3GPP TSG RAN WG1 #107bis-e R1-2200728

e-Meeting, January 17th – 25th, 2022

Source: Moderator (OPPO)

Title: Summary#2 of email thread [107bis-e-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.

[107bis-e-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: January 20
* Final check point: January 25

# 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.*

Agreement

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

* *The number of RBs is . Then follow Rel-15 procedure, i.e., LP HARQ-ACK is mapped to the rest REs after HP HARQ-ACK.*

Agreement

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

* *At least for PUCCH format 3/4, use the HP UCI bit number and HP RE number for ∆TF,b,f,c(i) formula selection and calculation*
* *For PUCCH format 1, use the total UCI bit number for ∆TF,b,f,c(i) calculation.*
* *FFS for PUCCH format 2.*

## Remaining issues on coding and resource determination

## Inputs from Tdocs

**Issue 2.2-1: 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 2 bits:**
  + Option 1: Reuse Rel-15 TS 38.212 Clause 5.3.3.2.
    - Nokia, vivo, ZTE, QC, E///, OPPO, DCM, Pana, Intel, Quectel
  + Option 2: Reuse R15 TS 38.212 Clause 5.3.3.3, i.e., padding to 3 bits and using RM coding.
    - HW, Samsung, CATT, E/// (2nd preference), LG, Spreadtrum
* **Encoder for HP HARQ-ACK or LP HARQ-ACK of 1 bit:**
  + Option 1a: Introduce Table 5.3.3.1-1A to TS 38.212 Clause 5.3.3.1. Reuse the Rel-15 PUCCH scrambling.
    - ZTE, QC, E///, OPPO, DCM, Pana, Quectel

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

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

* + Option 1b: Reuse Rel-15 TS 38.212 Clause 5.3.3.1. Apply the Rel-15 PUSCH scrambling.
    - Nokia, vivo, ZTE, QC, OPPO (compromise), DCM, Pana, Intel, Quectel
  + Option 2: Reuse Rel-15 TS 38.212 Clause 5.3.3.3, i.e., padding to 3 bits and using RM coding.
    - HW, Samsung, CATT, E/// (2nd preference), LG, Spreadtrum

**Issue 2.2-2: Bit mapping for 1bit HP/LP HARQ-ACK**

* + 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].
  + Nokia, HW, Samsung, LG

**Issue 2.2-3: Support of PUCCH format 2**

* **Option 1: Support multiplexing of HP HARQ-ACK and LP HARQ-ACK on PUCCH Format 2.** 
  + **Extend legacy agreements on PRB number determination to cover PUCCH Format 2.**
  + **Use the HP UCI bit number and HP RE number for *∆TF,b,f,c(i)* formula selection and calculation (as for PUCCH formats 3 & 4).**
    - H3C, Nokia, HW, vivo, ZTE, E///, OPPO, QC, CATT, DCM, Apple (PRB number adjustment), Quectel, LG, Sony, Spreadtrum, ETRI, WILUS
  + **For RE mapping,**
    - Option 1a: Concatenate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits sequentially and apply the procedures described in R15 TS 38.211 to the concatenated coded HARQ-ACK bit sequence in principle.
      * H3C, Nokia, HW, vivo, ZTE, CATT, DCM, Apple, LG (compromise), Sony, Spreadtrum
      * 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 2b: 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, WILUS
      * 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 2: Do not support multiplexing of HP HARQ-ACK and LP HARQ-ACK in PUCCH format 2 in Rel-17. Drop LP HARQ-ACK if the resulting PUCCH resource is with PUCCH format 2.**
  + - Samsung, Intel
    - No practical benefit and complicates specifications and UE/gNB implementation.

**Issue 2.2-4: CSI dropping or not:**

* + Option 1: Confirm WA: Drop CSI (including part 1 and part2, if exist) if CSI would multiplex on a PUCCH which has HP A/N.
    - Nokia, ZTE, QC
  + Option 2: Drop CSI part 2 if CSI would multiplex on a PUCCH which has HP A/N.
    - DCM, LG

**Issue 2.2-5: 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 the problem of ambiguity on LP HARQ-ACK type-1 codebook existence or LP HARQ-ACK type-2~~/type-1 codebook presence~~ codebook size due to DCI mis-detection, a new T-DAI field can be RRC configured:

* For multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH format 3/4,
  + A T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.
  + At most 2 bits are added to the DL DCI format associated with HP HARQ-ACK for the T-DAI of LP HARQ-ACK, compared to Rel-16.
  + FFS details.
* For multiplexing a LP Type-2/Type-1 HARQ-ACK codebook in a HP PUSCH,
  + A T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.
  + At most 2 bits are added to the UL DCI format scheduling the HP PUSCH for the T-DAI of LP HARQ-ACK, compared to Rel-16.
  + FFS details.
* Support: HW (up to 4 bits for CBG), Samsung, CATT, DCM, Pana, IDC, Intel, LG
* No enhancement: E///, OPPO
* **Other options:**
  + Option 1: Configure a dedicated PUCCH resource for HP and LP HARQ-ACK in the second PUCCH-Config.
    - vivo, Pana
  + Option 2: PRI+x in the HP DCI is used to implicitly determine an extended PUCCH resource
    - ZTE
  + Option 3a: The LP type 2 codebook size is quantized/rounded up to a nearest reference size. FFS reference size granularity.
    - QC
  + 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, LG
  + 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, NEC
    - 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.

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

**Issue 2.2-6: Overlapping between different sub-slot length:**

* 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.
  + Nokia

**Issue 2.2-7: Overlapping handling for Type 3 codebook HARQ-ACK**

UE does not expect the overlapping between HP PUCCH/PUSCH and LP HARQ-ACK subject to Type 3 codebook/enh. Type 3 codebook/one shot retransmission.

* + HW

**Issue 2.2-8: Multiplexing for SPS HARQ-ACK**

Option 1: HP SPS HARQ-ACK only and LP HARQ-ACK are not expected to be multiplexed.

* + HW

Option 2: A separate RRC parameter configures enabling/disabling multiplexing of LP HARQ-ACK and HP SPS HARQ-ACK.

* + Samsung

**Issue 2.2-9: Details on transmission power**

For multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH, if the calculated power based on is larger than the configured maximum output power , RRC configures whether to drop LP HARQ-ACK.

* + Samsung

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]

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.

* + Samsung

PUCCH PHR is not considered in Rel-17 URLLC.

