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

e-Meeting, November 11th – 19th, 2021

Source: Moderator (OPPO)

Title: Summary#1 of email thread [107-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#107 are summarized.

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

* Focus on PHY prioritization of overlapping DG-PUSCH/CG-PUSCH and remaining details on intra-UE multiplexing of UCI of different priorities on PUCCH and PUSCH (except multiplexing/overlapping resolution procedure)
* 1st check point: November 15
* Final check point: November 19

# Multiplexing UCIs of different priorities in a PUCCH

## Agreements in previous meetings

Agreements:

*Support multiplexing for following scenarios in R17:*

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

*For the above multiplexing scenarios,*

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

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

Agreements:

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

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

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

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

Agreements:

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

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

Agreements:

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

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

Working assumption:

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

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

Agreements:

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

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

Agreements:

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

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

Agreements:

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

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

Agreements:

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

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

Agreement:

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

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

Agreement:

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

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

Agreement

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

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

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

Agreement

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

Agreement

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

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

Agreement

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

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

Agreement

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

* *The number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format 3 is determined as following:*
  + - *If , the minimum number of RBs is determined as the number of , satisfying and* 
      * *Note: is multiplied at both sides to avoid mismatch between gNB and UE due to floating point operation. Editor to capture as suggested.*
    - *Otherwise,* 
      * *Alt1: the number of RBs is . FFS: Whether/How LP HARQ-ACK is dropped.*
      * *Alt2: the number of RBs is determined by HP ACK payload size. LP HARQ-ACK is fully dropped.*
      * *Other alternatives are not precluded.*
    - *r\_HP\_UCI is maxCodeRate configured for HP bits and r\_LP\_UCI is maxCodeRate configured for LP bits in the second PUCCH-Config (the PUCCH-config containing the PUCCH resource of the HP HARQ-ACK).*
      * *FFS whether more than one maxCodeRate can be configured for one priority.*
    - *If is not equal to  according to [4, TS 38.211], is increased to the nearest allowed value of nrofPRBs for PUCCH-format3 provided by the second PUCCH-Config**[12, TS 38.331].*
    - *HP coded bits and LP coded bits are not transmitted using the same RE(s)*
  + *FFS for PUCCH format 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 of 1-2 bit(s):**
  + Option 1: Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.
    - ZTE, Nokia, E/// (with modification for 5.3.3.1), QC, DCM, IDC, Intel, Pana, vivo, Sharp, Quectel, OPPO, NEC
    - PUCCH is only QPSK based and the scrambling is automatically avoided.
  + Option 2: Reuse R15 TS 38.212 Clause 5.3.3.3, i.e., padding to 3 bits and using RM coding.
    - HW, Nokia, Samsung, MTK, LG, Spreadtrum
    - Option 1 requires much spec change for PUCCH format 1 and 3/4. For example, in 38.211, both section 6.3.2.5 and 6.3.2.6 need to add the pseudo code currently defined for PUSCH scrambling.
* **Coding rate configuration**
  + Configure multiple coding rates for HARQ-ACK based on the payload size for a given priority.
    - QC
  + Not necessary to configure more than one maxCodeRate.
    - HW, Spreadtrum
* **RE mapping for PUCCH format 2**
  + Option 1: Aggregate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits and apply the procedures described in Sec. 6.3.2.5 of R15 TS 38.211 to the aggregated coded HARQ-ACK bit sequence.
    - HW, Nokia, CATT, Sony, ZTE, vivo, DOCOMO, Spreadtrum, Pana, NEC
    - Simple and straightforward way to avoid dropping LP HARQ-ACK.
    - Option 2 makes the specs complicated, e.g. how to determine the distance of the distribution mapping, and procedure considering the various scenarios, e.g., number of bits for HP HARQ-ACK is more than that of LP, or less than that of LP.
    - If frequency diversity is desired, frequency hopping can be applied.
  + Option 2: mapping encoded HP HARQ-ACK bits first with a distributed RE mapping in frequency domain, followed by mapping encoded LP HARQ-ACK bits onto remaining REs.
    - QC, LG, Quectel
    - Time length is too short to improve the reliability from the time domain for PUCCH format 2.
    - If current frequency-first mapping on PF2 is used as it is, HP HARQ-ACK performance would be degraded compared to Rel-16 HP HARQ-ACK, especially, in case where HP HARQ-ACK REs are mapped only on the first frequency hop in the PUCCH.
    - Similar distributed mapping rule has also been applied to UCI on PUSCH.
  + Option 3: Do not support multiplexing of HP HARQ-ACK and LP HARQ-ACK in PUCCH format 2 in Rel-17. Drop LP HARQ-ACK if the resulting PUCCH resource is with PUCCH format 2.
    - Samsung, Intel
    - No practical benefit and complicates specifications and UE/gNB implementation.
* **CSI dropping or not:**
  + Option 1: Confirm WA: Drop CSI (including part 1 and part2, if exist) if CSI would multiplex on a PUCCH which has HP A/N.
    - ZTE, Nokia, QC, Quectel, Apple (for LP CSI)
  + Option 2: Drop CSI part 2 if CSI would multiplex on a PUCCH which has HP A/N.
    - LGE, DCM
* **Power control:**
  + Opt.1: Use the HP UCI bit number and HP RE number for calculation.
    - Nokia (For PF 2/3/4, use the total UCI bit number for PF 1), Samsung, Apple, Sharp, Pana, CATT, NEC
  + Opt.2: Use the maximum value between based on LP BPRE and based on HP BPRE for PUCCH power control formula.
    - HW
  + Opt.3: The formula for is based on HP UCI size. No enhancement to the parameters in the formula.
    - E///
  + Opt.4: The BPRE for PUCCH power control is calculated based on the number of HP UCI bits and the number of REs mapped by HP UCI when both HP UCI and LP UCI are multiplexed in a PUCCH.
    - Quectel, IDC
  + Opt.5: No enhancement to the parameters in the formula.
    - Apple, IDC, Intel, Pana, Nokia
    - Unclear how much gain can be provided by changing the existing power control equation, and why the existing mechanism cannot work.
    - There is a huge discrepancy in Delta value w.r.t. spectral efficiency
    - Separate coding is also supported in Rel-15/16, but takes all UCI bits into account rather than using one UCI type.
* If a PUCCH carrying HP SPS HARQ-ACK overlaps with a PUCCH carrying LP HARQ-ACK, UE transmits HP SPS HARQ-ACK on PUCCH resource for HP SPS HARQ-ACK and drops LP HARQ-ACK.
  + - OPPO

