority PUSCH, drop CSI (including part 1 and part 2, if exist) if CSI would be multiplexed into the same PUSCH.** |
| vivo | ***Proposal 15: 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 16: When HP and LP HARQ-ACK are multiplexed on a HP PUSCH with HP CSI, the following alternatives can be investigated***   * + ***Alt 1: LP HARQ-ACK is dropped.***   + ***Alt 2: LP HARQ-ACK is jointly encoded with CSI part 1 or CSI part 2.*** |
| Spreadtrum | 1. ***If more than three encoding chains are needed in Rel-17 UCI multiplexing on PUSCH, some solutions are needed to compress number of encoding chains to be no more than three*** |
| QC | ***Proposal 13*: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if CSI would multiplex on the same PUSCH,**   * **Drop CSI part 2, if CSI is a low priority CSI.**    + **HP A/N reuse encoder and rate matching equation for Rel-15 A/N**   + **LP A/N reuse encoder and rate matching equation for Rel-15 CSI part 1**   + **LP CSI part 1 reuse encoder and rate matching equation for Rel-15 CSI part 2** * **Drop LP HARQ-ACK, if CSI is a high priority CSI.**    + **HP A/N reuse encoder and rate matching equation for Rel-15 A/N**   + **HP CSI part 1 reuse encoder and rate matching equation for Rel-15 CSI part 1**   + **HP CSI part 2 reuse encoder and rate matching equation for Rel-15 CSI part 2** * **FFS: RE mapping rules.**   ***Proposal 16*: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, the following RE mapping rules are supported.**   * **HP HARQ-ACK is rate match around by other UCIs (if exist) and UL-SCH (if exist)** * **LP HARQ-ACK is padded to 2 bits if it is 0 or 1 bit. The padded LP HARQ-ACK is rate matched around by other UCIs (if exist) and UL-SCH (if exist)** |
| 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.** |
| Quectel | **Proposal 8**: CSI part II (if exists) is dropped when HP HARQ-ACK and LP HARQ-ACK are multiplexed on a PUSCH. |
| ETRI | **Proposal 7: The TB is rate matched with the UCI assumption of total number of LP UCI and HP UCI.**  **Proposal 8: For HARQ-ACK codebook construction, sub-slot based HARQ-ACK codebooks are concatenated, and may be transmitted for PUSCH repetition.**  **Proposal 9: DL-DCI for HP UCI which is received after UL-DCI for LP TB may affect the PUSCH mapping.**  **Proposal 10: HP UCI may not be mapped at the second hop of the PUSCH.** |
| NEC | ***Proposal 3:*** *When multiplexing both low-priority HARQ-ACK and high-priority HARQ-ACK on a PUSCH scheduled by an UL non-fallback DCI with a DAI field, which HARQ-ACK codebook the DAI field is applied to should be configured by gNB.* |
| LGE | **Proposal #14: 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 #15: Consider to keep the reserved HARQ-ACK REs for same priority with PUSCH in case of piggybacking HARQ-ACK on PUSCH for different priority.**  **Proposal #16: Consider the mapping of HP HARQ-ACK starting from the first symbol in LP PUSCH with consideration of latency requirement for HP UCI.** |
| Sharp | **Proposal 14: 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 15: For multiplexing a 1-bit high-priority (HP) HARQ-ACK and a 1-bit low-priority (LP) HARQ-ACK into a PUSCH in R17, support joint coding by concatenating the HP and LP HARQ-ACK bits into 2 bits, and treat the concatenated 2 bits as HP.** |
| WILUS | * ***Proposal 10:*** *To multiplex with 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.* * ***Proposal 11:*** *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.* |

## 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, the LP HARQ-ACK can be multiplexed by reusing the encoder chain for legacy CSI part 1.
* If HP HARQ-ACK, LP HARQ-ACK, and LP CSI would be transmitted on LP PUSCH, the CSI part 2 is dropped, consider following sub-options:
  + Option 2a: LP HARQ-ACK reuses the encoder for Rel-15 CSI part 2.
  + Option 2b: LP HARQ-ACK reuses the encoder for Rel-15 CSI part 1, and CSI part 1 reuses the encoder for Rel-15 CSI part 2.
  + Option 2c: LP HARQ-ACK and LP CSI part 1 are encoded jointly and the same manner with Rel-15 CSI part 1 encoder is reused for LP HARQ-ACK and LP CSI part 1.
* If HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI would be transmitted on HP PUSCH, drop LP HARQ-ACK, and reuse Rel-15 encoders