* + Intel

**Additional coding rate configuration**

* + 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.
    - IDC

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| H3C | **Proposal 3: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, PUCCH Format 2 should be supported and use the same method on using the HP UCI bit number and HP RE number for ∆TF,b,f,c(i) formula selection and calculation as PUCCH Format 3/4.** |
| Nokia | **Proposal 3.1: For multiplexing high-priority and low-priority HARQ-ACKs on PUCCH Format 2, extend the RAN1#106bis-e and RAN1#107-e agreements on the PRB number determination to also cover PUCCH Format 2.**  **Proposal 3.2: 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 3.3: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK on PUCCH Format 2, use the HP UCI bit number and HP RE number for ∆TF,b,f,c(i) formula selection and calculation (as for PUCCH formats 3 & 4).**  **Proposal 3.4: For the scenario where a PUCCH carrying high-priority HARQ-ACK overlaps with another PUCCH carrying low-priority HARQ-ACK and the total payload size is two bits, the order of the multiplexed two bits could be [high-priority HARQ-ACK bit, low-priority HARQ-ACK bit].**  **Proposal 3.5: For the 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 3.6: 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.**  ***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 3.7: 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 high-priority HARQ-ACK: 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.**   **Proposal 3.10: 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.** |
| HW | ***Proposal 10: For the multiplexed 1 bit HP HARQ-ACK and 1 bit LP HARQ-ACK on PUCCH format 0/1, the HP HARQ-ACK bit should be mapped in prior to the LP HARQ-ACK bit.***  ***Proposal 11: 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 12: For the encoders* *of LP and HP HARQ-ACK bits with more than 2 bits total payload size***, ***and HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support option 2, i.e., padding and RM encoding.***  ***Proposal 13: 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 14: UE does not expect the overlapping between HP PUCCH and LP HARQ-ACK subject to Type 3 codebook/enh. Type 3 codebook/one shot retransmission.***  ***Proposal 15: HP SPS HARQ-ACK only and LP HARQ-ACK are not expected to be multiplexed.***  ***Observation 1: If LP Type 2 HARQ-ACK codebook includes two HARQ-ACK sub-codebooks separately for TB and CBG, 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 16: For multiplexing of HP HARQ-ACK and LP HARQ-ACK with two LP sub-codebooks, the one additional LP T-DAI field (i.e. 2bits) in HP DCI should be applied to both the first LP TB-based HARQ-ACK sub-codebook and the second LP CBG-based HARQ-ACK sub-codebook.*** |
| vivo | ***Proposal 1: 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 2: 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.***  ***Proposal 7: 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*** |
| ZTE | ***Proposal 3:*** *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 4:*** *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 5:*** *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 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,*   * *Coded bits of HP HARQ-ACK and LP HARQ-ACK are continuously mapped in the time-frequency resources for PF2.*   ***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.* |
| Samsung | **Proposal 1: 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 2: Do not support multiplexing of HP HARQ-ACK and LP HARQ-ACK in PUCCH format 2 in Rel-17.**   * **Drop LP HARQ-ACK if the resulting PUCCH resource is with PUCCH format 2.**   **Proposal 3: 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 4: A separate RRC parameter configures enabling/disabling multiplexing of LP HARQ-ACK and HP HARQ-ACK without a PDCCH.**  **Proposal 11：For multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH, if the calculated power based on is larger than the configured maximum output power , RRC configures whether to drop LP HARQ-ACK.**  **Proposal 12: When 1 bit LP HARQ-ACK is multiplexed with 1 bit HP HARQ-ACK, the HP HARQ-ACK bit is placed before the LP HARQ-ACK bit.** |
| CATT | ***Proposal 7: For multiplexing of HP HARQ-ACK and LP HARQ-ACK on PUCCH when total number of bits is more than 2, padding to 3 bits and using RM coding for HP HARQ-ACK or LP HARQ-ACK of 1 or 2 bits.***  ***Proposal 8: For HP HARQ-ACK and LP HARQ-ACK multiplexing on a PUCCH resource with PUCCH format 2, HP HARQ-ACK and LP HARQ-ACK are jointly coded.***  ***Proposal 12: 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*** |
| QC | ***Proposal 1: 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 2: 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 4*: In Rel-17, support HP UCI and LP UCI multiplexing on PUCCH format 2.**  ***Proposal 5*: 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 6*: 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 7*: 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 8*: 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 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 13*: For multiplexing a high-priority (HP) UCI and a low-priority (LP) UCI into PUCCH format 2, use the HP UCI bit number and HP RE number for ∆TF,b,f,c(i) formula selection and calculation.** |
| E/// | [Proposal 7 Update the scheduling restriction to allow multiplexing PUSCH and HARQ-ACK of different priorities.](#_Toc92834001)  [Proposal 8 As a first preference, adopt option 1a for encoding of 1 or 2 bit HARQ feedback when HP and LP HARQ-ACK are separately encoded and multiplexed onto a PUCCH. Adopt RM coding as a second preference.](#_Toc92834002)  [Proposal 9 Do not introduce a DCI field indicating the T-DAI of LP HARQ-ACK.](#_Toc92834003)  [Proposal 13 For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, the power control procedure for PUCCH format 3 and 4 is also applied to PUCCH format 2.](#_Toc92834007)  [Proposal 14 MAC may send two PDUs to two overlapping grants only if the later grant has higher PHY priority than the earlier grant.](#_Toc92834008)  [Proposal 17 Adopt the same understanding as in Rel-16, i.e., when *lch-basedPrioritization* is configured, Rel-16 UL skipping cannot be enabled in Rel-17.](#_Toc92834011) |
| OPPO | ***Proposal 14: For the coding scheme of HP HARQ-ACK or LP HARQ-ACK with up to 2 bits, when the total LP HARQ-ACK and HP HARQ-ACK bits is more than 2, we prefer option 1a and can compromise to option 1b.***  ***Proposal 15: Additional enhancement to avoid ambiguity caused by LP DCI missing is not supported.*** |
| 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 1a and Option 1b are preferable considering the potential overhead of padding for the separate coding method of 1-2 HARQ-ACK bit(s).*   + *Option 1a: Introduce Table 5.3.3.1-1A to TS 38.212 Clause 5.3.3.1. Reuse the Rel-15 PUCCH scrambling.*   + *Option 1b: Reuse Rel-15 TS 38.212 Clause 5.3.3.1. Apply the Rel-15 PUSCH scrambling.*   **Proposal 3:**   * *For the problem of ambiguity on LP HARQ-ACK type-1 codebook existence or LP HARQ-ACK type-2 codebook size due to DCI miss-detection, a T-DAI field is introduced in a DL DCI format and a UL DCI format to indicate the T-DAI of LP HARQ-ACK for multiplexing on PUCCH and PUSCH, respectively.*   **Proposal 4:**   * *Support UCI multiplexing of different priorities on PF2. The same PRB determination procedure is applied to PF2 as PF3.* |