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 13: For PUCCH format 2, support 2 encoding chains for the case of HP HARQ-ACK and LP HARQ-ACK multiplexing. Separate code rates can be configured for HP HARQ-ACK and LP HARQ-ACK for PUCCH format 2.***  ***Proposal 14: For the encoders* *of LP and HP HARQ-ACK bits with more than 2 bits total payload***, ***and HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support option 2, i.e., padding and RM encoding.***  ***Observation 1: It is feasible to consider an enhanced RE mapping rule in Rel-17.***  ***Proposal 15: For multiplexing of HP HARQ-ACK and LP HARQ-ACK, the distributed mapping between HARQ-ACK and LP HARQ-ACK could be considered for PUCCH format 2.***  ***Proposal 16: For the power control of multiplexed HP HARQ-ACK and LP HARQ-ACK on PUCCH, adopt the maximum value between based on LP BPRE and based on HP BPRE for PUCCH power control formula.***  ***Proposal 18: It is not necessary to configure more than one maxCodeRate.*** |
| ZTE | ***Proposal 1:*** *For HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding and reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit, reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.*  ***Proposal 2:*** *When the two UCIs with different priorities will be multiplexed on a PUCCH format 2/3/4 by separate coding, for a certain priority UCI,*   * If the payload size is more than 2 but less than 12, RM code is performed. * If the payload is more than 11 bits, Polar coding is performed.   ***Proposal 3:*** *Modify the agreement in RAN1#106-e to:*  *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17* ***in case of the total number of LP and HP HARQ-ACK bits >2****,*   * *HP A/N reuses rate matching equation, and RE mapping rules in Rel-15 for A/N+CSI-1.* * *LP A/N reuses rate matching equation, and RE mapping rules in Rel-15 for CSI-2.*   *Above applies at least for PUCCH format 3 and 4.*  ***Proposal 4:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is more than 2,*   * *Coded bits of HP HARQ-ACK and LP HARQ-ACK are continuously mapped in the time-frequency resources for PF2.* |
| Nokia | **Proposal 3.2: For the scenario where a PUCCH carrying high-priority HARQ-ACK overlaps with another PUCCH carrying low-priority HARQ-ACK and the total payload size is two bits, the order of the multiplexed two bits could be [high-priority HARQ-ACK bit, low-priority HARQ-ACK bit].**  **Proposal 3.4: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK where the high-priority or low-priority HARQ-ACK is 1-2 bits and the total payload size is greater than 2,**   * **Adopt Option 1 as follows: In case HARQ-ACK is 1 bit, use the existing Rel-15 1-bit information encoding scheme in TS 38.212 Sec. 5.3.3.1 to encode this HARQ-ACK; in case HARQ-ACK is 2 bits, use the existing Rel-15 2-bit information encoding scheme in TS 38.212 Sec. 5.3.3.2 to encode this HARQ-ACK.**   + **In case HARQ-ACK is 1 bit, the scrambling design for PUSCH could be reused to account for the placeholder bits.**   **Proposal 3.5: Confirm the RAN1#104bis-e meeting’s Working Assumption to not support multiplexing of CSI (including part 1 and part 2, if any) and high-priority HARQ-ACK on PUCCH and thus to drop the CSI and prioritize the high-priority HARQ-ACK.**  **Proposal 3.6: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, adopt the following approach for mapping the separately coded bits to PUCCH:**   * **Aggregate the coded high-priority HARQ-ACK bits and the coded low-priority HARQ-ACK bits, and apply the procedures described in Sec. 6.3.2.5 of TS 38.211 to this aggregated coded HARQ-ACK bit sequence.**   **Proposal 3.9: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, adopt the following regarding the power adjustment component:**   * **For PUCCH format 2/3/4, use the HP UCI bit number and HP RE number for calculation.** * **For PUCCH format 1, use the total UCI bit number for calculation.** |
| E/// | Proposal 6: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is more than 2, for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding. Introduce Table 5.3.3.1-1A to TS 38.212 Clause 5.3.3.1 for encoding 1-bit information. Reuse Rel-15 TS 38.212 Clause 5.3.3.2 for 2-bit. Apply the Rel-15 scrambling for PUCCH.  **Proposed Table 5.3.3.1-1A: Encoding of 1-bit information**   |  |  | | --- | --- | |  | **Encoded bits** | | **1** |  | | 2 |  |  1. If the total number of high priority UCI bits is 11 or lower, let , otherwise let . |
| CATT | ***Proposal 8: For separate coding of HP HARQ-ACK and LP HARQ-ACK when multiplexing on a PUCCH resource with PUCCH format 2, the encoded HP HARQ-ACK and LP HARQ-ACK are cascaded and mapping to PUCCH REs in increasing order of frequency domain followed by time domain.*** |
| Samsung | **Proposal 3: Zeros are appended to the LP/HP HARQ-ACK information bits if the payload of LP/HP HARQ-ACK is 1 or 2 bits when multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH.**  **Proposal 4: Do not support multiplexing of HP HARQ-ACK and LP HARQ-ACK in PUCCH format 2 in Rel-17.**   * **Drop LP HARQ-ACK if the resulting PUCCH resource is with PUCCH format 2.**   **Proposal 5: RRC configures presence of a T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.**  **Proposal 6: RRC separately configures enabling multiplexing of HP HARQ-ACK and LP HARQ-ACK for HP HARQ-ACK with and without a PDCCH.**  **Proposal 12：For determining the transmitting power for a PUCCH with HP HARQ-ACK and LP HARQ-ACK, the parameters configured for HP HARQ-ACK should be used to determine .**   * **FFS: Whether/How to drop LP HARQ-ACK if the calculated power based on is larger than the configured maximum output power .**   **Proposal 11: Multiplexing HP HARQ-ACK, HP SR and LP HARQ-ACK in a same PUCCH reuses the same rule of multiplexing of HP HARQ-ACK and LP HARQ-ACK in a same PUCCH by replacing HP HARQ-ACK with HP HARQ-ACK and HP SR for PUCCH resource determination, PRB number determination, rate matching and RE mapping.** |
| QC | ***Proposal 2: For PUCCH cell switch in NR Rel-17, use type 2 actual PHR to report PHR for an actual PUCCH transmission on Pcell or a Scell in a PUCH group, following the PHR calculation as below.***   * [dB]   ***Proposal 3: For PUCCH cell switch in NR Rel-17, support type 2 virtual PHR to report PUCCH PHR on Pcell or a Scell without actual PUCCH transmission in a PUCCH group.***  ***Proposal 6*: Confirm the working assumption made in RAN1 #104bis-e**  **For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,**   * **Drop CSI (including part 1 and part2, if exist) if CSI would multiplex on a PUCCH which has HP A/N.**   ***Proposal 7*: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into PUCCH format 3 or format 4, when the total number of LP and HP HARQ-ACK bits is more than 2, and when the number of HP or LP HARQ-ACK has less than or equal to 2 bits**   * **The HP or LP HARQ-ACK uses repetition encoding if the payload size is 1 bit, and uses the simplex encoding if the payload size is 2 bits**   ***Proposal 8*: In NR Rel-17, for multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into PUCCH, when the total number of low priority (LP) and high priority (HP) HARQ-ACK bits is more than 2**   * **For a given priority, support gNB to configure multiple coding rates for HARQ-ACK based on the payload size.**   ***Proposal 9*: For HP UCI and LP HARQ-ACK (in type 2 codebook) multiplexing on a PUCCH, round up LP HARQ-ACK size to a nearest reference size, in the calculation of total number of RBs for HP and LP UCI and in the PUCCH resource set determination.**  ***Proposal 10*: For HP UCI and LP UCI multiplexing on PUCCH format 2, support mapping encoded HP UCI bits first with a distributed RE mapping in frequency domain, followed by mapping encoded LP UCI bits onto remaining REs.**  ***Proposal 11*: the distance d for HP UCI distributed RE mapping is determined as , where**   * **is the payload size for HP UCI, is the coding rate for HP UCI.** * **S is number of OFDM symbols in the PUCCH resource.** * **L is the total number of RBs determined for multiplexed HP UCI and LP UCI transmission**   ***Proposal 12*: 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** |
| LG | **Proposal #1: Consider to apply RM coding with bit-padding for HP/LP HARQ-ACK of up to 2 bits (in case when the total number of LP and HP HARQ-ACK bits is more than 2), in order to minimize impacts to the specification as well as UE implementation.**  **Proposal #2: Consider the following UE behaviour for the multiplexing of CSI at least on PUCCH format 3/4.**   * **In case with HP HARQ-ACK and CSI (without LP HARQ-ACK), the HP HARQ-ACK and CSI part 1 can be separately encoded where CSI part 2 is dropped.** * **In case with HP HARQ-ACK, LP HARQ-ACK and CSI, the LP HARQ-ACK and CSI part 1 can be jointly encoded and the HP HARQ-ACK can be solely encoded where CSI part 2 is dropped.**   **Proposal #3: Consider to support separate encoding for HP HARQ-ACK and LP HARQ-ACK on PUCCH format 2.**   * **HP (coded) UCI is firstly mapped over distributed REs on the PUCCH resource (to guarantee the reliable HP UCI performance by achieving frequency diversity), then LP UCI is mapped to the remaining REs not occupied by the HP UCI.**   **Proposal #4: Consider the following for multiplexing of HP HARQ-ACK and LP HARQ-ACK on PUCCH format 0/1 with the total UCI payload size of 2 bits.**   * **HP UCI bit and LP UCI bit are mapped to MSB and LSB, respectively.** |
| Intel | **Proposal 9: For HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding by reusing R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.**  **Proposal 10: LP and HP HARQ-ACK multiplexing is not supported for PUCCH format 2.** |
| Pana | **Proposal 1: For the encoder for HP or LP HARQ-ACK of 1-2 bit(s) when the total number of LP and HP HARQ-ACK bits is more than 2**   * **Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit.** * **Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit** |
| Quectel | **Proposal 3**: Confirm the working assumption that CSI (including part 1 and part2, if exist) is dropped if CSI would multiplex on a PUCCH which has HP A/N.  **Proposal 4**: Option 1 is supported, i.e., R15 TS 38.212 Clause 5.3.3.1 is reused for 1-bit and R15 TS 38.212 Clause 5.3.3.2 is reused for 2-bit.  **Proposal 5**: Rate matching equation in Rel-15 for PF3/4 A/N+CSI-1 and rate matching equation in Rel-15 for PF3/4 CSI-2 are reused respectively for PF2 HP A/N and PF2 LP A/N.  **Proposal 9**: Interleaved multiplexing/RE mapping of HP HARQ-ACK and LP HARQ-ACK is supported when HP HARQ-ACK and LP HARQ-ACK are multiplexed in PUCCH with PF2.  **Proposal 11**: The BPRE for PUCCH power control is calculated based on the number of HP UCI bits and the number of REs mapped by HP UCI when both HP UCI and LP UCI are multiplexed in a PUCCH. |
| IDC | ***Proposal 5: Support* maxCodeRateAdd *parameter for the maximum coding rate of HP HARQ-ACK r1. In case the number of PRBs*** ***with r1 =* maxCodeRateAdd *is equal to the one obtained with r1=*maxCodeRate*, r1 is set to* maxCodeRateAdd*. Otherwise, r1 is set to* maxCodeRate*.***  ***Proposal 6: For a PUCCH format 3 when HP HARQ-ACK is multiplexed with LP HARQ-ACK, the PUCCH transmission power adjustment component TF,b,f,c is calculated based on the number of bits per resource elements (BPRE) for HP HARQ-ACK (including CRC if any).***  ***Proposal 7: For a PUCCH format 3 when HP HARQ-ACK is multiplexed with LP HARQ-ACK, the PUCCH transmission power adjustment component TF,b,f,c is set to the following:***   * ***TF,b,f,c =10 log10(K1 BPRE) for number of HP HARQ-ACK bits smaller than or equal to 11;*** * ***TF,b,f,c =10 log10(2K2 BPRE) for number of HP HARQ-ACK bits larger than 11;*** * ***K1=6, K2=2.4;*** * ***BPRE= Qm / NSFPUCCH,3;*** * ***is the applicable maximum coding rate for HP bits (e.g. maxCodeRate or maxCodeRateAdd);*** * ***Qm is the modulation order;*** * ***NSFPUCCH,3 is the spreading factor for PUCCH format 3.*** |
| Apple | **Proposal 9-1: leverage the Rel-15 design, LP HARQ-ACK is mapped to UCI Part II in separate encoding, adopt the UCI mapping in Figures 9-6a/9-6b.**  **Proposal 9-2:**  **Consider for PUCCH format 2 to support multiplexing of HP UCI(s) and LP UCI(s):**  **generating two encoded sequences for HP-ACK (with r1) and LP-ACK (with r2) separately and then concatenating those two encoded sequences into one encoded sequence, UCI mapping is not changed for PUCCH Format 2.**  **Proposal 13-1: For PUCCH formats 2/3/4, the delta factor is determined from UCI part 1:**   * **The number of resource elements for UCI part 1 where is the number of coded bits for UCI part 1** * **If is smaller or equal to 11,**   + **If a HARQ-ACK codebook with bits is included in UCI part 1,  is used instead of for the HARQ-ACK codebook:**   + **If more than one HARQ-ACK codebooks are included in UCI part 1 (e.g. one due to SPS HARQ deferral, another for HARQ feedback for dynamic grant PDSCH(s)), then replacement of the number of HARQ-ACK codebook size by the associated can be applied to each HARQ-ACK codebook.** * **otherwise**   + **where**      - **and** * **And = is applied to both UCI parts.** |
| vivo | ***Proposal 2: When the total number of LP and HP HARQ-ACK bits is more than 2 and for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), option 1 is preferred.***   * ***Option 1: Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.***   ***Proposal 3: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH format 2, the encoded HP HARQ-ACK and LP HARQ-ACK are concatenated and mapped to PUCCH REs in increasing order of frequency domain followed by time domain.*** |
| OPPO | ***Proposal 1: When the total LP HARQ-ACK and HP HARQ-ACK bits is more than 2 and one of HP HARQ-ACK and LP HARQ-ACK is not more than 2, reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit and reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.***  ***Proposal 2: PUCCH format 2 can be used for multiplexing of HP HARQ-ACK and LP HARQ-ACK.***  ***Proposal 8: If a PUCCH carrying HP SPS HARQ-ACK overlaps with a PUCCH carrying LP HARQ-ACK, UE transmits HP SPS HARQ-ACK on PUCCH resource for HP SPS HARQ-ACK and drops LP HARQ-ACK.*** |
| DCM | **Proposal 1:**   * *CSI part 2 is dropped if CSI would be multiplexed on a PUCCH which has HARQ-ACK information in case the total number of LP and HP HARQ-ACK bits is more than 2.*   **Proposal 2:**   * *Option 1 is slightly preferable considering the potential overhead of padding for the separate coding method of 1-2 HARQ-ACK bit(s).*   + *Option 1: Reuse R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.* |
| Spreadtrum | 1. ***For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH, if HP HARQ-ACK or LP HARQ-ACK is of 1-2 bit(s), reuse R15 TS 38.212 Clause 5.3.3.3, i.e., padding to 3 bits and using RM coding.*** 2. ***Support Alt. 1: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, aggregate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits and apply the procedures described in Sec. 6.3.2.5 of R15 TS 38.211 to the aggregated coded HARQ-ACK bit sequence.*** 3. ***Only one maxCodeRate can be configured for one priority per PUCCH format.*** 4. ***One maxCodeRate is configured for PUCCH format 2.*** |
| Sony | **Proposal 1: For RE mapping of HP UCI and LP UCI in PUCCH Format 2, aggregate the coded HP UCI bits and the coded LP UCI bits, where the HP UCI encoded bits are mapped first on earlier OFDM symbols followed by LP UCI encoded bits. The procedures described in Sec. 6.3.2.5 of R15 TS 38.211 to the aggregated coded UCI bit sequence are applied.** |
| ETRI | **Proposal 1: If some LP UCI (i.e., CSI or SR) is dropped, then it is dropped as a payload.**  **Proposal 8: The Rel-17 multiplexing behavior is applied regardless of UCI types.**  **Proposal 11: In order to adjust the power of PUCCH for payload from the other priority, the applied code rate can be used for scaling factor.** |
| NEC | ***Proposal 4:***  *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 multiplexes the LP HARQ-ACK and HP HARQ-ACK on a PUCCH based on total HARQ-ACK bits number of updated LP codebook and total HARQ-ACK bits number of HP codebook.*   ***Proposal 5:***  *For multiplexing of a low priority Type-2 HARQ-ACK codebook and a high priority Type-1/Type-2 HARQ-ACK codebook on a PUCCH in Rel-17,*   * *Support introducing an additional DCI field in DCI associated with high priority HARQ-ACK for determining the total number of LP HARQ-ACK bits.* |
| WILUS | * ***Proposal 2:*** *For PUCCH format 3/4,*    + *To maximize reliability of HP HARQ-ACK, the mapping rule of PUCCH format 3/4 in Rel-15 can be reused., i.e., the HP HARQ-ACK is mapped to adjacent symbols to DMRS symbols.*   + *To minimize latency of HP HARQ-ACK, the HP HARQ-ACK can be mapped to earlier symbols.* * ***Proposal 3:*** *For PUCCH format 2,*   + *Support PUCCH format 2 to multiplex LP HARQ-ACK and HP HARQ-ACK*   + *To maximize a reliability of HP HARQ-ACK, the HP HARQ-ACK is distributed to REs across RBs as much as possible.* * ***Proposal 5:*** *To multiplex HP-SR with PF0 and LP HARQ-ACK with PF0, we propose*   + *If HP-SR is negative, then transmit LP HARQ-ACK on HARQ-ACK resource.*     - *In case of 1-bit LP HARQ-ACK, use 2 CSs, i.e., {0, 6} CS index*     - *In case of 2-bit LP HARQ-ACK, use 4 CSs, i.e., {0, 3, 6, 9} CS index*   + *If HP-SR is positive, then transmit LP HARQ-ACK and HP-SR on HARQ-ACK resource*     - *In case of 1-bit LP HARQ-ACK, use 2 CSs, i.e., {3, 9} CS index*     - *In case of 2-bit LP HARQ-ACK, use 4 CSs, i.e., {1, 4, 7, 11} CS index*        * *To enhance HP-SR reliability, 2-bit LP HARQ-ACK can be bundled to 1-bit and then the 1-bit bundled LP HARQ-ACK is treated as 1-bit LP HARQ-ACK, i.e., use 2 CSs, {3, 9} CS index .* |
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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, when the total number of LP and HP HARQ-ACK bits is more than 2, for HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding. Introduce Table 5.3.3.1-1A to TS 38.212 Clause 5.3.3.1 for encoding 1-bit information. Reuse Rel-15 TS 38.212 Clause 5.3.3.2 for 2-bit. Apply the Rel-15 scrambling for PUCCH.

**Table 5.3.3.1-1A: Encoding of 1-bit information**

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| --- | --- |
|  | **Encoded bits** |
| **1** |  |
| 2 |  |

Proposal for 1st round discussion:

Down-select from the two alternatives:

* Alt. 1: For the multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2, aggregate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits and apply the procedures described in Sec. 6.3.2.5 of R15 TS 38.211 to the aggregated coded HARQ-ACK bit sequence.
* Alt.3: Do not support multiplexing of HP HARQ-ACK and LP HARQ-ACK in PUCCH format 2 in Rel-17. Drop LP HARQ-ACK if the resulting PUCCH resource is with PUCCH format 2.

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 the HP UCI bit number and HP RE number for calculation

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| Company | Comments |
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## Multiplexing enable/disable mechanism

## Inputs from Tdocs

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

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

RRC configuration of SPS with HP HARQ-ACK includes an indication of whether the UE can multiplex HP HARQ-ACK with LP HARQ-ACK or LP PUSCH.

* + IDC

RRC configuration of a HP SR resource includes an indication of whether the UE can multiplex HP SR with LP HARQ-ACK.