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| Company | Comments |
| Sony | I think it is sufficient to just say what is dropped. There is no need to specify which encoder the UE uses as this should be UE implementation. Hence we do not need Option 2a, 2b & 2c. That is the proposal can simply be:  *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 would be transmitted on LP PUSCH, the CSI part 2 is dropped,* * *If HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI would be transmitted on HP PUSCH*, drop LP HARQ-ACK, |
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## Enhancements for multiplexing parameters

## Beta-offset value and configuration

#### Inputs from Tdocs

**Support Beta-offset =0?**

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

**Other Beta-offset values**

* Non-numerical
  + Pana, Sony

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

* + E///, HW, OPPO, Intel, 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, ZTE, vivo, China Telecom
  + 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 HP HARQ-ACK/UCI on LP PUSCH
    - Multiplexing HP HARQ-ACK/UCI on HP PUSCH
    - QC, Pana, IDC, Sharp, Sony
  + Option 3: 2 sets of beta-offset values, i.e. one for HP, one for LP

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| Company | Proposals/observations from Tdocs |
| E/// | [Proposal 15 For UCI multiplexing on PUSCH, a different target code rate and beta factor is considered for high priority HARQ-ACK.](#_Toc68676154)  [Proposal 16 Support dynamically enable/disable multiplexing by beta factor (e.g. beta=0 to disable mux)](#_Toc68676155) |
| HW | ***Proposal 10: For multiplexing LP HARQ-ACK on HP PUSCH scheduled dynamically by UL grant, support beta-offset = 0 to disable the multiplexing.***  ***Proposal 12: For multiplexing HP HARQ-ACK/CSI and LP HARQ-ACK/CSI on one PUSCH, support different beta-offsets for these two UCIs.***  ***Proposal 13: For DCI format 0\_1/0\_2 with existing beta-offset bit-field, one codepoint of the field is linked to a quadruple {,,,} to jointly indicate the beta-offset values for HP HARQ-ACK, LP HARQ-ACK, CSI part 1 and CSI part 2.*** |
| Nokia | **Proposal 3.15: For the scenarios of multiplexing HARQ-ACK bits in DG PUSCH of different priorities,** gNB dynamically indicates via beta\_offset (e.g. beta\_offset = 0) in the corresponding scheduling DCI whether to multiplex HARQ-ACK in PUSCH of different PHY priority or not**. FFS whether to support multiplexing of HARQ-ACK bits on CG PUSCH of a different PHY priority.**  **Proposal 3.16: For the scenarios of multiplexing HARQ-ACK bits in PUSCH of different priorities, RAN1 should specify:**   * **three sets of beta\_offset values for:**   + **multiplexing HARQ-ACK on the PUSCH with the same priority (specified already);**   + **multiplexing low-priority HARQ-ACK on high-priority PUSCH;**   + **multiplexing high-priority HARQ-ACK on low-priority PUSCH;** * **for multiplexing of both low-priority and high-priority HARQ-ACK, 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* |
| vivo | ***Proposal 13: 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 14: 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 14*: 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 15: Beta-offset values should be separately configured for different priority combinations.*** |
| China Telecom | **Proposal 6: Up to three sets of beta-offset values can be configured by RRC signal corresponding to the cases for multiplexing a LP HARQ-ACK in a HP PUSCH, multiplexing a HP HARQ-ACK in a LP PUSCH, and multiplexing HARQ-ACK on the PUSCH with same priority.**   * **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 14:**   * **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 8: For multiplexing of UCI into PUSCH of different L1 priorities, the gNB is able to configure four different sets of ** offsets.** |
| LGE | **Proposal #12: Support 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.** |
| IDC | ***Proposal 11: 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 12: 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 13: 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 10:**   * *Support beta-offset =0 or a value disabling the UCI multiplexing on PUSCH of different priorities*   **Proposal 11:**   * *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.* |
| MTK | 1. Two sets of beta-offset could be defined one for high priority UCI and one for low priority UCI multiplexing. |
| ITRI | **Proposal 5:**  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 6:**  For PUCCH multiplexed in PUSCH, beta-offset configuration can be used to enable or disable the multiplexing. The multiplexing disabled if beta-offset=0; otherwise the UE should perform the multiplexing. |
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#### 1st round discussion

Proposal for 1st round discussion:

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

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| Company | Comments |
| Sony | Not agree.  For same priority HARQ-ACK + PUSCH, different beta should be used for:   * HP HARQ-ACK + HP PUSCH * LP HARQ-ACK + LP PUSCH |
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## Separate configurations of alpha values?