| Pana | **Proposal 2: Support multiplexing of HP HARQ-ACK and LP HARQ-ACK on PUCCH format 2.**   * **Concatenate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits sequentially and apply the procedures described in Rel.15 TS 38.211 to the concatenated coded HARQ-ACK bit sequence in principle.**   **Proposal 3: 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.**   **Proposal 4: Either of following option is taken.**   * **Option 1: 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.** * **Option 2: Total DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the total DAI of LP HARQ-ACK.** |
| IDC | ***Proposal 1: 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 2: DCI indicating HP HARQ-ACK includes an indication of the DAI of LP HARQ-ACK.***  ***Proposal 3: RRC can configure 2-bits field combining priority indication and DAI of LP HARQ-ACK.*** |
| Intel | **Proposal 6: For HP HARQ-ACK or LP HARQ-ACK of 1-2 bit(s), support separate coding by reusing R15 TS 38.212 Clause 5.3.3.1 for 1-bit. Reuse R15 TS 38.212 Clause 5.3.3.2 for 2-bit.**  **Proposal 7: LP and HP HARQ-ACK multiplexing is not supported for PUCCH format 2.**  **Proposal 8: For multiplexing a HP HARQ-ACK and LP HARQ-ACK into a PUCCH, additional T-DAI for LP HARQ-ACK can be indicated by the DCI scheduling HP HARQ-ACK/HP PUSCH.**  **Proposal 11: When cg-UCI-Multiplexing is enabled, CG-UCI is jointly encoded with HP HARQ-ACK with beta offset for the HP HARQ-ACK, if both HP and LP HARQ-ACK are to be multiplexed into CG-PUSCH that includes CG-UCI.**  **Proposal 13: PUCCH PHR is not considered in Rel-17 URLLC.** |
| Apple | **Proposal 5-1: considering coding rates of UCI parts in the 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 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)**  **Proposal 8: clarify whether periodic CSI report or an SP CSI report with 4 bit subband CQI should be treated as high priority or not.**  **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 10-1: consider PRB # adjustment and CSI omission/HARQ compaction for the PUCCH resource under multi-CSI-PUCCH-ResourceList and pucch-CSI-ResourceList.**  **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.** |
| Quectel | **Proposal 2**: Option 1 is supported, i.e., Rel-15 TS 38.212 Clause 5.3.3.1 is reused for 1-bit and Rel-15 TS 38.212 Clause 5.3.3.2 is reused for 2-bit.  **Proposal 3**: HP A/N and LP A/N multiplexing on a PUCCH format 2 (PF2) is supported.  **Proposal 4**: Rate matching equation in Rel-15 for PF3/4 A/N+CSI-1 and rate matching equation in Rel-15 for PF3/4 CSI-2 are reused respectively for PF2 HP A/N and PF2 LP A/N.  **Proposal 5**: The HP UCI bit number and HP RE number are used for PF2 ∆TF,b,f,c(i) formula selection and calculation. |
| LG | **Proposal #3: 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 #4: 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 #5: Apply separate encoding and RE mapping 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.** * **Alternatively, frequency first RE mapping can be reused after concatenating HP (coded) UCI bits and LP (coded) UCI bits sequentially (if it is hard to have a consensus to apply the distributed RE mapping as in above).**   **Proposal #6: Apply 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.**   **Proposal #7: Adopt 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 UE, the HP 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 HP PUCCH resource corresponding to the PRI indicated in the last LP DCI is selected.**   **Proposal #8: 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 #9: 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.**   * **For Type-1 codebook based LP HARQ-ACK, one of {full codebook, no HARQ-ACK} is indicated by 1-bit field in HP DCI.** * **For Type-2 codebook based LP HARQ-ACK, one of {X-bit, Y-bit, Z-bit, W-bit} (where X < Y < Z < W) is indicated by 2-bit field in HP DCI.** |
| Sony | **Proposal 3: 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.** |
| 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 multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2.***  * ***Concatenate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits sequentially and apply the procedures described in R15 TS 38.211 to the concatenated coded HARQ-ACK bit sequence in principle.***  1. ***One maxCodeRate is configured for PUCCH format 2.*** 2. ***Number of RBs for multiplexing HP HARQ-ACK and LP HARQ-ACK on a PUCCH format 2 remains the same as Rel-15*** |
| ETRI | **Proposal 7: The scheduling DL-DCI has an additional field whether or not to allow multiplex HP UCI and LP UCI, or otherwise by the RRC signalling.**  **Proposal 8: The LP DCI determines the final PUCCH resource in at least for the HP SPS case.**  **Proposal 9: The PUCCH format 2 can also be included in the agreement for calculation.** |
| CTC | **Proposal 1: For the problem of ambiguity on LP HARQ-ACK existence,**   * **for 1-bit LP HARQ-ACK and 1-bit HP HARQ-ACK multiplexed in PF0, CS=0, 3, 6, 9 is mapped to (HP HARQ-ACK, LP HARQ-ACK)=(NACK, NACK), (NACK, ACK), (ACK, NACK), (ACK,ACK);**   **for 1-bit LP HARQ-ACK and 1-bit HP HARQ-ACK multiplexed in PF1, (HP HARQ-ACK, LP HARQ-ACK) is QPSK modulated using** |
| 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.*  ***Proposal 4:***  *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.* |
| ITRI | **Proposal 1:**  Dynamic indication in multiple DCIs associated with a group of overlapping channels should be consistent.  **Proposal 2:**  UE should not expect to receive a dynamic indication resulting in demultiplexing of previously multiplexed PUCCHs/PUSCHs channels.  **Proposal 3:**  An UL channel associated with a DCI disabling multiplexing can collide with another UL channel of a same priority if dynamic indication in multiple DCIs associated with a group of overlapping channels are consistent.  **Proposal 4:**  The configuration of prioritization/multiplexing for channels without dynamic indication can be determined according to the dynamic indication of validation DCI, if any. Otherwise, the UE should always assume the Rel-17 multiplexing is enabled for the channels, the multiplexing timeline should be satisfied and handled by gNB configuration.  **Proposal 5:**  If a set of UL channels without dynamic indication are decided to be multiplexed, UE should not expect the set of UL channel would overlap with other UL channel which is dynamically indicated to disable the multiplexing. |
| WILUS | * ***Proposal 1:*** *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 2:*** *For PUCCH format 2,*   + *Support PUCCH format 2 to multiplex LP HARQ-ACK and HP HARQ-ACK*   + *To maximize reliability of HP HARQ-ACK, the HP HARQ-ACK is distributed to REs across RBs as much as possible.* * ***Proposal 3:*** *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.* * ***Proposal 4: To multiplex HP-SR with PF0 and LP HARQ-ACK with PF0, we propose***    + *If HP-SR is negative, then transmit LP HARQ-ACK on HARQ-ACK resource.*     - *In case of 1-bit LP HARQ-ACK, use 2 CSs, i.e., {0, 6} CS index*     - *In case of 2-bit LP HARQ-ACK, use 4 CSs, i.e., {0, 3, 6, 9} CS index*   + *If HP-SR is positive, then transmit LP HARQ-ACK and HP-SR on HARQ-ACK resource*     - *In case of 1-bit LP HARQ-ACK, use 2 CSs, i.e., {3, 9} CS index*     - *In case of 2-bit LP HARQ-ACK, use 4 CSs, i.e., {1, 4, 7, 11} CS index*        * *To enhance HP-SR reliability, 2-bit LP HARQ-ACK can be bundled to 1-bit and then the 1-bit bundled LP HARQ-ACK is treated as 1-bit LP HARQ-ACK, i.e., use 2 CSs, {3, 9} CS index.* |
|  |  |