* + IDC

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 12: 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.*** |
| ZTE | ***Proposal 5****: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, support DCI+RRC configuration for gNB to enable/disable the multiplexing when DCI is applied.*   * *For SPS HARQ-ACK, the enable/disable scheme falls back to RRC configuration.*   ***Proposal 6****: The indicator of intra-UE multiplexing UCI with different priorities should be carried on the scheduling DCI or RRC parameter for the high priority transmission.* |
| Nokia | **Proposal 3.1: The gNB dynamically indicates, via an explicit field in the last DCI scheduling HARQ-ACK, whether multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK (or more generally low-priority multiplexed UCIs) is enabled or disabled.**   * **FFS: It is up to gNB to configure the dynamic multiplexing using a new DCI field (i.e., if not configured the multiplexing is enabled through RRC configuration only).**   **Proposal 3.3: For the scenario where a PUCCH carrying high-priority HARQ-ACK overlaps with another PUCCH carrying low-priority HARQ-ACK: If the low- and high-priority HARQ-ACK does not have a corresponding PDCCH (i.e., low- and high priority ‘SPS’ HARQ only), the multiplexing is not supported.** |
| Samsung | **Proposal 1: Support multiplexing UCI of different priorities subject to timeline conditions and RRC configuration and/or dynamic indication from gNB.**  **Proposal 2: The UCI types with first priority that can be multiplexed in a PUCCH/PUSCH of a second priority are configurable by the network.**  **Proposal 15: If a UE is configured by RRC for HP/LP multiplexing, the UE can be configured a 1-bit field in DCI format 0\_1/0\_2 to indicate whether or not HP/LP multiplexing is enabled.** |
| QC | ***Observation 1*: Dynamic indication for enabling/disabling intra-UE multiplexing in Rel-17 has the following issues need to be solved:**   * **Conflict between semi-static indication and dynamic indication**   + **Demultiplexing issue due to dynamic indication override semi-static indication from Rel-17 multiplexing to Rel-16 cancellation**   + **Regenerating dropped PUCCH/PUSCH due to dynamic indication override semi-static indication from Rel-16 cancellation to Rel-17 multiplexing** * **Ambiguity between UE and gNB caused by missing DCI at the UE** * **Conflict between dynamic indications**   ***Proposal 1:* dynamic enabling/disabling intra-UE multiplexing is not supported in Rel-17, unless the issues in observation 1 are resolved.** |
| Intel | **Proposal 6: Support dynamic indication for enabling/disabling multiplexing by DCI. A UE does not expect conflicted indication by multiple DCIs with same priority for the same UL channel.** |
| MTK | 1. Dynamic indication of the multiplexing activation/de-activation is not supported. 2. Guard gap timeline of the new multiplexed PUCCH is of the earliest PUCCH. |
| Pana | **Proposal 4:**   * **For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH in Rel.17, the enabling/disabling multiplexing is RRC configured.**   + **Dynamic indication for enabling/disabling should also be supported.** |
| IDC | ***Proposal 1: DCI indicating HP HARQ-ACK also indicates if UE multiplexes HP HARQ-ACK with LP HARQ-ACK.***  ***Proposal 2: 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 3: RRC configuration of a HP SR resource includes an indication of whether the UE can multiplex HP SR with LP HARQ-ACK.*** |
| vivo | ***Proposal 13: Dynamic indication of intra-UE multiplexing and prioritization manner can be supported in Rel-17.***  ***Proposal 14: For dynamic indication, multiplexing or prioritization indication field can be included in DCI for HP or LP or both HP and LP service.*** |
| DOCOMO | **Proposal 6:**   * *RRC configuration should be baseline for enabling/disabling multiplexing of LP and HP PUCCH* |
| Spreadtrum | 1. ***Support RRC configuration method for multiplexing enable/disable mechanism for UCI on PUCCH.*** |
| Sony | **Proposal 2: The gNB dynamically enables/disables multiplexing in an HP PUCCH by using a new Multiplexing Indicator in the DL Grant scheduling the HP PUCCH.**  **Proposal 3: In the unlikely event that the gNB sends contradictory Multiplexing Indicators to the UE in different HP DL Grants, the UE follows the Multiplexing Indicator of the last HP DL Grant prior to the scheduled colliding HP PUCCH.** |
| Xiaomi | ***Proposal 4: For enabling/disabling multiplexing of channels of different priorities, semi-static configuration is preferred.*** |
| ETRI | **Proposal 9: The scheduling DL-DCI has an additional field whether or not to allow multiplex HP UCI and LP UCI, or otherwise by the RRC signalling.** |
| TCL | **Proposal 1: Support explicit indication to enable multiplexing procedure between HP UCI and LP UCI via RRC configuration.** |
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## PUCCH resource determination and mapping for multiplexing between HARQ-ACKs with different priorities

## Inputs from Tdocs

**If ,**

* Option 1: LP HARQ-ACK is compressed/bundled/compaction.
  + ZTE, QC, LG, Apple, MTK, Sharp
* Option 2: The the number of RBs is . Transmit the LP HARQ-ACK with higher code rate than configured code rate as long as it does not exceed the maximum tolerated code rate; otherwise drop all LP HARQ-ACKs.
  + HW, Quectel, IDC, Intel, Pana, vivo
* Option 3: LP HARQ-ACK is dropped. The number of RBs is determined by HP HARQ-ACK payload size
  + Nokia, LG, OPPO, DCM
* Option 4: Further check possible multiplexing in the next sub-slot.
  + Leno/Moto
* Option 5: It is not expected that RBs cannot accommodate the total number of HP HARQ-ACK bits and LP HARQ-ACK bits.
  + CATT, Spreadtrum
* Option 6: HP HARQ-ACK and LP HARQ-ACK multiplexing in PUCCH is implicitly disabled if the PRI in DCI indicates a PUCCH resource that cannot accommodate both HP HARQ-ACK and LP HARQ-ACK.
  + Quectel

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

* **Proposal from last meeting discussion:**
  + For multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH format 3/4,
    - RRC configures presence of a T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.
  + For multiplexing a LP Type-2 HARQ-ACK codebook in a HP PUSCH,
    - RRC configures an additional T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.
  + HW, ZTE, Samsung, CATT, IDC, Intel

**Other options:**

* Option 1: Configure a dedicated PUCCH resource for HP and LP HARQ-ACK in the second PUCCH-Config.
  + vivo
* Option 2: PRI+x in the HP DCI is used to implicitly determine an extended PUCCH resource
  + ZTE
* Option 3a: The LP type 2 codebook size is quantized/rounded up to a nearest reference size. FFS reference size granularity.
  + QC
* Option 3b: Configuration of semi-static size reservation for LP HARQ-ACK payload is provided by RRC. LP HARQ-ACK semi-static size reservation is used instead of determined LP HARQ-ACK codebook size when selecting the PUCCH resource set.
  + Nokia, CATT (FFS whether it is semi-static), LG, Quectel, DCM, Pana
* Option 4: Additional DCI field in DCI corresponding HP HARQ-ACK or HP PUSCH for determining the number of LP HARQ-ACK bits multiplexed on PUCCH/PUSCH.
  + Nokia, CATT, LG
  + Alt-A: A new DCI field is used to indicate the corresponding total DAI or CB size for low-priority HARQ-ACK to avoid discrepancy on the low-priority HARQ-ACK codebook size.
  + Alt-B: Different values in a new DCI field are used to indicate either (i) to not multiplex the low-priority HARQ-ACK or (ii) to multiplex the low priority HARQ-ACK and the corresponding total DAI or CB size for low-priority HARQ-ACK to avoid discrepancy on the low-priority HARQ-ACK codebook size.
* Option 5: Introduce a 1-bit “last DL Grant” indicator in the DL Grant to indicate whether a DL Grant is the last DL Grant associated with a LP PUCCH.
  + Sony

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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