#### Inputs from Tdocs

* Yes
  + QC, CMCC, 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 3.17: For the scenarios of multiplexing HARQ-ACK bits in a PUSCH of different priorities, do not support separate configurations of the scaling factor “alpha”.** |
| CMCC | **Proposal 9: Support separate configuration of alpha for multiplexing with different priority combinations of HARQ-ACK and PUSCH.** |
| QC | ***Proposal 15*: In NR Rel-17, up to four sets of scaling factors alpha can be configured to the UE to indicate separate alpha values for the following cases:**   * **Multiplexing LP HARQ-ACK/UCI on LP PUSCH** * **Multiplexing LP HARQ-ACK/UCI on HP PUSCH** * **Multiplexing HP HARQ-ACK/UCI on LP PUSCH** * **Multiplexing HP HARQ-ACK/UCI on HP PUSCH** |
| 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 9: 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 9**: 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. |
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| 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. |
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## Multiplexing enable/disable mechanism

## Inputs from Tdocs

Multiplexing enable/disable mechanism

* Option 1: By beta\_offset (e.g. beta=0 or non-numerical value to disable mux)
  + CATT, CMCC, Sony, IDC, DCM
* Option 2: By new DCI field
  + E///, ZTE (in HP DCI or RRC), vivo, Intel, Quectel, ETRI, IDC
* Option 3: By RRC configuration
  + ZTE (in HP DCI or RRC), QC, CATT, CMCC, China Telecom, Intel, Quectel, TCL, ETRI (when no DCI indication), LGE, IDC (for CG PUSCH and SPS), Xiaomi, Sharp, 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 10****: 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.*** |
| CMCC | **Proposal 10: For multiplexing HARQ-ACK on PUSCH of different priorities, RRC signaling and/or beta-offset=0 can be used for gNB enable/disable the multiplexing.** |
| QC | ***Proposal 22:* The Rel-17 intra-UE multiplexing feature is enabled/disabled via RRC configuration on per UE basis.** |
| 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.** |
| Intel | **Proposal 13: DCI and higher layer indication can be provided to enable multiplexing of UCI onto DG PUSCH and CG PUSCH, respectively.** |
| Sony | **Proposal 11: The gNB dynamically indicates whether to enable/disable multiplexing of UCI bits into PUSCH of different L1 priorities.**  **Proposal 12: The “*beta\_offset indicator*” DCI field in the UL Grant scheduling the PUSCH is used to enable/disable multiplexing of UCI bits into PUSCH, where some of the indices have non-numerical value, 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 11**: Dynamic enabling/disabling by DCI for UCI-PUSCH multiplexing with different priorities is supported on top of RRC configuration. |
| TCL | **Proposal 5: RRC configuration for enabling UCI multiplexing on PUSCH with different priorities should be supported.** |
| ETRI | **Proposal 6: 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 13: DCI scheduling HP PUSCH indicates if UE multiplexes LP HARQ-ACK in HP PUSCH.***  ***Proposal 14: DCI indicating HP HARQ-ACK also indicates if UE multiplexes HP HARQ-ACK in LP PUSCH.***  ***Proposal 15: A beta\_offset indicator field set to 0 indicates that UE disables multiplexing of LP HARQ-ACK in HP PUSCH.***  ***Proposal 16: RRC configuration for each HP CG configuration includes an indication of whether the UE can multiplex LP HARQ-ACK in corresponding HP PUSCH.***  ***Proposal 17: RRC configuration of SPS with HP HARQ-ACK includes an indication of whether the UE can multiplex HP HARQ-ACK in LP PUSCH.***  ***Proposal 18: 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.***  ***Proposal 19: Support multiplexing of high-priority SR in PUSCH by selection of DMRS sequence in PUSCH.*** |
| Xiaomi | ***Proposal 9: For enabling/disabling multiplexing of channels of different priorities, semi-static configuration is preferred.*** |
| Sharp | **Proposal 3: RRC configuration is used to separately enable/disable of UCI multiplexing on PUSCH for each scenario.** |
| MTK | 1. Dynamic indication of the multiplexing activation/de-activation is not supported. |
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| APT | Proposal 8 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 high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, support RRC configuration and DCI indication for gNB to enable/disable the multiplexing at least for HARQ-ACK with DCI.