## 1st round discussion

Proposal for 1st round discussion:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is more than 2, for HP HARQ-ACK or LP HARQ-ACK of 2 bits, support separate coding and down-select from the following options:

* Option 1: Reuse Rel-15 TS 38.212 Clause 5.3.3.2.
  + Nokia/NSB, Huawei/Hisi (can accept), Sony, Sharp, Panasonic, DOCOMO, Spreadtrum (can accept), QC, ITRI, NEC, ZTE, CATT (can accept), Intel, vivo, Quectel, E///, OPPO
* Option 2: Reuse Rel-15 TS 38.212 Clause 5.3.3.3, i.e., padding to 3 bits and using RM coding.
  + Huawei/Hisi, Spreadtrum, Samsung, New H3C, CATT, E/// (can accept if Opt.2 is selected for 1-bit)

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Option 1 (slight preference) |
| Huawei/Hisi | Our first preference is Option 2, and we can accepet Option 1. |
| Sony | Option 1 |
| Sharp | Option 1 |
| Panasonic | For 2-bit case, Option 1 provides better performance. In order to have unified solution for 1-bit and 2-bit case, we prefer Option 1. |
| DOCOMO | Option 1 |
| Spreadtrum | Our first preference is Option 2, it is easiest way to go, just padding to 3-bit would be enough. We are fine with Option 1 if it is majority view. |
| Samsung | The proposal is not necessary, we already made the following agreement   |  | | --- | | 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.* |   We support Option 2.  Option 1 is not acceptable - it is an unnecessary optimization, will not offer any actual benefit, and complicates specifications and gNB/UE implementation. It is straightforward to pad to 3 bits and use RM coding (as in Rel-15). It cannot be possibly acceptable to introduce new UE/gNB implementations for no reason. |
| QC | Option 1 |
| New H3C | We support Option 2. |
| ITRI | Option 1 |
| NEC | Option 1 |
| ZTE | Option 1. This issue has been discussed for long time. It is obvious that option 1 has distinct performance gain against option 2. Moreover, option 1 has no specification impact as it reuses the legacy way. Please note, for HP HARQ-ACK or LP HARQ-ACK of 2 bits, there is no scrambling issue at all. |
| CATT | Our first preference is Option 2 with aligned behavior for 1 and 2-bit cases and less specificiation impact, but we can accepet Option 1 given performance gain of Option 1 over Option 2 shown in the simulation results provided by some companies. |
| Intel | Option 1 due to better performance shown by companies. |
| vivo | Option 1 |
| Quectel | Option 1 |
| Ericsson | First preference is Option 1. But if RM coding is used for 1-bit case, then Option 2 is preferred so that the same procedure is used for both 1-bit and 2-bit |
| OPPO | Option 1 |
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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 bits, support separate coding and down-select from the following options:

* Option 1a: Introduce Table 5.3.3.1-1A to TS 38.212 Clause 5.3.3.1. Reuse the Rel-15 PUCCH scrambling.
  + Panasonic, DOCOMO, QC, ITRI, ZTE (can accept), Quectel (can accept), E///, OPPO

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

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

* Option 1b: Reuse Rel-15 TS 38.212 Clause 5.3.3.1. Apply the Rel-15 PUSCH scrambling.
  + Nokia/NSB, Huawei/Hisi (can accept), Sony, Panasonic, DOCOMO, Spreadtrum (can accept), QC, ITRI, ZTE, CATT (can accept if Opt.1 is selected for 2-bit), Intel, Quectel, OPPO
* Option 2: Reuse Rel-15 TS 38.212 Clause 5.3.3.3, i.e., padding to 3 bits and using RM coding.
  + Nokia/NSB (can accept if Opt.2 is selected for 2-bit), Huawei/Hisi, Apple, Spreadtrum, Samsung, CATT, E/// (can accept)