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 17: If the maximum PRB number in the resulting PUCCH cannot carry multiplexed HP HARQ-ACK and LP HARQ-ACK, consider hybrid of Alt.1 and Alt.2: transmit the LP HARQ-ACK with higher code rate than configured code rate as long as it does not exceed the maximum tolerated code rate; otherwise drop all LP HARQ-ACKs and the number of PRBs is determined solely based on the HP HARQ-ACK.***  ***Proposal 19: Additional LP T-DAI indication can be introduced in HP DL DCI to resolve the issue of ambiguous LP HARQ-ACK payload size in case of collision with HP HARQ-ACK.***   * ***2 bits LP T-DAI for Type 2 HARQ-ACK codebook to indicate the LP HARQ-ACK payload size.*** * ***1 bit LP T-DAI for Type 1 HARQ-ACK codebook to indicate the presence of LP HARQ-ACK.***   ***Proposal 20: UE does not expect the overlapping between HP PUCCH and LP HARQ-ACK subject to Type 3 CB/enh. Type 3 CB/one shot retransmission.***  ***Proposal 21: HP SPS HARQ-ACK only and LP HARQ-ACK are not expected to be multiplexed.***  ***Observation 2: If LP Type 2 HARQ-ACK codebook includes two HARQ-ACK sub-codebooks, then adding two additional T-DAI fields (i.e. 4bits) in HP DCI for two LP HARQ-ACK sub-codebooks will lead to too large HP DCI overhead.***  ***Proposal 22: For multiplexing of HP HARQ-ACK and LP HARQ-ACK with two LP sub-codebooks, introduce only one additional LP T-DAI field (i.e. 2bits) in HP DCI applicable to both the first LP HARQ-ACK sub-codebook and the second LP HARQ-ACK sub-codebook.***  ***Proposal 25: Additional LP UL DAI indication can be introduced in HP UL DCI to resolve the issue of ambiguous LP HARQ-ACK payload size in case of collision with HP PUSCH.***   * ***2 bits LP UL DAI for Type 2 HARQ-ACK codebook to indicate the LP HARQ-ACK payload size.*** * ***1 bit LP UL DAI for Type 1 HARQ-ACK codebook to indicate the presence of LP HARQ-ACK. The UE should not transmit LP HARQ-ACK on HP PUSCH in case of UL DAI = 0 regardless of other conditions.*** |
| ZTE | ***Observation 1:*** *The ambiguity problem due to LP HARQ-ACK non-existence, in case the total number of LP and HP HARQ-ACK bits is no more than 2 bits, is very severe and need to be solved.*  ***Observation 2:*** *The ambiguity problem on LP HARQ-ACK type-2 codebook size due to DCI miss-detection, is not severe and could be solved by gNB implementation.*  ***Observation 3:*** *The option 3/4/5 aiming to solve issue of ambiguity on LP HARQ-ACK type-2 codebook size due to DCI miss-detection, have kinds of shortcomings, such as DCI overhead increase and less efficient to over-optimize a low probability event.*  ***Proposal 7****: For the case that the total number of bits is no more than 2 bits, the PRI+x in the HP DCI is used to implicitly determine an extended PUCCH resource from the same PUCCH set in the PUCCH-config with high priority for the multiplexed UCI.*  *x is predefined, e.g., x=1.*  ***Proposal 21:*** *LP UCI compression is slightly preferred in case there is no enough resource left for LP UCI.* |
| Nokia | **Proposal 3.7: For the PRB number determination of the selected PUCCH resource that would carry the multiplexed high-priority HARQ-ACK and low-priority HARQ-ACK: when the required number of PRBs is larger than the configured number of PRBs, , adopt Alt2 as follows:**   * **Alt2: the number of RBs is determined by HP HARQ-ACK payload size. LP HARQ-ACK is fully dropped.**   ***Observation 3.1: Errors in low-priority HARQ-ACK codebook size determination e.g. due to missed DCI may cause selection of different PUCCH resource set or use of smaller number of PRBs for the multiplexed high-priority and low-priority HARQ-ACKs feedback than what gNB would expect.***  **Proposal 3.8: To avoid discrepancy between the UE and the gNB on the determination of PUCCH resource set and number of PRBs for UCI containing multiplexed high-priority and low-priority HARQ-ACKs, support Option 3b:**   * **Option 3b: Configuration of semi-static size reservation for low-priority HARQ-ACK payload is provided by RRC.**   **Otherwise, support Option 4:**   * **Option 4: Provide dynamic indication for low-priority HARQ-ACK codebook size in a DCI corresponding to HP HARQ-ACK.**   + **Alt-A: A new DCI field is used to indicate the corresponding total DAI or CB size for low-priority HARQ-ACK to avoid discrepancy on the low-priority HARQ-ACK codebook size.**   + **Alt-B: Different values in a new DCI field are used to indicate either (i) to not multiplex the low-priority HARQ-ACK or (ii) to multiplex the low priority HARQ-ACK and the corresponding total DAI or CB size for low-priority HARQ-ACK to avoid discrepancy on the low-priority HARQ-ACK codebook size.** |
| CATT | ***Proposal 9: It is not expected that RBs cannot accommodate the total number of HP HARQ-ACK bits and LP HARQ-ACK bits if multiplexing between HP HARQ-ACK and LP HARQ-ACK is performed.***  ***Proposal 13: 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 15: An additional UL DAI bit field can be considered to be added in the UL DCI for multiplexing PUCCH and PUSCH with different priorities.*** |
| Samsung | **Proposal 13: For multiplexing a LP Type-2 HARQ-ACK codebook in a HP PUSCH**   * **RRC configures an additional T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.** * **A number of REs is reserved for LP HARQ-ACK in a HP CG-PUSCH.** |
| QC | ***Proposal 9*: For HP UCI and LP HARQ-ACK (in type 2 codebook) multiplexing on a PUCCH, round up LP HARQ-ACK size to a nearest reference size, in the calculation of total number of RBs for HP and LP UCI and in the PUCCH resource set determination.**  ***Proposal 22:* In Rel-17 UCI multiplexing, support low priority HARQ-ACK compression.**   * **FFS conditions to trigger low priority HARQ-ACK compression** * **FFS details of compression scheme.** |
| LGE | **Proposal #7: Consider the following LP HARQ-ACK handling for the case of exceeding the maximum UCI coding rate on PUCCH.**   * **Partial (or full) dropping for LP HARQ-ACK according to HARQ-ACK codebook type.** * **HARQ-ACK bundling for LP HARQ-ACK in spatial domain and/or CBG domain.**   **Proposal #8: Consider the following to determine a PUCCH resource in the HP PUCCH resource set selected based on total UCI payload size.**   * **In case when at least one HP DL DCI is received by the UE, the PUCCH resource corresponding to the PRI indicated in the last HP DCI is selected.** * **In case when LP DL DCI is only received by the UE, the PUCCH resource corresponding to the PRI indicated in the last LP DCI is selected.**   **Proposal #14: Consider the following aspect by taking potential missing of the DCI corresponding to HP HARQ-ACK by the UE into account.**   * **The reserved REs corresponding to 2-bit HARQ-ACK on PUSCH are to be generated based on the beta offset configured for HP HARQ-ACK and to be mapped even on LP PUSCH as well as HP PUSCH, even in case when there is no HP HARQ-ACK from UE perspective.** |
| Intel | **Proposal 11: When sufficient resource is not available for accommodating LP HARQ-ACK on HP PUCCH, LP HARQ-ACK payload bits can be partially dropped to ensure a proper coding rate with PRBs.**  **Proposal 12: For multiplexing a HP HARQ-ACK and LP HARQ-ACK into a PUCCH in R17, additional T-DAI for LP HARQ-ACK can be indicated by the DCI triggering HP HARQ-ACK.** |
| MTK | 1. Group-bundling is supported when multiplexing and when the resulted UCI payload is large. |
| Pana | **Proposal 2: For determining the PUCCH resource to carry the multiplexed HP and LP HARQ-ACKs, if , the number of RBs is .**  **Proposal 3: Configuration of semi-static size reservation for LP HARQ-ACK payload is provided by RRC. LP HARQ-ACK semi-static size reservation is used instead of determined LP HARQ-ACK codebook size when selecting the PUCCH resource set and PRB number determination.** |
| Quectel | **Proposal 6**: The approach of PRB number determination for HP A/N and LP A/N on PF3 (except for the FFT size restriction) is also applied for PF2.  **Proposal 7**: If , Alt2, i.e., the number of RBs is determined by HP HARQ-ACK payload size and LP HARQ-ACK is fully dropped, is applied.  **Proposal 8**: Reference/quantized LP type 2 HARQ-ACK codebook sizes are used for PUCCH resource set determination and/or PUCCH PRB number determination. The configuration of the reference/quantized size is FFS, e.g., RRC, DCI or a hybrid of RRC and DCI.  **Proposal 10**: HP HARQ-ACK and LP HARQ-ACK multiplexing in PUCCH is implicitly disabled if the PRI in DCI indicates a PUCCH resource that cannot accommodate both HP HARQ-ACK and LP HARQ-ACK. |
| IDC | ***Proposal 4: In case the minimum number of RBs for transmitting all HP and LP HARQ-ACK bits would be higher than the configured number of RBs for the PUCCH and if CBG-based HARQ-ACK is not configured, the UE transmits all HP HARQ-ACK and the largest possible subset of LP HARQ-ACK codebook (starting from first position) such that the minimum number of RBs is equal to the configured number of RBs.***  ***Proposal 8: DCI indicating HP HARQ-ACK includes an indication of the DAI of LP HARQ-ACK.*** |
| 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 for PUCCH format 2 is given by**    **And the stop condition for PRB number adjustment is as follows:**    **Proposal 5-3: If a UE is provided a first interlace of PRBs by interlace0 in InterlaceAllocation, the UE has HARQ-ACK, SR and wideband or sub-band CSI reports to transmit, and the UE determines a PUCCH resource with PUCCH format 2, or the UE has HARQ-ACK, SR and wideband CSI reports to transmit and the UE determines a PUCCH resource with PUCCH format 3, or the UE has HARQ-ACK, SR and sub-band CSI reports to transmit, and the UE determines a PUCCH resource with PUCCH format 3, where**  **- the UE determines the PUCCH resource using the PUCCH resource indicator field in a last of a number of DCI formats with a value of a PDSCH-to-HARQ\_feedback timing indicator field indicating a same slot for the PUCCH transmission, from a PUCCH resource set provided to the UE for HARQ-ACK transmission, and after the UE determines the PUCCH resource set**  **- if**  **,**  **the UE transmits the HARQ-ACK, SR, and CSI reports bits in a PUCCH over the first interlace**  **- else, if the UE is provided a second interlace of PRBs by interlace1 and if**  **,**  **the UE transmits the HARQ-ACK, SR, and CSI reports bits in a PUCCH over both the first and second interlaces**  **- else, the UCI omission procedure is same as the corresponding one when the UE is provided PUCCH-ResourceSet by replacing with , or, if the UE is provided interlace1, by .**  **Proposal 6-1: Consider different coding rates for UCI parts in UCI omission rule.**  **Proposal 6-2: With two UCI parts, the omission rule is as follows:**  **The following conditions are used for UCI omission:**    **If all UCI part II is dropped, then the the following is examined to determine remaining UCIs in UCI part I:**  **.**  **Proposal 7-1:**  **when HP CSI is present, only the following UCIs are carried in UCI part I and part II:**  **HP HARQ-ACK > HP SR > (HP CSI) > LP HARQ-ACK > (LP SR)**  **When HP CSI is absent, only the following UCIs are carried UCI part I and part II**  **HP HARQ-ACK > HP SR > LP HARQ-ACK > (LP SR) > LP CSI**  **Proposal 8-1: consider joint PUCCH resource set selection and PUCCH resource selection.**  **Proposal 8-2: if joint PUCCH resource set selection and PUCCH resource selection is supported, and are configured per PUCCH format or per PUCCH resource.**  **Proposal 10-1: consider PRB # adjustment and CSI omission/HARQ compaction for the PUCCH resource under multi-CSI-PUCCH-ResourceList and pucch-CSI-ResourceList.** |
| vivo | ***Proposal 8：For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUCCH in R17, option 1 are preferred***   * ***Option 1: Configure a dedicated PUCCH resource for HP and LP HARQ-ACK in the second PUCCH-Config.***   ***Proposal 9: For PRB determination, if , the UE transmits the PUCCH over PRBs.*** |
| OPPO | ***Proposal 3: If a PUCCH resource with PUCCH format 3 is determined for multiplexing of HP HARQ-ACK and LP HARQ-ACK, and , UE transmits HP HARQ-ACK on a PUCCH resource determined based on HP HARQ-ACK bits only, and LP HARQ-ACK is fully dropped.***  ***Proposal 4: When multiple code rates are supported in a PUCCH carrying UCIs with different*** ***priorities, option 1 or option 2 can be considered.*** |
| DCM | **Proposal 3:**   * *For the problem of ambiguity on LP HARQ-ACK existence or LP HARQ-ACK type 2 codebook size due to DCI miss-detection, support Option 3b.*   + *Option 3b:* *Configuration of semi-static size reservation for LP HARQ-ACK payload is provided by RRC. LP HARQ-ACK semi-static size reservation is used instead of determined LP HARQ-ACK codebook size when selecting the PUCCH resource set.*   **Proposal 4:**   * *Support UCI multiplexing of different priorities on PF2. The same PRB determination procedure is applied to PF2 as PF3.*   **Proposal 5:**   * *For PRB determination in case of insufficient PRBs, support Alt.2.*   + *Alt2: the number of RBs is determined by HP ACK payload size. LP HARQ-ACK is fully dropped.* |
| Spreadtrum | 1. ***UE does not expect for PUCCH format 3.***   ***Proposal 10. Number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format 2 remains the same as Rel-15*** |
| Sony | **Proposal 4: Since misalignment on the number of LP HARQ-ACK *NLP* for Type 2 HARQ-ACK Codebook is caused by the UE missing the last DL Grant associated with the LP PUCCH, any proposed solution should address this issue directly with no overhead to either the PUCCH or DCI.**  **Proposal 5: Introduce a 1-bit “*last DL Grant*” indicator in the DL Grant to indicate whether a DL Grant is the last DL Grant associated with a LP PUCCH. This “*last DL Grant*” indicator can reuse the Multiplexing Indicator field, such that;**   * **If *Priority Indicator* = “1”, then the Multiplexing Indicator indicates whether UCI multiplexing of different L1 priority in a PUCCH is enabled or disabled** * **If *Priority Indicator* = “0”, then the Multiplexing Indicator indicates whether or not the DL Grant is the last DL Grant associated with a LP PUCCH .**   **Proposal 6: The UE performs UCI multiplexing if it detects a positive Multiplexing Indicator in one (i.e. the last) of the LP DL Grants and a positive multiplexing Indicator in at least one of the HP DL Grants, otherwise the UE drops the LP PUCCH.** |
| Xiaomi | ***Proposal 1:*** ***For scenario that multiplexing a HP HARQ-ACK and LP HARQ-ACK into a PUCCH,*** ***PRB number determination is based on maxCodeRate configured for HP UCI in high priority PUCCH and nominal UCI payload size, where nominal UCI payload size = the number of HP UCI bits + the number of LP UCI bits\* Coderate HP/ Coderate LP.*** |
| Leno/Moto | * **Proposal 1:** A PUCCH resource for multiplexing UCI of mixed priorities including HARQ-ACK is selected from a PUCCH resource set configured by the second PUCCH-Config, based on:   + a last DCI format indicating a higher priority index, or   + a last DCI format if no DCI format indicating a higher priority index is detected, or   + a PUCCH resource configured for UCI of mixed priorities for a given UCI size range, when there is no corresponding DCI format. * **Proposal 3:** UE determines whether to multiplex LP HARQ-ACK with HP UCI in a PUCCH resource of PUCCH format 2, 3, or 4 of higher priority index, based on the total UCI payload size and configured max. code rate/max PRB parameters. * **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. |
| ETRI | **Proposal 10: The LP DCI determines the final PUCCH resource in at least for the HP SPS case.** |
| Sharp | **Proposal 1: A HP PUCCH resource is determined by the total payload of the HP HARQ-ACK and LP HARQ-ACK if the total payload is within the PUCCH capacity.**   * **For determining the PUCCH resource to carry the multiplexed high-priority and low-priority HARQ-ACKs, the number of RBs is given by the minimum between the formula in the agreement and the .** * **LP HARQ-ACK is not dropped.**   **Proposal 2: LP HARQ-ACK payload reduction can be configured by higher layer signaling, and be applied if the total payload exceeds the PUCCH capacity**   * **FFS the supported payload reduction methods and the signaling.** |
| 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.* |
| WILUS | ***Proposal 1:*** *Further discuss whether/how to multiplex HP HARQ-ACK and LP HARQ-ACK in a PUCCH resource if the second PUCCH-Config contains only the first PUCCH resource (for 1- or 2-bit HARQ-ACK information).*  ***Proposal 4:*** *If the required # of RBs for low-priority HARQ-ACK information exceeds the limit of PUCCH formats, then bundle the low-priority HARQ-ACK information. Detail bundling rules should be further discussed in Rel-17 URLLC/IIoT WI.* |
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## 1st round discussion

Proposal for 1st round discussion:

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

* The the number of RBs is . Transmit the LP HARQ-ACK with higher code rate than configured code rate as long as it does not exceed the maximum tolerated code rate;
* Otherwise drop all LP HARQ-ACKs.

Proposal for 1st round discussion:

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

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

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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.
      * TCL

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

* Option 1: UE behavior fallbacks to Rel-16 prioritization.
  + Intel
* Option 2:
  + If a UE doesn’t support Rel-16 prioritization, the UE doesn’t expect the multiplexing timeline conditions are not satisfied.
  + If the UE support Rel-16 prioritization, UE behavior fallbacks to Rel-16 prioritization.
  + OPPO
* Option 3: The UE would 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.
  + LG

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| Company | Proposals/observations from Tdocs |
| QC | ***Proposal 21:* For d1 defined for PUCCH vs PUCCH or PUCCH vs PUSCH cancellation with different priorities, support subcarrier spacing dependent d1 values. FFS exact d1 values for each subcarrier spacing.** |
| LGE | **Proposal #5: Consider additional condition for the processing of inter-priority multiplexing and the latency requirement for HP UCI.**  **Proposal #6: Consider to support the following UE behaviour for inter-priority multiplexing of UCIs on PUCCH/PUSCH.**   * **The UE would 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.** |
| Xiaomi | ***Proposal 3: The R15 multiplexing timeline can be reused for PUCCH/PUSCH with different priorities.*** |
| TCL | **Proposal 2: 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.** |
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## Multiplexing HARQ-ACK and SR with different priorities