* FFS: Interaction between the enable/disable mechanism and other multiplexing conditions
* FFS for other types of UCI.

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| Company | Comments |
| Sony | Agree.  We assume that in this proposal, the RRC configuration is a to configure the the beta-factors or new field to Enable/Disable field in the DCI. |
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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
  + Intel, Sony, TCL, LGE
* Option 2: The LP UCI is compressed/bundled.
  + QC, OPPO, ZTE, TCL, LGE, MTK

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| Company | Proposals/observations from Tdocs |
| OPPO | ***Proposal 8: To support multiplexing UCI in one PUSCH when the UE would transmit multiple overlapping PUCCH and PUSCH with different priority, the following mechanisms should be supported to ensure the latency and reliability of high-priority information:***   * ***The timeline of ending symbols used for UCI transmission should be considered.*** * ***Beta-offset values and*** ***scaling factors should be separately configured for different priorities.*** * ***Low-priority HARQ-ACK should be compressed when the actual coding rate is higher than a threshold.***   ***Proposal 16: LP HARQ-ACK transmitted on HP PUSCH should be compressed when the actual coding rate is higher than a threshold.*** |
| ZTE | ***Proposal 11:*** *LP UCI compression is slightly preferred in case there is no enough resource left for LP UCI.* |
| Sony | **Proposal 10: When multiplexing UCI bits into PUSCH of different L1 priorities, if there are insufficient REs in a PUSCH to carry the UCI bits, the LP UCI bits are dropped.** |
| TCL | **Proposal 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.** |
| LGE | **Proposal #13: 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.** |
| 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 2: Multiplexing is performed only if the last symbol of PUSCH resource carrying multiplexed UCI and UL-SCH is not X symbol(s) later than the original PUCCH resource for HP HARQ-ACK
  + CMCC
* 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.
  + Intel, Xiaomi, 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 11: 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 3.18: For the scenario of the multiplexing between HARQ-ACK and PUSCH with different priorities,**   * **RAN1 should confirm the working assumption of Rel-15 timeline conditions for multiplexing HARQ-ACK and PUSCH can be reused.** * **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.* |
| CMCC | **Proposal 7: The following conditions can be considered for multiplexing of HARQ-ACK into PUSCH with different priorities on top of reusing Rel-15 intra-UE PUCCH/PUSCH multiplexing timeline requirements:**   * **Latency check, i.e. for multiplexing of HP HARQ-ACK into LP PUSCH, multiplexing is performed only if the last symbol of PUSCH resource carrying multiplexed UCI and UL-SCH is not X symbol(s) later than the original PUCCH resource for HP HARQ-ACK** |
| QC | ***Proposal 20:* For d1 defined for PUCCH vs PUCCH or PUCCH vs PUSCH cancellation with different priorities, support subcarrier spacing dependent d1 values. FFS exact d1 values for each subcarrier spacing.**  ***Proposal 21:* 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 13: 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 a UE doesn’t support Rel-16 prioritization, the UE doesn’t expect the conditions are not satisfied.*** * ***If the UE support Rel-16 prioritization, when the timeline conditions are 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. |
| Xiaomi | ***Proposal 1: Confirm the working assumption to reuse Rel-15 intra-UE PUCCH/PUSCH multiplexing timeline requirements for Rel-17 intra-UE PUCCH/PUSCH multiplexing with different priorities.***  ***Proposal 2:*** ***When the multiplexing timeline is not met, HP channels can be transmitted and LP channels is dropped.*** |
| 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 |
| 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. 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. 3. 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. |
| Nokia | **Proposal 3.20: 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 3.21: Multiplexing high-priority SR in low-priority PUSCH is supported. FFS detailed ways of carrying high-priority SR information.** |
| QC | ***Proposal 17*: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, reuse the same power control formula as in Rel-15.** |
| CATT | **Proposal 1: Support multiplexing a high priority SR in a low priority PUSCH conveying UL-SCH and/or low priority HARQ-ACK/CSI in R17.** |
| Intel | **Proposal 11: CG-UCI is regarded as high priority and can be multiplexed in a similar manner as HP HARQ-ACK onto PUSCH.**  **Proposal 12: 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.** |
| Quectel | **Proposal 10**: 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 11: Further study how to adjust the power of PUSCH for payload from the other priority.** |
| LGE | Proposal #20: Consider enhanced collision handling between HP PUSCH and LP PUSCH with UCI piggybacking. |
| Moto/Leno | * **Proposal 7:** UE does not multiplex SR of a given physical layer priority into a PUSCH of the given physical layer priority but may multiplex SR of a physical layer priority different than the given physical layer priority into the PUSCH. * **Proposal 8:** If a UE would transmit semi-persistent or aperiodic CSI on a PUSCH determined for multiplexing mixed priority UCI of PUCCH, the UE may multiplex the semi-persistent or aperiodic CSI with the mixed priority UCI of PUCCH in the PUSCH. * **Proposal 9:** 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. |
| WILUS | ***Proposal 10: In case of HP-PUSCH or LP-PUSCH contains LP-HARQ and HP-HARQ, it should be discussed how to indicate the presence of LP-HARQ and/or HP-HARQ to be multiplexed and “beta offset” for LP-HARQ and/or HP-HARQ.*** |