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| Company | Comments |
| Nokia/NSB | Option 1b. If RM coding for the first proposal is to be selected, then Option 2 should be chosen (to align the behavior). |
| Huawei/Hisi | Our first preference is Option 2, and we can accepet Option 1b. As the evevtual effect of Option 1a and Option 1b is the same, it is more direct to adopt the scrambling way by referring UCI-on-PUSCH. |
| Sony | Option 1b |
| Apple | Option 2 |
| Panasonic | We support Option 1a or Option 1b. |
| DOCOMO | Fine with Option 1a and 1b. |
| Spreadtrum | We prefer Option 2. It is easiest way to go, just padding to 3-bit would be enough. And we are fine with Option 1b if it is majority view. |
| Samsung | Not support.  The proposal violates a previous agreement below. Option 1a should not be considered.   |  | | --- | | 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.* |   The result of Option 1a and Option 2 is exactly the same, i.e., repetition without scrambling, and there is no point to agree on 1a because it has additional spec impact without benefit.  The issue should be discussed together with the first proposal. According to the previous agreement, a unified solution should be used. |
| QC | We are fine with option 1a or 1b |
| ITRI | Fine with Option 1a and Option 1b. |
| ZTE | Prefer 1b, for sake of progress, can accept 1a. |
| CATT | Our first preference is Option 2 as for 2-bit case. But if Option 1 is adopted for 2-bit case, we prefer Option 1b for 1-bit case. |
| Intel | We prefer option 1b. |
| Quectel | Fine with Option 1a or Option 1b. First preference is Option 1b. |
| Ericsson | First preference is Option 1a, second preference is Option 2.  For Option 1b, it is incorrect to apply Rel-15 PUSCH scrambling. We don’t see that the spec can simply refer to PUSCH scrambling without causing unintended consequences.  Other than the placeholder bit handling, PUSCH scrambling in 38.211 section 6.3.1.1:    But PUCCH scrambling in 38.211:    Hence PUSCH scrambling cannot be applied without changing the meaning of n\_ID and n\_RNTI variables when the scrambling is in fact performed for PUCCH.  Option 1a stays with PUCCH scrambling, and the placeholder bit is handled in a simple way without involving PUSCH spec. |
| OPPO | Option 1a or 1b |
|  |  |

Proposal for 1st round discussion:

Support multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2.

* Extend legacy agreements on PRB number determination for Rel-17 (RAN1#106bis-e and RAN1#107-e) to cover PUCCH Format 2.
* Use the HP UCI bit number and HP RE number for ∆TF,b,f,c(i) formula selection and calculation (as for PUCCH formats 3 & 4).
* Concatenate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits sequentially and apply the procedures described in R15 TS 38.211 to the concatenated coded HARQ-ACK bit sequence ~~in principle~~.

Note: It was agreed to support multiplexing a high-priority HARQ-ACK and a low-priority HARQ-ACK into a PUCCH in R17.

* Support: Nokia/NSB, Huawei/Hisi, Sony, InterDigital, Apple, Panasonic, DOCOMO, Spreadtrum, QC, ITRI, ZTE, CATT, Quectel, E///, OPPO
* Not support: Samsung, Intel
  + Increase the number of coding chains for PUCCH format 2 and complicate the UE/gNB implementation.
  + PUCCH format 2 is only 1 or 2 symbols, with Rel-15 timeline, it is likely that gNB can properly schedule a PUCCH resource for both LP and HP to avoid overlapping for such case.

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| Company | Comments |
| Nokia/NSB | Support the proposal in general.  We suggest removing the term “in principle” from the third bullet-point. |
| Huawei/Hisi | Support. As the PUCCH format 2 is typically adopted for serving latency sensitive traffic, it is of great benefit to introduce HP and LP separate coding in Rel-17 so that the resulting PUCCH can keep short for serving latency sensitive traffics. |
| Sony | Support the proposal. |
| InterDigital | Support. |
| Apple | Support |
| Panasonic | We support the proposal. |
| DOCOMO | Support |
| Spreadtrum | Support. PUCCH format 2 is a typical configuration for HP HARQ-ACK. If it is not supported for Rel-17 intra-UE multiplexing, it would be largely decrease the functions of HP and LP UCI multiplexing.  It is easiest way to extend PUCCH format 2 to support carrying HP and LP bits, which only requires one code operation for PUCCH format 2. The advantage part is it can reuse the most part of the current mechanism. Little changes is needed. |
| Samsung | Not support.  No need to increase the number of coding chains for PUCCH format 2 and complicate the UE/gNB implementation. That has been the agreed design principle in RAN1 - unnecessary exceptions are not acceptable.  For the 1st sub-bullet, previous agreement cannot be directly used for PF2, “*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].*” is not needed.  We have a clarification question on the 3rd sub-bullet, does it mean HP HARQ-ACK and LP HARQ-ACK are separately coded and then concatenated? |
| QC | We can support the proposal, although the concatenation RE mapping is not our preference. It is important to support PUCCH format 2 (which is a typical use case) for Rel-17 UCI mux for URLLC. |
| ITRI | Support. |
| ZTE | Support |
| CATT | Support the proposal and agree with Nokia’s comment to remove “in principle” from the 3rd bullet. |
| Intel | Not support.  We share same view with Samsung, it is undesirable to add additional coding chain for PUCCH format 2 that increases UE complexity.  Besides, PUCCH format 2 is only 1 or 2 symbols, with Rel-15 timeline, it is likely that gNB can properly schedule a PUCCH resource for both LP and HP to avoid overlapping for such case. Even if LP PUCCH is dropped, we still have other tools to recover the HARQ-ACK, e.g., HARQ-ACK retransmission. |
| Quectel | Support. |
| Ericsson | Support |
| OPPO | Support |
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Proposal for 1st round discussion:

For the ambiguity on LP HARQ-ACK type-1 codebook existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection, a new T-DAI field can be RRC configured:

* For multiplexing HP HARQ-ACK and Type-2/Type-1 LP HARQ-ACK codebook in a PUCCH format 2/3/4,
  + A T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.
  + At most 2 bits are added to the DL DCI format associated with HP HARQ-ACK for the T-DAI of LP HARQ-ACK, compared to Rel-16.
* For multiplexing a LP Type-2/Type-1 HARQ-ACK codebook in a HP PUSCH,
  + A T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.
  + At most 2 bits are added to the UL DCI format scheduling the HP PUSCH for the T-DAI of LP HARQ-ACK, compared to Rel-16.
* If the new T-DAI field is not RRC configured,
  + Alt.1 (Most of companies support): the ambiguity on LP HARQ-ACK type-1 codebook existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection is handled by gNB implementation.
  + Alt.2 (QC proposal): the legacy T-DAI field is double interpreted to indicate both T-DAI of HP HARQ-ACK and LP HARQ-ACK.
  + Alt.3 (CTC proposal):
    - for 1-bit LP HARQ-ACK and 1-bit HP HARQ-ACK multiplexed in PF0, CS=0, 3, 6, 9 is mapped to (HP HARQ-ACK, LP HARQ-ACK)=(NACK, NACK), (NACK, ACK), (ACK, NACK), (ACK,ACK);
    - for 1-bit LP HARQ-ACK and 1-bit HP HARQ-ACK multiplexed in PF1, (HP HARQ-ACK, LP HARQ-ACK) is QPSK modulated using .
* Support: Nokia/NSB, Huawei/Hisi, InterDigital, Panasonic, DOCOMO, Samsung (remove last bullet), ITRI, ZTE, CATT, QC (alternative for last bullet), Intel (clarify 1-bit T-DAI), Quectel (remove last bullet), CTC (alternative for last bullet), OPPO
* Not support: Spreadtrum, E///