## Inputs from Tdocs

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

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

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

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

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

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

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| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 23: For positive SR, the multiplexed HP SR and LP HARQ-ACK should be carried on a different PUCCH of the second PUCCH-config from the PUCCH for HP SR only.***  ***Proposal 24: 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*** * ***Introduce dedicated PUCCH resource sets at the second PUCCH-Config for transmitting the multiplexed SR and HARQ-ACK.*** |
| ZTE | ***Proposal 8:*** *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 9:*** *Adopt the following rules to multiplex high priority SR and low priority HARQ-ACK.*   |  |  |  |  | | --- | --- | --- | --- | | *HARQ-ACK*  *SR* | *PUCCH format 0* | *PUCCH format 1* | *PUCCH format 2/3/4* | | *PUCCH format 0* | *For positive SR, the UE transmits the PUCCH in the resource using PUCCH format 0 in PRB(s) for SR. The same way in Rel-15 can be reused for the UE to determine the value of  and  for computing the value of cyclic shift .*  *For negative SR, the UE transmits only a PUCCH with HARQ-ACK information.* | | *For positive SR, the UE Reuse Rel-15 rules.*  *For negative SR, the UE transmits only a PUCCH with HARQ-ACK information and drops the PUCCH with negative SR.* | | *PUCCH format 1* | *For positive SR, the UE transmits the PUCCH in the resource using PUCCH format 1 in PRB(s) for SR. The value of cyclic shift of sequence, i.e., , of this PUCCH format 1 is determined by HARQ-ACK, and the bit, i.e., b(0), of this PUCCH format 1 is determined by SR*  *For negative SR, the UE transmits only a PUCCH with HARQ-ACK information and drops the PUCCH with negative SR.* | *Reuse Rel-15 rules.* | |
| Nokia | **Proposal 3.10: For the scenario where a PUCCH carrying high-priority SR overlaps with a PUCCH carrying low-priority HARQ-ACK:**   * **If SR is with F0 and HARQ-ACK is with F0/F1, adopt one of the following options:**    + **Opt.1b: The positive SR and HARQ-ACK are multiplexed and transmitted on the SR resource. For negative SR, the UE transmits only HARQ-ACK on the HARQ-ACK resource.**   + **Opt.1c: The SR and HARQ-ACK are multiplexed and transmitted on the SR resource.** * **If SR is with F1 and HARQ-ACK is with F0/F1, adopt Opt.3: Transmit HARQ-ACK on the SR resource if SR is positive; and transmit HARQ-ACK on the HARQ-ACK resource when SR is negative.** * **If SR is with F0/F1 and HARQ-ACK is with F2/F3/F4: If SR is positive, transmit SR on the SR resource and drop HARQ-ACK; if SR is negative, transmit HARQ-ACK only on the HARQ-ACK resource.** |
| CATT | ***Proposal 10: 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 11: 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 12: For multiplexing of 1 bit HP HARQ-ACK, 1 bit LP HARQ-ACK and 1 bits HP SR, 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 is supported.*** |
| Samsung | **Proposal 7: Drop LP HARQ-ACK PUCCH when a LP HARQ-ACK PUCCH with PF0/1 overlaps with a HP SR PUCCH.**  **Proposal 8: Support multiplexing of LP HARQ-ACK and HP SR when HARQ-ACK is transmitted in a PUCCH using format 2/3/4**   * **Use Rel-15 mechanism as a baseline assuming HARQ-ACK and SR have same priority.** * **FFS: how to ensure latency and reliability of HP SR.** |
| QC | ***Proposal 13*: In NR Rel-17, if a HARQ-ACK (with single priority) transmission on PUCCH format 0 or PUCCH format 1 collide with one SR, the UE performs the actions in Table 1 to resolve the collision.**   * **FFS: collision resolution for 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK overlapping with 1-bit HP or LP SR**   Table 1. Collision resolution for overlapping HARQ-ACK and SR in NR Rel-17   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | Ack: PF0, LP | Ack: PF1, LP | Ack: PF0, HP | Ack: PF1, HP | | SR: PF 0, LP | Same as Rel-15 (i.e., multiplex on HARQ-ACK resource). | Same as Rel-15 (i.e., drop SR) | Multiplex the HARQ-ACK and SR on the HARQ-ACK resource (as in Rel-15), with a power boost to the multiplexed transmission. | Same as Rel-15 (drop SR). | | SR: PF1, LP | Same as rel-15 (i.e., multiplex on HARQ-ACK resource) | Same as Rel-15 (RB selection) | Multiplex the HARQ-ACK and SR on the HARQ-ACK resource (as in Rel-15), with a power boost to the multiplexed transmission. | RB selection (as in Rel-15) but with the enhancement that, if SR is positive, the power of the PUCCH transmission follows the power of the HARQ-ACK resource. | | SR: PF0, HP | Use the SR resource to transmit multiplexed SR and HARQ-ACK, with a power boost to the multiplexed transmission. | Perform RB selection (i.e., if SR is negative, then transmit HARQ-ACK on the HARQ-ACK resource. Otherwise, transmit HARQ-ACK on the SR resource.) | Same as Rel-15 | Same as Rel-15 | | SR: PF1, HP | Perform RB selection (i.e., if SR is negative, then transmit HARQ-ACK on the HARQ-ACK resource. If SR is positive, transmit HARQ-ACK on the SR resource.) | Same as Rel-15 (i.e., RB selection). | Same as Rel-15 | Same as Rel-15 |   ***Proposal 14*: 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 14 and Fig 15.**  ***Proposal 15*: 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.** |
| LG | **Proposal #11: Consider to support a single unified handling for the multiplexing of HP SR PF0/1 + LP HARQ-ACK PF0/1 as the following way.**   * **For positive SR, transmit HARQ-ACK on the SR PUCCH resource.** * **For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.** |
| Intel | **Proposal 13:**  **HP SR PF0, LP HARQ PF0**:   * If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.   **HP SR PF0, LP HARQ PF1**:   * For positive SR, transmit SR on the SR resource and drop HARQ-ACK. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource   **HP SR PF1, LP HARQ PF0**:   * If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource. |
| Pana | **Proposal 5: When a PUCCH carrying HP SR with PUCCH format 0 overlaps with a PUCCH carrying LP HARQ-ACK with PUCCH format 0, the SR and HARQ-ACK are multiplexed and transmitted on the HARQ-ACK resource.**  **Proposal 6:**   * **When a PUCCH carrying HP SR with PUCCH format 0 overlaps with a PUCCH carrying LP HARQ-ACK with PUCCH format 1, either of following options is supported.**   + **Option 4: For positive SR, transmit SR on the SR resource and drop HARQ-ACK. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.**   + **Option 5: No enhancement over Rel.16**   **Proposal 7: When a PUCCH carrying HP SR with PUCCH format 1 overlaps with a PUCCH carrying LP HARQ-ACK with PUCCH format 0, no enhancement is necessary over Rel.16.**  **Proposal 8:**   * **When a PUCCH carrying HP SR with PUCCH format 1 overlaps with a PUCCH carrying LP HARQ-ACK with PUCCH format 1, either of following options is supported.**   + **Option 1: Same multiplexing mechanism as in Rel.15/16.**   + **Option 2: The SR and HARQ-ACK are multiplexed and transmitted on the SR resource.**     - **1-bit for LP HARQ-ACK information bit is appended to SR information bit. For 2-bits HARQ-ACK information, bundling is used.**   **Proposal 9:**   * **When a PUCCH carrying HP SR with PUCCH format 0 or 1 overlaps with a PUCCH carrying LP HARQ-ACK with PUCCH format 2, 3, or 4, following options are supported.**   + **The SR and HARQ-ACK are multiplexed and transmitted on the HARQ-ACK resource if the latency condition is satisfied; otherwise, LP HARQ-ACK is dropped, and HP SR is transmitted.** |
| Quectel | **Proposal 20**: 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 21**: 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 22**: 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. |
| IDC | ***Proposal 9: 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 10: 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 11: 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.*** |
| vivo | ***Proposal 1: Support multiplexing a high-priority HARQ-ACK and a low-priority SR into a PUCCH in Rel-17.***  ***Proposal 4: When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, option 2c is adopted, i.e.,***   * ***If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.***   ***Proposal 5: When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, option 4 is adopted, i.e.,***   * ***For positive SR, transmit SR on the SR resource and drop HARQ-ACK. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.***   ***Proposal 6: When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, option 2c is adopted, i.e.,***   * ***If SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.***   ***Proposal 7: For the overlapping of different priorities between SR and HARQ-ACK with PUCCH format 2/3/4, Rel-15 mechanism can be reused.*** |
| OPPO | ***Proposal 5:*** ***When PF0/1 is used by HP SR and LP HARQ-ACK, if HP SR is negative, UE should transmit LP HARQ-ACK on PUCCH resource for LP HARQ-ACK.***  ***Proposal 6: When PF0/1 is used by HP SR and LP HARQ-ACK , multiplexing methods are summarized in the table 1.***  Table 1: Multiplexing of LP HARQ-ACK and HP SR   |  |  |  |  | | --- | --- | --- | --- | |  | | LP HARQ-ACK | | | PF 0 | PF 1 | | HP SR  (positive) | PF 0 | The UE transmits HARQ-ACK in PRB configured for HARQ-ACK with a special cyclic shift, i.e. same as Rel-15. | The UE transmits SR on PUCCH resource for SR and drop HARQ-ACK. | | PF 1 | The UE transmits SR on PUCCH resource for SR and drop HARQ-ACK. | The UE transmits HARQ-ACK on PUCCH resource for SR |   ***Proposal 7: If a PUCCH carrying HP SR overlaps with a PUCCH carrying LP HARQ-ACK with more than 2 bits,***   * ***If HP SR is positive, UE transmits HP SR on PUCCH resource for SR and drops LP HARQ-ACK;*** * ***If HP SR is negative, UE should transmit LP HARQ-ACK on PUCCH resource for LP HARQ-ACK.*** |
| DOCOMO | **Proposal 7:**   * *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 8:**   * *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.* |
| Spreadtrum | 1. ***If a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, if SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.*** 2. ***When a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF1, for positive SR, LP HARQ-ACK can be dropped. For negative SR, transmit HARQ-ACK on the HARQ-ACK resource.*** 3. ***If a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0, if SR is positive, SR is multiplexed on HARQ-ACK resource in the same way as Rel-15. If SR is negative, transmit only HARQ-ACK on HARQ-ACK resource.*** |
| Sony | **Proposal 7: 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 8: When HP SR using PF0 multiplexes with LP HARQ-ACK using PF1:**   * **The positive SR and HARQ-ACK are multiplexed and transmitted on the SR resource** * **For negative SR, the UE transmits only HARQ-ACK on the HARQ-ACK resource.**   **Proposal 9: 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.** |
| Xiaomi | ***Proposal 5: 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.*** |
| Leno/Moto | **Proposal 2**: For multiplexing a HP SR and 1- or 2-bit LP HARQ-ACK into a PUCCH, treat the LP HARQ-ACK as HARQ-ACK bits with high priority, determine a HP PUCCH resource for the LP HARQ-ACK, and apply Rel-15 SR/HARQ-ACK multiplexing rules based on the determined HP PUCCH resource. |
| Sharp | **Proposal 3: If a HP SR PUCCH with PF0/1 and negative HP SR overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1, transmit LP HARQ-ACK on the LP HARQ-ACK PUCCH resource.**  **Proposal 4: If a PUCCH with PF1 and a positive HP SR overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1, report LP HARQ-ACK on the PUCCH resource for the positive HP SR with PF1.**  **Proposal 5: If a PUCCH with PF0 and a positive HP SR overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1, report the LP HARQ-ACK on the HP SR PUCCH resource with a CS value representing the HARQ-ACK if multiple CS values are configured for the HP SR PUCCH resource with PF0.**  **Proposal 6: For overlapping between HP SR PUCCH(s) and a LP HARQ-ACK with PF 2/3/4,**   * **HP SR bits can be generated based on the number of overlapping HP SR PUCCH resources.** * **FFS on the HP SR and LP HARQ-ACK ordering, and whether LP SRs should be included.**   **Proposal 7: For multiplexing of HP HARQ-ACK, LP HARQ-ACK and SR, a HP PUCCH resource with more than 2 bits of payload is used.**   * **FFS on the SR bit generation methods, and multiplexing order of HP HARQ-ACK, LP HARQ-ACK and the SR.** |
| WILUS | * ***Proposal 6:*** *We propose to support Option 2b for multiplexing with HP-SR with PF0 and LP HARQ-ACK with PF1.*   + *To multiplex HP-SR with PF0 and LP HARQ-ACK with PF1, use the HARQ-ACK resource.*      - *Applying QPSK for SR+1-bit HARQ-ACK. For the case of 2-bit HARQ-ACK, the HARQ-ACK is reduced/compressed to 1-bit.* * ***Proposal 7:*** *To multiplex HP-SR with PF1 and LP HARQ-ACK with PF0, reuse multiplexing rule for HP-SR with PF0 and LP HARQ-ACK with PF0.* |
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## 1st round discussion

Since various options are proposed for different PUCCH format combinations, which have different pros and cons on different perspectives, this topic becomes very controversial. It is suggested to strive for a unified solution as much as possible.