# 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, ZTE, vivo, CMCC, Intel, Samsung, Sharp, MTK
* Option 2: PHY collision handling of low priority DG PUSCH and high priority CG PUSCH is left up to UE implementation and no RAN1 specification change is necessary.
  + Xiaomi

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 18: 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.*** |
| 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.* |
| vivo | ***Proposal 19: 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.*** |
| CMCC | **Proposal 11: For collision handling between high priority CG and low priority DG, UE is expected to transmit the PUSCH corresponding to the configured grant, and cancel the low priority DG-PUSCH at the latest, by the first symbol that is overlapping with the high priority CG-PUSCH.** |
| 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 13-1: Clarify the Rel-16 UE behavior concerning DG/CG transmission.** |
| Samsung | **Proposal 16: 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.** |
| Xiaomi | ***Proposal 12:*** ***The case of HP CG-PUSCH overlapping with LP DG-PUSCH should be handled by UE implementation.*** |
| Sharp | **Proposal 16: PHY layer can make the prioritization so that**   * **For collision between HP CG-PUSCH and LP DG PUSCH, the UE is expected to transmit the HP CG-PUSCH and cancel the LP DG-PUSCH at least from the first overlapping symbol.** * **For collision between LP CG-PUSCH and HP DG PUSCH, the UE is expected to transmit the HP DG-PUSCH and cancel the LP CG-PUSCH at least from the first overlapping symbol, but not before Tproc,2+d1 after the scheduling DCI of the HP 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 | 1. 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.
    - ZTE, vivo, CMCC, Samsung, Sharp, 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, Xiaomi
* Option 3: On top of Rel-16 cancellation time (N2+d1) for PUCCH/PUCCH or PUCCH/PUSCH collision, additional time d2 is needed (which results N2+d1+d2 in total cancellation time) for LP CG-PUSCH and HP DG-PUSCH collision resolution.
  + QC
* Option 4: Per UE capability.
  + Intel

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 19: For collision between HP DG PUSCH and LP CG PUSCH, PHY layer can make the prioritization so that the UE is expected to transmit the DG PUSCH and cancel the CG PUSCH by the first overlapping symbol at the latest.***   * ***The UE expects to transmit the DG PUSCH no earlier than Tproc,2+d1 after the last symbol of the PDCCH scheduling the DG PUSCH.*** |
| 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.* |
| vivo | ***Proposal 20: 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.*** |
| CMCC | **Proposal 12: For collision handling between high priority DG-PUSCH and low priority CG-PUSCH, 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 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.** |
| QC | ***Proposal 19:* On top of Rel-16 cancellation time (N2+d1) for PUCCH/PUCCH or PUCCH/PUSCH collision, additional time d2 is needed (which results N2+d1+d2 in total cancellation time) for LP CG-PUSCH and HP DG-PUSCH collision resolution. The additional number of OFDM symbols (d2) needed is listed in following table**  Table 3. d2 for LP CG-PUSCH and HP DG-PUSCH collision resolution   |  |  | | --- | --- | |  | d2 [symbols] | | **0** | **1** | | **1** | **2** | | **2** | **4** | | **3** | **8** | |
| 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.** |
| Samsung | **Proposal 17: If transmission of a DG-PUSCH with priority 1 starts after a transmission of a CG-PUSCH with priority 0 from a UE on a same serving cell and the two PUSCHs overlap, a UE is expected to cancel the CG-PUSCH before the first overlapping symbol.** |
| LGE | Proposal #18: For PHY prioritization for the case where low-priority CG-PUSCH collides with high-priority DG-PUSCH, Rel-15 timeline requirements between dynamic grant and configured grant is applied. |
| Xiaomi | ***Proposal 13:*** ***For LP CG-PUSCH overlaps with HP DG-PUSCH, related cancelation behaviour for LP CG-PUSCH defined in R16 can be reused.*** |
| Sharp | **Proposal 16: PHY layer can make the prioritization so that**   * **For collision between HP CG-PUSCH and LP DG PUSCH, the UE is expected to transmit the HP CG-PUSCH and cancel the LP DG-PUSCH at least from the first overlapping symbol.** * **For collision between LP CG-PUSCH and HP DG PUSCH, the UE is expected to transmit the HP DG-PUSCH and cancel the LP CG-PUSCH at least from the first overlapping symbol, but not before Tproc,2+d1 after the scheduling DCI of the HP 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 | 1. Support PHY prioritization for the case where high-priority DG-PUSCH collides with low-priority CG-PUSCH. 2. The UE is expected to transmit the HP-DG PUSCH and cancel the overlapping LP-CG PUSCH. Further, the UE expects that the first overlapping symbol of the high priority DG is not earlier than Tproc,2+d1 after the last symbol of the PDCCH scheduling the HP-DG PUSCH. |