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| Company | Comments |
| Nokia/NSB | Support the proposal. |
| Huawei/Hisi | Support in principle. A minor editorial change on the first bullet to align the descriptions between the first and the second bullet.  “   * For multiplexing HP HARQ-ACK and LP Type-2/Type-1 HARQ-ACK codebook in a PUCCH format 3/4,   ”  In addition, we believe the last bullet is a Note w/o additional spec impact, right? |
| InterDigital | Support. |
| Panasonic | We are fine with the proposal. |
| DOCOMO | Support |
| Spreadtrum | We do not support it.  It aims to handle some error cases. For example, the last DCI of LP HARQ-ACK is lost when it uses Type 2 HARQ-ACK codebook. However, only DAI is not enough to sovle this problem. Because if LP HARQ-ACK PUCCH does not collide with HP PUCCH, it is still an error case, UE and gNB still does not know when and how to do UCI multiplexing.  Second reason is we don’t think there is such problem when LP HARQ-ACK configured with Type 1 HARQ-ACK codebook. Its size has been decides beforehand. There is no need to provide additional DAI for it. Actually, there is no DAI for type 1 HARQ-ACK CB in DL grant DCI since Rel-15. |
| Samsung | Support in principle.  The “in a PUCCH format 3/4” should be removed, the proposal also applies to PF 0/1.  The last bullet should be removed – there is no reason for it, not even as a note.  Regarding Spreadtrum’s comment “Because if LP HARQ-ACK PUCCH does not collide with HP PUCCH, it is still an error case, UE and gNB still does not know when and how to do UCI multiplexing.” We don’t agree. We have UL DAI for PUSCH and a PUSCH can be non-overlapping with a HARQ-ACK PUCCH. There is no difference form UL DAI. |
| QC | We support the proposal in principle but don’t support the current form of the proposal. The reason is that there is better variation of the proposal, which does not require additional DAI. But that variation is not included in this proposal.  We can accept the following modified proposal.  For the ambiguity on LP HARQ-ACK type-1 codebook existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection, a new T-DAI field can be RRC configured:   * For multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH format 3/4,   + A T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.   + At most 2 bits are added to the DL DCI format associated with HP HARQ-ACK for the T-DAI of LP HARQ-ACK, compared to Rel-16. * For multiplexing a LP Type-2/Type-1 HARQ-ACK codebook in a HP PUSCH,   + A T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.   + At most 2 bits are added to the UL DCI format scheduling the HP PUSCH for the T-DAI of LP HARQ-ACK, compared to Rel-16. * If the new T-DAI field is not RRC configured, the legacy T-DAI field is double interpreted to indicate both T-DAI of HP HARQ-ACK and LP HARQ-ACK.  ~~the ambiguity on LP HARQ-ACK type-1 codebook existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection is handled by gNB implementation~~.   The advantage of the solution with double interpretation is that it does not introduce new DAI field. And how it works is the following.  If BS issued 3 LP PDSCH and 1 HP PDSCH as following: LP DCI 1 with DAI =1, LP DCI 2 with DAI =2, LP DCI 3 with DAI =3, HP DCI 1 with DAI =1. If UE missed the LP DCI 3, UE first follow the DAI =1 in HP DCI 1 to decide HP A/N codebook size =1. Then, according to double interpretation, UE reuse DAI=1 in HP DCI 1 to decide LP A/N codebook size. For LP A/N, it received a previous DCI 2 with DAI =1, then UE should interpret LP A/N size =1+4=5 bits. We admit the solution might require UE to pad NACKs in sometime, but not always.  The modified proposal offers gNB flexibility whether it want to put the additional overhead in DL DCI or on dummy NACKs in HARQ-ACK codebook. If gNB can torelate DL DCI overhead, it can go head to configure the additional DAI field. If gNB can torelate UL UCI overhead, it can choose not to configure additional DAI field. I hope this offers a tool to solve the concern from companies (such as Spreadtrum) on DCI overhead. |
| ITRI | Support. |
| ZTE | Support. Fine with Huawei’s revision. |
| CATT | Support the proposal in principle.  If the above proposal to support multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2 is agreed, the first bullet point should be extended for PF 2 as well.  One question for clarification is that whether there is any specific reason to have “Type-2/Type-1” instead of “Type-1/Type-2”. |
| Intel | We’re generally fine with the proposal.  Some clarifcation questions for type-1 codebook.   * How many bits for T-DAI? Only 1 bit as Rel-15/16 ?   For the case of 1-bit HARQ-ACK without codebook, is T-DAI value 0 or 1? Can T-DAI help gNB to differentiate 0 or 1 bit HARQ-ACK ? |
| Quectel | Fine with removal of the last bullet. |
| CTC | We understand why the new T-DAI field can be RRC configured is the concern about the permanent overhead for the additional T-DAI field in HP and LP (for size alignment) DCI to deal with the ambiguity issue, which can be solved in other ways without DCI overhead in some case or gNB implementation.  For the case total LP and HP HARQ-ACK bit number is 2, adjusting the (HP HARQ-ACK, LP HARQ-ACK) bits to the current CS or modulated symbol mapping for UCI multiplexing on HP PUCCH resource could avoid LP HARQ-ACK DTX-to-ACK error problem caused by LP HARQ-ACK existence ambiguity without DCI overhead increasing. We suggest to adopt the approach for 2 bit LP and HP HARQ-ACK, which could also be applied when the new T-DAI field is not RRC configured.   * **for 1-bit LP HARQ-ACK and 1-bit HP HARQ-ACK multiplexed in PF0, CS=0, 3, 6, 9 is mapped to (HP HARQ-ACK, LP HARQ-ACK)=(NACK, NACK), (NACK, ACK), (ACK, NACK), (ACK,ACK);** * **for 1-bit LP HARQ-ACK and 1-bit HP HARQ-ACK multiplexed in PF1, (HP HARQ-ACK, LP HARQ-ACK) is QPSK modulated using .** |
| Ericsson | Do not support.  This increases the DCI size for a corner case, namely,   * UE missed the last DCI associated with LP HARQ-ACK, and * HARQ-ACK codebook is Type 2, and * LP HARQ-ACK is to be multiplexed with HP HARQ-ACK.   The proposal does not solve the issue of HP CG-PUSCH, i.e., no scheduling DCI.  It’s sufficient that gNB implementation handles it, e.g., by giving the DCI associated with LP HARQ-ACK same level of reliability (e.g., AL=16) as HP HARQ-ACK. |
| OPPO | Support |
|  |  |