Proposal for 1st round discussion:

When a PUCCH carrying HP SR with PF1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1,

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

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

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

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| Company | Comments |
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## Other enhancements

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| Company | Proposals/observations from Tdocs |
| Nokia | **Proposal 3.11: 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.** |
| LG | **Proposal #9: Consider how to generate the HARQ-ACK payload per each of LP and HP for the multiplexing of LP/HP HARQ-ACK on PUCCH (or PUSCH), according to HARQ-ACK codebook type (e.g. Type-1/2/3 codebook).**  **Proposal #10: Consider to introduce an additional field in the DL/UL HP DCIs for determining the number of LP HARQ-ACK bits multiplexed on PUCCH/PUSCH for both Type-1 and Type-2 codebooks, in order to handle potential ambiguity on the presence of LP HARQ-ACK feedback or the size of LP HARQ-ACK codebook.** |
| Apple | Proposal 13-2: The spectral efficiency calculation is based on the payload size of HP UCI(s) and REs for HP UCI(s). |
|  |  |
| 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.*

Agreement

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

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

Agreement

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

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

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

## Inputs from Tdocs

**Encoder and CSI dropping:**

* If HP HARQ-ACK, LP HARQ-ACK, and LP CSI would be transmitted on LP PUSCH,
  + Option 1: Both CSI part 1 and part 2 are dropped, the LP HARQ-ACK can be multiplexed by reusing the encoder chain, rate matching and RE mapping for Rel-15 CSI part 1.
    - Nokia, vivo
* Option 2: The CSI part 2 is dropped. LP HARQ-ACK and CSI part 1 can be multiplexed by reusing the encoder chain, rate matching and RE mapping for Rel-15 CSI part 1 and part 2 respectively.
  + Option 2a: LP HARQ-ACK has lower priority than LP CSI part 1, and LP HARQ-ACK may be dropped (similar to Rel-15 CSI-part2);
  + Option 2b: LP HARQ-ACK has higher priority than LP CSI part 1, and LP CSI part 1 may be dropped (similar to Rel-15 CSI-part1);
    - HW, ZTE, CATT, Samsung, QC, Quectel, Intel, vivo, OPPO, Pana, Spreadtrum
* Option 3: The CSI part 1 is dropped. CSI part 2 is similarly treated as CSI part 1 in Option 2.
* Option 4: No CSI is dropped. LP HARQ-ACK and LP CSI part 1 are jointly encoded and reuse the coding method used for CSI part 1 in Rel-15. CSI part 2 reuses the coding method used for CSI part 2 in Rel-15.
  + - vivo, DCM, Apple
* If HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI including two parts would be transmitted on HP PUSCH,
  + LP HARQ-ACK is dropped. CSI part 1 and CSI part 2 can be multiplexed by reusing the encoder chain, rate matching and RE mapping for Rel-15 CSI part 1 and part 2 respectively.
    - HW, Nokia, CATT (if HP CSI includes two parts), QC, Quectel, Intel, Spreadtrum
  + The CSI part 2 is dropped. LP HARQ-ACK and CSI part 1 can be multiplexed by reusing the encoder chain, rate matching and RE mapping for Rel-15 CSI part 1 and part 2 respectively.
    - ZTE
  + LP HARQ-ACK is jointly encoded with CSI part 1 or CSI part 2.
    - Apple, vivo, DCM, Pana

**PUSCH selection**

* If a HP/LP HARQ-ACK PUCCH overlaps with multiple LP/HP PUSCHs, the priority for PUSCH selection can be PUSCH without UCI > PUSCH with UCI.
* If a PUCCH with HP HARQ-ACK and LP HARQ-ACK overlaps with both LP and HP PUSCHs, the priority for PUSCH selection can be HP PUSCH > LP PUSCH.
  + Samsung

**Power control:**

* For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, reuse the same power control formula as in Rel-15.
  + QC
* For multiplexing high-priority HARQ-ACK bits on a low-priority PUSCH, UE can be configured with a dedicated set of power control parameters to be used only when multiplexing high-priority HARQ-ACK on low-priority PUSCH in order to guarantee the required reliability for high-priority HARQ-ACK.
  + Nokia
* For PUSCH power allocation in case of CA, a LP PUSCH with HP HARQ-ACK should be prioritized over a PUSCH without HP HARQ-ACK.
  + Samsung
* **Others:**

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.

* + IDC

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Proposal 26: UE does not expect the overlapping between HP PUSCH and LP HARQ-ACK subject to Type 3 CB/enh. Type 3 CB/one shot retransmission.***  ***Proposal 27: 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: HP HARQ-ACK should reuse the encoding chain for legacy HARQ-ACK, LP HARQ-ACK should reuse the encoding chain for legacy CSI part 1, CSI part 1 should reuse the encoding chain for legacy CSI part 2, and the CSI part 2 should be dropped if any.***  ***Proposal 28: For collision of HP HARQ-ACK and LP HARQ-ACK with PUSCH with or without CSI, 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.***  ***Proposal 29: If HP HARQ-ACK, LP HARQ-ACK, and A-CSI including two parts would be transmitted on HP PUSCH, the LP HARQ-ACK should be dropped.*** |
| ZTE | ***Proposal 11:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, the coding scheme, rate matching and RE mapping of HP HARQ-ACK reuse the mechanism of HARQ-ACK multiplexed in PUSCH in Rel-15.*  ***Proposal 12:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH, a new T-DAI field for LP HARQ-ACK is added in HP DCI.*  ***Proposal 13:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,*   * *The LP CSI part 2 is dropped firstly.* * *LP HARQ-ACK is coded separately from HP HARQ-ACK and CSI part 1.* * *The coding scheme, rate matching and RE mapping of LP HARQ-ACK and LP CSI part 1 will respectively follow the rules of Rel-15 CSI-part 1 and Rel-15 CSI-part 2.* * *If the leftover resources for LP HARQ-ACK and LP CSI part 1 is not sufficient, LP HARQ-ACK has higher priority than LP CSI part 1, and LP CSI part 1 may be partially dropped or compressed.*   ***Proposal 14:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and HP CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH,*   * *Dropping HP A-CSI part 2.* * *The coding scheme, rate matching and RE mapping of LP HARQ-ACK and HP CSI part 1 will respectively follow the rules of Rel-15 CSI-part 1 and Rel-15 CSI-part 2.* * *If the leftover resources for LP HARQ-ACK and HP CSI part 1 is not sufficient, LP HARQ-ACK has lower priority than HP CSI part 1, and LP HARQ-ACK may be partially dropped or compressed.*   ***Proposal 15:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH, LP CSI is dropped and multiplexing with HP PUSCH is not allowed.*  ***Proposal 16:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and HP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,* *HP CSI is allowed to multiplex with LP PUSCH. The multiplexing principle follows the way which HP HARQ-ACK, LP HARQ-ACK, and HP CSI consisting of two parts are transmitted on HP PUSCH conveying UL-SCH.*  ***Proposal 17:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and HP/LP CSI consisting of two parts would be transmitted on HP/LP PUSCH not conveying UL-SCH, UE follows the same behaviour as that in case of PUSCH conveying UL-SCH.*  ***Proposal 22:*** *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.* |
| Nokia | **Proposal 3.16: For the scenario of the multiplexing between HARQ-ACK and PUSCH with different priorities, RAN1 should not support joint coding of different UCI types, for example low-priority HARQ-ACK and CSI.**  **Proposal 3.17: For the scenario where high-priority HARQ-ACK bits, low-priority HARQ-ACK bits and CSI would be multiplexed into a low-priority PUSCH, drop CSI (including part 1 and part 2, if exist).**  **Proposal 3.18: For the scenarios where a high-priority PUSCH overlaps with a PUCCH carrying low-priority CSI, the low-priority CSI is always dropped.**  ***Observation 3.3: For the scenario where multiplexing both high-priority HARQ-ACK bits and low-priority HARQ-ACK bits into a high-priority PUSCH without CSI, the number of encoding chains is sufficient.***  **Proposal 3.19: For the scenario where both high-priority HARQ-ACK bits and low-priority HARQ-ACK bits would be multiplexed into a high-priority PUSCH carrying CSI, drop low-priority HARQ-ACK.**  **Proposal 3.20: For the scenario where multiplexing high-priority HARQ-ACK bits on a low-priority PUSCH, UE can be configured with a dedicated set of power control parameters to be used only when multiplexing high-priority HARQ-ACK on low-priority PUSCH in order to guarantee the required reliability for high-priority HARQ-ACK.** |
| CATT | ***Proposal 16: For overlapping between PUCCH and multiple PUSCHs with different priorities, it is proposed that UCI of PUCCH is multiplexed on a PUSCH with a different priority only when there is no PUSCH with same priority overlaps with the PUCCH.***  ***Proposal 17: For multiplexing HP HARQ-ACK, LP HARQ-ACK and HP A/SP-CSI on PUSCH, LP HARQ-ACK can be dropped in case the HP A/SP-CSI includes two parts.***  ***Proposal 18: For multiplexing HP HARQ-ACK, LP HARQ-ACK and LP CSI on PUSCH, it is proposed to drop CSI part 2 if exists.*** |
| Samsung | **Proposal 21: For multiplexing LP/HP HARQ-ACK and CSI in a PUSCH, LP HARQ-ACK is treated as CSI part 1, CSI part 1 is treated as CSI part 2, and CSI part 2 is dropped.**  **Proposal 22: If a HP/LP HARQ-ACK PUCCH overlaps with multiple LP/HP PUSCHs, the priority for PUSCH selection can be PUSCH without UCI > PUSCH with UCI.**  **Proposal 23: If a PUCCH with HP HARQ-ACK and LP HARQ-ACK overlaps with both LP andHP PUSCHs, the priority for PUSCH selection can be HP PUSCH > LP PUSCH.**  **FFS: LP DG PUSCH > HP CG PUSCH**  **Proposal 24: For PUSCH power allocation in case of CA, a LP PUSCH with HP HARQ-ACK should be prioritized over a PUSCH without HP HARQ-ACK.** |
| QC | ***Proposal 16*: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI, less than 3 bits LP HARQ-ACK is padded to 3 bits, reuse Rel-15 RM encoding, followed by R15 Part 1 CSI rate matching and RE mapping.**  ***Proposal 17*: 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, rate matching/puncturing, and RE mapping for Rel-15 A/N**   + **LP A/N reuse encoder and rate matching, and RE mapping for Rel-15 CSI part 1**   + **LP CSI part 1 reuse encoder, rate matching, and RE mapping for Rel-15 CSI part 2** * **Drop LP HARQ-ACK, if CSI is a high priority CSI.**    + **HP A/N reuse encoder, rate matching/puncturing, and RE mapping for Rel-15 A/N**   + **HP CSI part 1 reuse encoder and rate matching, and RE mapping for Rel-15 CSI part 1**   + **HP CSI part 2 reuse encoder, rate matching, and RE mapping for Rel-15 CSI part 2**   ***Proposal 18*: 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.** |
| LG | **Proposal #12: Consider at least the following aspects for determining UCI RE mapping rule (order) on PUSCH, according to various combinations of UCI and PUSCH.**   * **Whether the CSI to be multiplexed on PUSCH consists of two parts or single part.**   + **UCI RE mapping rule (order) could be different according to the above.** * **Whether the PUSCH for multiplexing of the UCIs is conveying UL-SCH or not.**   + **UCI RE mapping rule (order) could be different according to the above.**   **Proposal #13: Consider to decide the following two cases first for determining the UCI RE mapping rule (order) on PUSCH.**   * **Case 1: Overlapping of {HP HARQ-ACK, LP HARQ-ACK, HP CSI part 1, HP CSI part 2} and HP PUSCH with UL SCH**   + **{HP HARQ-ACK, LP HARQ-ACK, HP CSI part 1} are multiplexed on the HP PUSCH, by dropping HP CSI part 2.** * **Case 2: Overlapping of {HP HARQ-ACK, LP HARQ-ACK, LP CSI part 1, LP CSI part 2} and LP PUSCH with UL SCH**   + **{HP HARQ-ACK, LP HARQ-ACK, LP CSI part 1} are multiplexed on the HP PUSCH, by dropping LP CSI part 2.** |
| Intel | **Proposal 14: For multiplexing a HP HARQ-ACK and LP HARQ-ACK onto a PUSCH with A-CSI**   * **If there is A-CSI on LP PUSCH, reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK, Rel-15 CSI part 1 for LP HARQ-ACK, Rel-15 CSI part 2 for LP CSI part 1, and drop LP CSI part 2, if any.** * **If there is A-CSI on HP PUSCH, reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK, Rel-15 CSI part 1 for HP CSI part 1, Rel-15 CSI part 2 for HP CSI part 2 or LP HARQ-ACK (if no HP CSI part2).**   **Proposal 16: For multiplexing HARQ-ACK with priority *i* onto a PUSCH with priority *j* with and without A-CSI, reuse Rel-15 HARQ-ACK rate matching and RE mapping for HARQ-ACK with priority *i*, Rel-15 CSI part 1 for CSI part 1 with priority *j* (if any), and Rel-15 CSI part 2 for CSI part 2 with priority *j* (if any).** |
| Pana | **Proposal 11: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUSCH in Rel.17, if HP HARQ-ACK and LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH**   * **CSI part 2 is dropped.** * **Reuse Rel.15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle.** * **Reuse Rel.15 Part 1 CSI rate matching and RE mapping for LP HARQ-ACK in principle.** * **Reuse Rel.15 Part 2 CSI rate matching and RE mapping for LP CSI Part 1 in principle.**   **Proposal 12: For multiplexing a HP HARQ-ACK and a LP HARQ-ACK into a PUSCH in Rel.17, if HP HARQ-ACK and LP HARQ-ACK, and HP A-CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH, either of following options is supported.**   * **Option 1:**   + **Reuse Rel.15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle.**   + **Reuse Rel.15 Part 1 CSI rate matching and RE mapping for HP CSI Part 1 in principle.**   + **Reuse Rel.15 Part 2 CSI rate matching and RE mapping for HP CSI Part 2 in principle.** * **Option 3:**   + **Reuse Rel.15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK in principle.**   + **Reuse Rel.15 Part 1 CSI rate matching and RE mapping for HP CSI Part 1 in principle.**   + **Reuse Rel.15 Part 2 CSI rate matching and RE mapping for LP HARQ-ACK in principle.**   **Proposal 13: Multiplexing a HP SR in a LP PUSCH (conveying UL-SCH only) should be supported by the identical design with multiplexing a HP HARQ-ACK in a LP PUSCH (conveying UL-SCH only).** |
| Quectel | **Proposal 12**: LP CSI part 2 (if exists) is dropped when HP HARQ-ACK and LP HARQ-ACK are multiplexed in a LP PUSCH.  **Proposal 13**: Multiplexing of LP HARQ-ACK in a HP PUSCH is not supported when HP A/N and HP CSI part 2 simultaneously exist in the HP PUSCH.  **Proposal 15**: LP HARQ-ACK is zero padded to 3 bits prior to channel coding if the number of LP HARQ-ACK information bits is smaller than 3 and the channel encoder for Rel-15 CSI Part 1 is reused. The length of rate matching output sequence is calculated based on 3-bit LP HARQ-ACK.  **Proposal 16**: Reuse Rel-15 HARQ-ACK channel coding, rate matching/puncturing and RE mapping for LP HARQ-ACK in case LP HARQ-ACK is multiplex on a HP PUSCH conveying UL-SCH only.  **Proposal 17**: For HP HARQ-ACK and LP HARQ-ACK multiplexing on a PUSCH, if there is no HP HARQ-ACK, RE reservation is performed based on the beta-offset value configured for LP HARQ-ACK on the PUSCH.  **Proposal 18**: Zero padding is applied to HP HARQ-ACK prior to channel coding only if the number of HP HARQ-ACK information bits is smaller than 2 and the PUSCH carries only HP HARQ-ACK and LP HARQ-ACK.  **Proposal 19**: for Type-1 HARQ-ACK codebook or for Type-2 HARQ-ACK codebook disables multiplexing of HARQ-ACK in PUSCH with different priorities. |
| IDC | ***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.*** |
| Apple | **Proposal 11-1: Between two options of mapping LP HARQ-ACK into UCI Part I and UCI Part II, RAN1 select one of them consistently across multiplexing scenarios.**  **Proposal 11-2: Adopt Alt. 1 or Alt. 2 design from Tables 11-1 and 11-2.**  **Observation 11-1: multiplexing of CSI part I and HARQ-ACK is supported over PUCCH and there is no fundamental difference in terms of implementation complexity between PUCCH and PUSCH.**  **Observation 11-2: If CSI part II is dropped in total by design when accommodating HP/LP HARQ-ACK multiplexing, then the CSI feedback is useless.**  **Proposal 11-3: For a UCI part, UCI omission/compaction is applied to the right-most UCI first among UCIs in that UCI part as in Tables 11-1 and 11-2. Before all the later-placed UCIs are omitted, an early UCI is not omitted or compacted.**  Proposal 11-4: LP HARQ-ACK can be multiplexed to either CSI part 1 or CSI part 2, CSI part 2 is NOT dropped by design due to the presence of LP HARQ-ACK on PUSCH. |
| vivo | ***Proposal 11: When HP and LP HARQ-ACK are multiplexed on a LP PUSCH with LP CSI, the following alternatives can be investigated:***   * + ***Alt 1: Drop LP CSI part 2. LP HARQ-ACK reuses the encoder of LP CSI part 1 and LP CSI part 1 reuses the encoder of LP CSI part 2.***   + ***Alt 2: LP HARQ-ACK and LP CSI part 1 are encoded jointly and reuse the encoder of LP CSI part 1.***   ***Proposal 12: When HP and LP HARQ-ACK are multiplexed on a HP PUSCH with HP CSI, LP HARQ-ACK is jointly encoded with CSI part 1 or CSI part 2.*** |
| OPPO | ***Proposal 13: For multiplexing HP HARQ-ACK into a LP PUSCH, if the number of REs determined based on the beta-offset for HP HARQ-ACK is greater than the maximum number of REs determined based on the alpha, UE transmits HP HARQ-ACK on PUCCH and drops the LP PUSCH.*** |
| DCM | **Proposal 9:**   * *If HP HARQ-ACK and LP HARQ-ACK would be transmitted on LP PUSCH with LP CSI, LP CSI part 1 is jointly encoded with LP HARQ-ACK.*   + *For HP HARQ-ACK, reuse the Rel-15 coding scheme, rate matching, and RE mapping of HARQ-ACK.*   + *For LP HARQ-ACK and LP CSI part 1, reuse the Rel-15 coding scheme, rate matching, and RE mapping of CSI part 1.*   + *For LP CSI part 2, reuse the Rel-15 coding scheme, rate matching, and RE mapping of CSI part 2.* * *If HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP PUSCH with HP CSI,*   + *HP CSI part 2 is dropped.*   + *For HP HARQ-ACK, reuse the Rel-15 coding scheme, rate matching, and RE mapping of HARQ-ACK.*   + *For HP CSI part 1, reuse the Rel-15 coding scheme, rate matching, and RE mapping of CSI part 1.*   + *For LP HARQ-ACK , reuse the Rel-15 coding scheme, rate matching, and RE mapping of CSI part 2.* |
| Spreadtrum | 1. ***For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK and HP A-CSI consisting of two parts would be transmitted on HP PUSCH conveying UL-SCH, LP HARQ-ACK is dropped.*** 2. ***Support Proposal for 2nd round discussion:***   ***For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,***   * ***The CSI part 2 is dropped.*** * ***Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details.*** * ***Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK in principle. FFS details.*** * ***Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part 1 in principle. FFS details.*** * ***~~FFS for the case where LP CSI consisting of two parts is transmitted on HP PUSCH conveying UL-SCH.~~*** * ***FFS for LP CSI consisting of single part.*** * ***~~FFS for LP PUSCH not conveying UL-SCH.~~*** |
| Leno/Moto | * **Proposal 6:** 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 7:** If a UE would transmit semi-persistent or aperiodic CSI on a PUSCH determined for multiplexing mixed priority UCI, the UE may multiplex the semi-persistent or aperiodic CSI with the mixed priority UCI in the PUSCH. |
| ETRI | **Proposal 13: UCI into a PUSCH with different priorities can be applied to any type, provided that the number of encoding chains kept not increased.** |
| Sharp | **Proposal 8: For multiplexing of HP HARQ-ACK on LP PUSCH, RAN1 should specify detailed multiplexing methods, e.g. the multiplexing location and multiplexing symbol restrictions.**  **Proposal 9: For multiplexing of HP HARQ-ACK and LP HARQ-ACK on LP PUSCH, FFS on the order of HARQ-ACK multiplexing.**  **Proposal 10: Support HP SR multiplexing on a LP PUSCH if timeline can be satisfied; and specify enhanced channel dropping rules based on whether HP UCI is multiplexed on the LP PUSCH.** |
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| 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.* |
| WILUS | * ***Proposal 8:*** *To multiplex LP HARQ-ACK and HP HARQ-ACK into a PUSCH in case of UCI on PUSCH, reuse Rel-15 rules as much as possible.*   + *The number of REs for LP HARQ-ACK and HP HARQ-ACK is determined by Rel-15 RE calculation rules for HARQ-ACK.*   + *RE positions for LP HARQ-ACK and HP HARQ-ACK in a PUSCH are determined by Rel-15 RE mapping rules for HARQ-ACK.* |
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## 1st round discussion