# 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, TCL, QC

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| Company | Proposals/observations from Tdocs |
| E/// | Proposal 4 Support simultaneous PUCCH/PUSCH transmission of same PHY priorities over different cells can be RRC configured within the same PUCCH group  Proposal 5 When simultaneous PUCCH/PUSCH transmissions is enabled by RRC configuration, simultaneous PUCCH/PUSCH transmissions can be dynamically disabled. |
| 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 23:* 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 15: Dynamic indication of simultaneous PUCCH/PUSCH transmission is not supported.*** |
| TCL | **Proposal 8: Dynamic indication for simultaneous PUCCH/PUSCH should not be supported.** |
| MTK | 1. 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:
  + E///, CATT, MTK
* No:
* Nokia, DCM

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| Company | Proposals/observations from Tdocs |
| E/// | 1. Support simultaneous PUCCH/PUSCH transmission of same PHY priorities over different cells can be RRC configured within the same PUCCH group |
| 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 16: Simultaneous PUCCH/PUSCH transmission of same PHY priority over different cells for inter-band CA can be supported.*** |
| DCM | **Proposal 18:**  *Not to introduce the simultaneous PUCCH and PUSCH transmission for same priority case.* |
| MTK | 1. Per UE with the capability of inter-band CA, simultaneous PUCCH/PUSCH transmission of the same PHY priority over different cells can be RRC configured within the same PUCCH group. |

## 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) , Samsung (no need to differentiate between intra-band CA and inter-band CA), 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 17: Simultaneous PUCCH/PUSCH transmission for intra-band CA can be supported.*** |
| Intel | **Proposal 21: Discussion on support of simultaneous transmission of PUSCH and PUCCH over different carriers for intra-band CA is deprioritized.** |
| Apple | **Proposal 14-1: Simultaneous PUCCH/PUSCH transmission for intra-band CA is not supported if phase discontinuity problem cannot be addressed.**  **Proposal 14-2: consider the feasibility of introducing PTRS for PUCCH to handle phase discontinuity problem in simultaneous PUCCH/PUSCH transmissions for intra-band CA.** |
| Samsung | **Observation 3: In RAN1 specifications, there needs to be no differentiation between intra-band CA and inter-band CA for simultaneous PUSCH and PUCCH transmissions from a UE.**  **Proposal 14: Send an LS to RAN4 to inquire about the feasibility/MPR for simultaneous PUCCH and PUSCH transmissions on a same cell.** |
| MTK | 1. Support simultaneous PUCCH/PUSCH transmissions on different cells for intra-band CA for the same numerology both with aligned and non-aligned channel case. 2. Support simultaneous PUCCH/PUSCH transmissions on different cells for intra-band CA for different numerology if the transmissions are aligned on symbol-level (with the symbol of the lowest SCS as a reference).  * i.e. Allocation on the carrier with higher numerology doesn’t start during an ongoing symbol on the other carrier with the smaller numerology.  1. The UE is to be configured separately for inter-band and intra-band simultaneous PUCCH/PUSCH transmissions. |
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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 14-3: 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 24:* 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 19:**   * *Support PHR for simultaneous PUCCH and PUSCH transmission on different carriers.*   **Proposal 20:**   * *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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