Proposal for 1st round discussion:

For multiplexing HP HARQ-ACK and LP HARQ-ACK in a PUCCH, if the calculated power based on is larger than the configured maximum output power , RRC configures whether to drop LP HARQ-ACK.

* Support: Samsung
* Not support: Nokia/NSB, Huawei/Hisi, Sony, InterDigital, DOCOMO, QC, ZTE, CATT, Intel, Quectel, E///, OPPO

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| Company | Comments |
| Nokia/NSB | Do not support.  Actually, we are not sure about the intention of the proposal as, in the related agreement, only the HP bits and HP RE number are used for the calculation of ∆TF,b,f,c(i).  In addition, we don’t want to add some additional conditions on when to drop the LP HARQ-ACK; if we really wanted to control multiplexing, a simpler and general approach would have been to let the gNB dynamically enable/disable the multiplexing. |
| Huawei/Hisi | We do not observe there is a need for optimization here. The UE can transmit with the max power  without any issue; the gNB can schedule the non-overlapped channels if the power is really a big problem. |
| Sony | Do not support. |
| InterDigital | Do not support. The network would not know when the UE drops LP HARQ-ACK. |
| DOCOMO | Do not support. We share similar views with Nokia/NSB and InterDigital. It seems the proposal is an optimization and it would lead to gNB ambiguity on when UE drops LP HARQ-ACK. |
| Samsung | Support  If the calculated power based on is larger than the configured maximum output power , the reliability of HP HARQ-ACK is compromised.  We also agree the issue can be simplied handled by dynamic indication as Nokia pointed out, but for CAP#1 UE, the issue still exists. |
| QC | Not support the proposal |
| ZTE | Not support. gNB can’t know the UE behavior to drop the LP HARQ-ACK as the judgement on power is only handled in UE side. |
| CATT | Do not support. We think it is under gNB’s control and there is no need for optimization. |
| Intel | We don’t support the proposal, with same reason as provided by other companies that Gnb may not know whether maximum power is reached or not at UE side. |
| Quectel | Not support |
| Ericsson | Do not support |
| OPPO | Not support |
|  |  |

## 2nd round discussion

#### Issue 2.2-1

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 bits, Ericsson raised concerns in the 1st round about Option 1b as below. The 2nd round is to discuss the problem. Proponent of Option 1b is encouraged to reply the comments from Ericssion *(as copied below)*.

*For Option 1b, it is incorrect to apply Rel-15 PUSCH scrambling. We don’t see that the spec can simply refer to PUSCH scrambling without causing unintended consequences.*

*Other than the placeholder bit handling, PUSCH scrambling in 38.211 section 6.3.1.1:*

**

*But PUCCH scrambling in 38.211:*

**

*Hence PUSCH scrambling cannot be applied without changing the meaning of n\_ID and n\_RNTI variables when the scrambling is in fact performed for PUCCH.*

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#### Issue 2.2-3

Proposal for 1st round discussion:

Support multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2.

* Extend legacy agreements on PRB number determination for Rel-17 (RAN1#106bis-e and RAN1#107-e) to cover PUCCH Format 2.
* Use the HP UCI bit number and HP RE number for ∆TF,b,f,c(i) formula selection and calculation (as for PUCCH formats 3 & 4).
* Concatenate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits sequentially and apply the procedures described in R15 TS 38.211 to the concatenated coded HARQ-ACK bit sequence.

Note: It was agreed to support multiplexing a high-priority HARQ-ACK and a low-priority HARQ-ACK into a PUCCH in R17.

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#### Issue 2.2-5

Splitting to two proposals, please input your comments separately. For the second proposal, companies introduced three options for discussion.

Proposal for 2nd round discussion:

For the ambiguity on LP HARQ-ACK type-1 codebook existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection, a new T-DAI field can be RRC configured:

* For multiplexing HP HARQ-ACK and Type-2/Type-1 LP HARQ-ACK codebook in a PUCCH format 2/3/4,
  + A T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.
  + At most 2 bits are added to the DL DCI format associated with HP HARQ-ACK for the T-DAI of LP HARQ-ACK, compared to Rel-16.
* For multiplexing a LP Type-2/Type-1 HARQ-ACK codebook in a HP PUSCH,
  + A T-DAI field in a UL DCI format scheduling the HP PUSCH to indicate the T-DAI of LP HARQ-ACK.
  + At most 2 bits are added to the UL DCI format scheduling the HP PUSCH for the T-DAI of LP HARQ-ACK, compared to Rel-16.

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Proposal for 1st round discussion:

If the new T-DAI field is not RRC configured, down-select from the belows:

* Alt.1: the ambiguity on LP HARQ-ACK type-1 codebook existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection is handled by gNB implementation.
* Alt.2 (QC proposal): the legacy T-DAI field is double interpreted to indicate both T-DAI of HP HARQ-ACK and LP HARQ-ACK.
* Alt.3 (CTC proposal):
  + for 1-bit LP HARQ-ACK and 1-bit HP HARQ-ACK multiplexed in PF0, CS=0, 3, 6, 9 is mapped to (HP HARQ-ACK, LP HARQ-ACK)=(NACK, NACK), (NACK, ACK), (ACK, NACK), (ACK,ACK);
  + for 1-bit LP HARQ-ACK and 1-bit HP HARQ-ACK multiplexed in PF1, (HP HARQ-ACK, LP HARQ-ACK) is QPSK modulated using .