Proposal for 1st round discussion:

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

* The CSI part 2 is dropped.
* Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle. FFS details.
* Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK.
* Reuse R15 CSI part 2 rate matching and RE mapping for LP CSI part 1.
* FFS for LP CSI consisting of single part.

Proposal for 1st round discussion:

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

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

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## Enhancements for multiplexing parameters

## Beta-offset value and configuration

#### Inputs from Tdocs

**Support Beta-offset =0?**

* Yes
  + Nokia, CATT, Pana, ITRI
* No
  + ZTE

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| Company | Proposals/observations from Tdocs |
| ZTE | ***Proposal 20****: Up to 3 sets of beta offset values can be configured to the UE to indicate separate beta\_offset values for the following cases:*   * *Multiplexing HARQ-ACK on the PUSCH with same priority* * *Multiplexing LP HARQ-ACK on HP PUSCH* * *Multiplexing HP HARQ-ACK on LP PUSCH* |
| Nokia | **Proposal 3.13: Multiplexing of HARQ-ACK bits on CG PUSCH of a different PHY priority is not supported.**  ***Observation 3.2: No additional sets of beta-offset values are needed to support multiplexing HARQ-ACK on PUSCH (same and/or different priority). For multiplexing of both low-priority and high-priority HARQ-ACK bits, the beta-offset indicator field in the DCI points to the respective two sets of beta-offset values to be applied respectively for low- and high-priority HARQ-ACK.***  **Proposal 3.14: For the scenarios of multiplexing HARQ-ACK bits in PUSCH of different priorities, RAN1 shall support an additional** beta-offset value of 0 to enable gNB flexibly enabling/disabling multiplexing HARQ-ACK in DG PUSCH of different priority**.** |
| CATT | ***Proposal 14: A value of zero for beta-offset in a DCI can be used to dynamically indicate that LP UCI is not multiplexed on the HP PUSCH scheduled by the DCI.*** |
| QC | ***Proposal 19*: 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** |
| Pana | **Proposal 10:**   * **For multiplexing a LP HARQ-ACK in a HP PUSCH (conveying UL-SCH only), enhancement of beta-offset values including , which allows for dropping LP HARQ-ACK should be supported.** * **For multiplexing a HP HARQ-ACK in a LP PUSCH (conveying UL-SCH only), enhancement of beta-offset values including specific or non-numerical value, which allows for dropping LP PUSCH should be supported.** |
| IDC | ***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.*** |
| Apple | **Proposal 12-1: a beta offset set can be looked up according to physical layer priority, beta offset selection, and the presence of mixed UCIs.** |
| vivo | ***Proposal 10: In Rel-17, the same set of beta-offset value is used for UCI multiplexing with the same priority on PUSCH.*** |
| Spreadtrum | 1. ***update the agreement:***   ***In NR Rel-17, ~~[at least]~~ 2 new set of beta offset values can be configured to the UE to indicate separate beta\_offset values for the following cases:***   * ***Multiplexing LP HARQ-ACK on HP PUSCH*** * ***Multiplexing HP HARQ-ACK on LP PUSCH*** |
| ITRI | **Proposal 5:**  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.  **Proposal 6:**  When UCIs corresponding to different priorities multiplexed in a PUSCH, the beta-offset of UCI with the priority equal to PUSCH is determined by RRC; while the beta-offset of UCI with the priority different from the PUSCH is determined by the scheduling DCI. |
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## Separate configurations of alpha values?

#### Inputs from Tdocs

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

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| Company | Proposals/observations from Tdocs |
| Nokia | **Proposal 3.15: For the scenarios of multiplexing HARQ-ACK bits in a PUSCH of different priorities, do not support separate configurations of the scaling factor “alpha”.** |
| LG | **Proposal #16: Consider separate configuration of beta offset as well as alpha factor per each of UCI priority or per UCI priority combination (e.g. for LP and HP, or for LP only case and other cases) for each priority (e.g. LP, HP) of PUSCH, to ensure reliability/protection of HP PUSCH.** |
| Quectel | **Proposal 14**: Separate configuration of scaling factors (“alpha”) is supported for UCI-PUSCH multiplexing with different priority combinations. |
| Sony | **Proposal 10: For multiplexing of UCI into PUSCH of different L1 priorities, the gNB is able to configure separate ** offsets for different PUSCH L1 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)
  + Nokia, IDC, DCM, Sony, ITRI
* Option 2: By DCI field
  + ZTE (in HP DCI or RRC), IDC, Intel, vivo, ETRI
* Option 3: Only RRC configuration
  + HW, IDC (for CG PUSCH and SPS), Spreadtrum, TCL

The arguments are similar to that for Section 2.3.

RRC configuration for each HP CG configuration includes an indication of whether the UE can multiplex LP HARQ-ACK in corresponding HP PUSCH.

* + IDC

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| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 12: 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.*** |
| ZTE | ***Proposal 18****: The beta\_offset should not be used to disable the intra-UE multiplexing UCI with data*.  ***Proposal 19****: The indicator of intra-UE multiplexing UCI with data exists in the scheduling DCI or RRC parameter for the high priority transmission.* |
| Nokia | Proposal 3.12: For the scenarios of multiplexing HARQ-ACK bits in DG PUSCH of different priorities, gNB dynamically indicates via beta-offset in the corresponding scheduling DCI whether to multiplex HARQ-ACK in PUSCH of different PHY priority or not (e.g. beta-offset = 0 is used to disable multiplexing). |
|  | ***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.*** |
| DOCOMO | **Proposal 10:**   * *Support beta-offset =0 or a value disabling the UCI multiplexing on PUSCH of different priorities* |
| Spreadtrum | 1. ***Support RRC configuration method for multiplexing enable/disable mechanism for UCI on PUSCH.*** |
| Sony | **Proposal 12: The gNB dynamically indicates whether to enable/disable multiplexing of UCI bits into PUSCH of different L1 priorities.**  **Proposal 13: The “*beta\_offset indicator*” DCI field in the UL Grant scheduling the PUSCH is used to enable/disable multiplexing of UCI bits into PUSCH, where some of the indices have non-numerical values, i.e. “NOT MULTIPLEX”, to indicate that multiplexing is not used and that the UE performs prioritisation. That is:**   * **If *beta\_offset indicator* is numerical then:**   + **LP UCI is multiplexed into HP PUSCH using the indicated ** offset value**   + **HP UCI is multiplexed into LP PUSCH using the indicated ** offset value** * **If *beta\_offset indicator* = “NOT MULTIPLEX” or non-numerical then:**   + **For the case of LP UCI & HP PUSCH, the LP UCI is dropped and HP PUSCH is transmitted**   + **For HP UCI & LP PUSCH, the LP PUSCH is dropped and HP UCI is transmitted on PUCCH** |
| ETRI | **Proposal 12: 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.** |
| TCL | **Proposal 3: RRC configuration for enabling UCI multiplexing on PUSCH with different priorities should be supported.** |
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## If no enough resource

## Inputs from Tdocs

When sufficient resource is not available for accommodating LP HARQ-ACK on HP PUSCH,

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

For multiplexing HP HARQ-ACK into a LP PUSCH, if the number of REs determined based on the beta-offset for HP HARQ-ACK is greater than the maximum number of REs determined based on the alpha, UE transmits HP HARQ-ACK on PUCCH and drops the LP PUSCH.

* + OPPO

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| Company | Proposals/observations from Tdocs |
| LG | **Proposal #17: Consider the bundling/dropping of LP UCI on PUSCH based on the maximum UCI coding rate as for the case of LP UCI on PUCCH.** |
| Intel | **Proposal 15: When sufficient resource is not available for accommodating LP HARQ-ACK on HP PUSCH, LP HARQ-ACK payload bits can be partially dropped.** |
| OPPO | ***For multiplexing HP HARQ-ACK into a LP PUSCH, if the number of REs determined based on the beta-offset for HP HARQ-ACK is greater than the maximum number of REs determined based on the alpha, UE transmits HP HARQ-ACK on PUCCH and drops the LP PUSCH.*** |
| Sony | **Proposal 11: 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.** |
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| TCL | **Proposal 7: For the multiplexing between low priority UCI and high priority PUSCH, if the resource is not sufficient for the multiplexing, considering bundling or partially drop the low priority UCI.** |
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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
  + TCL, ITRI
* Option 3: Multiplexing is only allowed when the ending symbol used for UCI transmission in a LP PUSCH is not later than the ending of HP PUCCH.
  + OPPO

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

* Option 1: UE behavior fallbacks to Rel-16 prioritization.
  + 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 |
| OPPO | ***Proposal 11: 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.*** |
| TCL | **Proposal 4: 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.** |
| 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 ending symbol of PUSCH/PUCCH resource for multiplexed UCI transmission is not later than the ending symbol of PUCCH for the higher priority UCI. |
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## Other enhancements

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| Company | Proposals/observations from Tdocs |
| Nokia | **Proposal 3.21: Multiplexing high-priority SR on low-priority PUSCH is supported. RAN1 agrees the way of carrying high-priority SR information on low-priority PUSCH.**  **Proposal 3.22: Multiplexing of more than one PUCCH carrying HARQ-ACK on a PUSCH of different priorities should not be supported, as the multiplexing is also not supported for the scenario where PUSCH and HARQ-ACK are with the same priority.**  **Proposal 3.23: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.** |
| Samsung | **Proposal 18: A UE does not expect to multiplex a HP HARQ-ACK in a LP PUSCH which would be canceled by HP SR.**  **Proposal 20: A UE does not expect to multiplex a HP HARQ-ACK in a LP PUSCH which would be canceled by UL CI.** |
| LG | **Proposal #18: Consider how to determine the priority of CG-UCI and how to encode the CG-UCI payload (and how to map the CG-UCI REs) in case of UCI multiplexing on NR-U CG PUSCH with different priority.**  **Proposal #23: Consider enhanced collision handling between HP PUSCH and LP PUSCH with UCI piggybacking.** |
| Intel | **Proposal 17: If cg-UCI-Multiplexing is enabled, CG-UCI and HARQ-ACK are jointly encoded.**   * **If HARQ-ACKs only with one priority are to be multiplexed into CG-PUSCH that includes CG-UCI, CG-UCI is jointly encoded with the HARQ-ACK with beta offset for the HARQ-ACK.**   **If both HP and LP HARQ-ACK are to be multiplexed into CG-PUSCH that includes CG-UCI, CG-UCI is jointly encoded with HP HARQ-ACK with beta offset for the HP HARQ-ACK.** |
| DCM | **Proposal 11:**  Regarding prioritization for transmission power reduction, any PUSCH including HP HARQ-ACK has the same priority for power allocation as HP PUCCH including HARQ-ACK and/or SR, or HP PUSCH including HARQ-ACK. |
| ETRI | **Proposal 14: The CG-UCI has an additional field whether or not to multiplex HP UCI and LP UCI.**  **Proposal 15: For HARQ-ACK codebook construction, sub-slot based HARQ-ACK codebooks are concatenated, and may be transmitted for PUSCH repetition.**  **Proposal 16: Further discuss how to adjust the power of PUSCH for payload from the other priority.** |
| WILUS | * ***Proposal 8:*** *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.* |
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# 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. |

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.*

**Agreement**

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

* *Note: For the DG PUSCH, it is up to UE implementation to handle OFDM symbols of the DG PUSCH before the start of HP CG PUSCH which are nonoverlapping with the HP CG PUSCH.*
* *FFS: How to handle the collision when there is repetition for CG and/or DG PUSCH*

## How to handle the collision when there is repetition for CG and/or DG PUSCH

## Inputs from Tdocs

For collision of DG-PUSCH and CG-PUSCH of different priorities, the cancellation is applied per repetition, if DG-PUSCH and/or CG-PUSCH is repeated.

* + E///, Nokia

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| Company | Proposals/observations from Tdocs |
| Nokia | **Proposal 2.2: The Rel-16 collision handling of per PUCCH repetition is also adopted for the additional Rel-17 PUSCH collision scenarios between HP CG PUSCH and LP DG PUSCH and between HP DG PUSCH and LP CG PUSCH.** |
| E/// | Proposal 9 For collision of DG-PUSCH and CG-PUSCH of different priorities, the cancellation is applied per repetition, if DG-PUSCH and/or CG-PUSCH is repeated. |
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## 1st round discussion

Proposal for 1st round discussion:

For collision of DG-PUSCH and CG-PUSCH of different priorities, the cancellation is applied per repetition, if DG-PUSCH and/or CG-PUSCH is repeated.

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## 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.
  + E///
  + Option 1a:The UE expects that the first [overlapping] symbol of the high priority DG PUSCH is not earlier than Tproc,2+d1 after the last symbol of the PDCCH scheduling the DG PUSCH.
    - ZTE, Samsung
  + 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.
* 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.
  + HW, QC, LG
* Option 4: Per UE capability.
  + Intel

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| Company | Proposals/observations from Tdocs |
| Huawei | ***Observation 3: The prioritization between LP CG PUSCH and HP DG PUSCH in Rel-17 is more complex than Rel-16 cancelation with respect to both cancellation and preparation of PUSCH.***  ***Proposal 30: 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 HP DG PUSCH and cancel the LP CG PUSCH by the first overlapping symbol at the latest. The UE expects to transmit the HP DG PUSCH no earlier than N2+d1+d2 after the last symbol of the PDCCH scheduling the HP DG PUSCH.***   * ***The value of d1is 0,1,2 symbols same as Rel-16.*** * ***d2 is reported by the UE with expanded values as in Table 1 (2/4/8/16 symbols for =0/1/2/3 respectively).*** |
| ZTE | ***Proposal 24:*** *For the overlapping between LP CG and HP DG, PHY layer can make the prioritization so that the UE is expected to cancel the overlapping low priority CG PUSCH by the first overlapping symbol at the latest. Further, a UE expects that the first [overlapping] symbol of the high priority DG PUSCH is not earlier than Tproc,2+d1 after the last symbol of the PDCCH with the DCI format scheduling the high priority channel.* |
| Nokia | **Proposal 2.1: 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.** |
| E/// | [Proposal 8 For collision between LP CG PUSCH and HP DG PUSCH, if MAC delivers two MAC PDUs to PHY, PHY layer can make the prioritization so that the UE is expected to transmit the HP DG PUSCH and cancel the LP CG PUSCH at latest from the first symbol that is overlapping with the HP DG PUSCH.](#_Toc87041554)  [Proposal 10 MAC may send two PDUs to two overlapping grants only if the later grant has higher PHY priority than the earlier grant.](#_Toc87041556)  [Proposal 11 DG/CG prioritization is performed before Step 1 of the framework WA for multiplexing/prioritization.](#_Toc87041557)  [Proposal 12 Identification of PUSCH for UCI multiplexing is performed after CG-vs-DG prioritization.](#_Toc87041558)  [Proposal 13 When *lch-basedPrioritization* is configured, Rel-16 UL skipping related procedure is not enabled in Rel-17.](#_Toc87041559)  [Proposal 14 For the scenario of HP DG vs LP CG, reuse Rel-15 timeline.](#_Toc87041560)  [Proposal 15 For the scenario of LP DG vs HP CG, it is up to UE implementation to perform the DG/CG prioritization.](#_Toc87041561) |
| Samsung | **Proposal 26: 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.** |
| QC | ***Proposal 20:* 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** | |
| LG | **Proposal #22: Consider to introduce additional time offset on the top of Rel-16 cancelation timeline at least for the collision handling between low priority CG and high priority DG.** |
| 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.** |
| Apple | **Proposal 14-1: Clarify the Rel-16 UE behavior concerning DG/CG transmission.** |
| 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.*   + *If two MAC PDUs are delivered to PHY for any collision case where LP CG PUSCH and HP DG PUSCH are overlapping, UE is expected to cancel the overlapping LP CG PUSCH by the first overlapping symbol at the latest.*     - *The UE expects that the first [overlapping] symbol of the high priority DG PUSCH is not earlier than Tproc,2+d1 after the last symbol of the PDCCH scheduling the DG PUSCH.* |
| Xiaomi | ***Proposal 6:*** ***For LP CG-PUSCH overlaps with HP DG-PUSCH, related cancelation behaviour for LP CG-PUSCH defined in R16 can be reused.*** |
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## 1st round discussion

Proposal for 1st round discussion:

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

* 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.

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# About RRC parameter table

HW proposal:

***Proposal 3: Use only one RRC parameter to enable/disable the multiplexing of inter-priority PUCCH/PUCCH and inter-priority PUCCH/PUSCH.***

Samsung proposal:

**Proposal 14: RRC separately configures enabling multiplexing of HP PUSCH and LP HARQ-ACK for HP DG PUSCH and HP CG PUSCH.**

**Proposal 19: RRC separately configures enabling multiplexing of LP PUSCH and HP HARQ-ACK for LP DG PUSCH and LP CG PUSCH.**

# About UE feature list

HW proposal:

***Proposal 1: Separate UE capabilities should be introduced for Rel-15+Rel-17 inter-priority multiplexing and Rel-16+Rel-17 inter-priority prioritization/multiplexing.***

Intel proposal:

**Proposal 4: Support the following two UE capabilities for Rel-17 intra-UE operation timeline**

* **Capability #A: Rel-15 timeline is applied for multiplexing and cancellation in step 2. The cancellation of LP channel is performed from 1st symbol of LP channel.**
* **Capability #B: Rel-15 timeline is applied for multiplexing, Rel-16 timeline is applied for cancellation in step 2. The cancellation of LP channel is performed from 1st overlapped symbol of LP and HP channels.**

**Proposal 5: For both UE capability #A and capability #B, gNB ensures the arrival of PDCCHs and scheduled overlapped channels compliant with the multiplexing and cancellation timeline respectively, for multiplexing and cancellation operation in step 2.**

# References

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2. R1-2110819 Intra-UE multiplexing enhancements Huawei, HiSilicon
3. R1-2110916 Discussion on enhanced intra-UE multiplexing ZTE
4. R1-2111007 Remaining issues on intra-UE Multiplexing/Prioritization for Rel-17 URLLC vivo
5. R1-2111096 Discussion on intra-UE multiplexing/prioritization Spreadtrum Communications
6. R1-2111140 On UL intra-UE prioritization and multiplexing enhancements Nokia, Nokia Shanghai Bell
7. R1-2111190 Intra-UE Multiplexing/Prioritization Enhancements for IIoT/URLLC Ericsson
8. R1-2111250 Intra-UE multiplexing and prioritization CATT
9. R1-2111343 Enhancements on intra-UE multiplexing/prioritization OPPO
10. R1-2111359 Discussion on Intra-UE Multiplexing/Prioritization Quectel, Langbo
11. R1-2111392 Remaining issues in Intra-UE UL Multiplexing Sony
12. R1-2111436 Discussion on Intra-UE multiplexing of different priority Panasonic Corporation
13. R1-2111491 Remaining open details of intra-UE uplink channel multiplexing and prioritization Intel Corporation
14. R1-2111569 Intra-UE multiplexing prioritization for URLLC IIoT Xiaomi
15. R1-2111705 Discussion on Intra-UE prioritization and multiplexing NEC
16. R1-2111732 Uplink intra-UE multiplexing and prioritization Samsung
17. R1-2111791 Intra-UE multiplexing and prioritization InterDigital, Inc.
18. R1-2111869 Intra-UE Multiplexing/Prioritization in Rel-17 Apple
19. R1-2111944 Intra-UE multiplexing enhancement for IIoT/URLLC Lenovo, Motorola Mobility
20. R1-2111990 Intra-UE Multiplexing/Prioritization ETRI
21. R1-2112014 Enhancements on intra-UE UCI multiplexing and channel collision resolution framework Sharp
22. R1-2112054 Discussion on Intra-UE multiplexing/prioritization LG Electronics
23. R1-2112083 Intra-UE multiplexing and prioritization TCL Communication Ltd.
24. R1-2112103 Discussion on intra-UE multiplexing/prioritization for Rel.17 URLLC NTT DOCOMO, INC.
25. R1-2112174 Discussion on intra-UE multiplexing ITRI
26. R1-2112211 Intra-UE multiplexing and prioritization for IOT and URLLC Qualcomm Incorporated
27. R1-2112287 Methods for intra-UE multiplexing and prioritization MediaTek Inc.
28. R1-2112387 Discussion on intra-UE multiplexing/prioritization for URLLC/IIoT WILUS Inc.