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## Multiplexing HARQ-ACK and SR with different priorities

## Inputs from Tdocs

**Issue 2.3-1: HP SR multiplexed with LP HARQ-ACK**

**Proposals for unified solutions:**

* When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1,
* For positive SR, transmit HARQ-ACK on the SR PUCCH resource.
* For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.
* Nokia, HW, CATT, E///, OPPO, IDC, LG, Spreadtrum
* When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF2/3/4:
* Option 1:
  + For positive SR, transmit SR on the SR PUCCH resource and drop HARQ-ACK.
  + For negative SR, transmit HARQ-ACK only on the HARQ-ACK PUCCH resource.
  + Nokia, CATT, OPPO
* Option 2: Multiplexing HP SR and LP HARQ-ACK
  + Adopt separate coding to HP SR and LP HARQ-ACK on one PUCCH resource.
  + Introduce dedicated PUCCH resource sets that supports PUCCH format 2/3/4 at the second PUCCH-Config for transmitting the multiplexed SR and HARQ-ACK.
  + HW,

**Other options from companies:**

* **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, DCM, Quectel, Sharp, WILUS
  + Opt.1c: For negative SR, the UE transmits SR and HARQ-ACK on the SR resource
    - 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.
    - vivo, Pana
* Opt.3: No enhancement over Rel-16.
  + Samsung, Intel
* **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.
    - DCM, Sharp
  + Opt.1c: For negative SR, the UE transmits SR and HARQ-ACK on the SR resource
    - 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, 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).
  + vivo, Samsung, Pana, Quectel, Intel, 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.
  + 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.
    - vivo
  + 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, QC, DCM, IDC, Quectel, Sharp
* Opt.4: No enhancement over Rel-16.
  + Samsung, Pana, Intel

**Issue 2.3-2: HP SR multiplexed with LP HARQ-ACK and HP HARQ-ACK**

* **When a PUCCH carrying HP SR and HP HARQ-ACK overlaps with a PUCCH carrying LP HARQ-ACK,**
* Information bits for K HP SRs are appended to HP HARQ-ACK bits, and treat them as HP UCI;
* The number of HP UCI bits is , same as Rel-15;
* Reuse other procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource with PF 2/3/4, i.e. separate coding, PRB determination, rate matching and power control.
* If the HP HARQ-ACK is a dynamic HARQ-ACK, a PUCCH resource indicated by PRI is used for multiplexing.
* If the HP HARQ-ACK is a SPS HARQ-ACK, a PUCCH resource determined from the PUCCH resource(s) provided by sps-PUCCH-AN-List or n1PUCCH-AN is used for multiplexing.
* OPPO

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| Company | Proposals/observations from Tdocs |
| Nokia | **Proposal 3.8: When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1:**   * **For positive SR, transmit HARQ-ACK on the SR PUCCH resource.** * **For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.**   **Proposal 3.9: When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF2/3/4:**   * **For positive SR, transmit SR on the SR PUCCH resource and drop HARQ-ACK.** * **For negative SR, transmit HARQ-ACK only on the HARQ-ACK PUCCH resource.** |
| HW | ***Proposal 17: When a PUCCH carrying HP SR with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PUCCH format 0/1,***   * ***For positive SR, transmit HARQ-ACK on the SR PUCCH resource.*** * ***For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.***   ***Proposal 18: For multiplexing HP SR and LP HARQ-ACK with format 2/3/4:***   * ***Adopt separate coding to HP SR and LP HARQ-ACK on one PUCCH resource.*** * ***Introduce dedicated PUCCH resource sets that supports PUCCH format 2/3/4 at the second PUCCH-Config for transmitting the multiplexed SR and HARQ-ACK.***   ***Proposal 19: For the collision between LP HARQ-ACK, LP SR and HP UCIs, LP SR can be jointly encoded with LP HARQ-ACK and follow the same handling rule as LP HARQ-ACK only and HP UCIs. For the collision between HP HARQ-ACK, HP SR and LP UCIs, HP SR can be jointly encoded with HP HARQ-ACK and follow the same handling rule as HP HARQ-ACK only and LP UCIs.***  ***Proposal 20: For the collision between LP HARQ-ACK (and LP SR if any), LP CSI and HP UCIs, LP CSI is dropped.***  ***Proposal 21: For the collision between HP UCI and LP UCI with LP SR and/or LP CSI without LP HARQ-ACK, LP SR and/or LP CSI should be dropped.*** |
| vivo | ***Proposal 3: 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 4: 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 5: 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 6: For the overlapping of different priorities between SR and HARQ-ACK with PUCCH format 2/3/4, Rel-15 mechanism can be reused.*** |
| 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.* | |
| Samsung | **Proposal 5: Drop LP HARQ-ACK PUCCH when a LP HARQ-ACK PUCCH overlaps with a HP SR PUCCH with positive SR.**  **Proposal 8: Multiplexing HP HARQ-ACK, HP SR and LP HARQ-ACK in a same PUCCH reuses the same rule as for multiplexing 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.** |
| CATT | ***Proposal 9: 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 10: 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 11: 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.*** |
| QC | ***Proposal 10*: In NR Rel-17, if a HARQ-ACK (with single priority) transmission on PUCCH format 0 or PUCCH format 1 collide with one SR, the UE performs the actions in Table 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**  |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | Ack: PF0, LP | Ack: PF1, LP | Ack: PF0, HP | Ack: PF1, HP | | SR: PF 0, LP | Same as Rel-15 (i.e., multiplex on HARQ-ACK resource). | Same as Rel-15 (i.e., drop SR) | Multiplex the HARQ-ACK and SR on the HARQ-ACK resource (as in Rel-15), with a power boost to the multiplexed transmission. | Same as Rel-15 (drop SR). | | SR: PF1, LP | Same as rel-15 (i.e., multiplex on HARQ-ACK resource) | Same as Rel-15 (RB selection) | Multiplex the HARQ-ACK and SR on the HARQ-ACK resource (as in Rel-15), with a power boost to the multiplexed transmission. | RB selection (as in Rel-15) but with the enhancement that, if SR is positive, the power of the PUCCH transmission follows the power of the HARQ-ACK resource. | | SR: PF0, HP | Use the SR resource to transmit multiplexed SR and HARQ-ACK, with a power boost to the multiplexed transmission. | Perform RB selection (i.e., if SR is negative, then transmit HARQ-ACK on the HARQ-ACK resource. Otherwise, transmit HARQ-ACK on the SR resource.) | Same as Rel-15 | Same as Rel-15 | | SR: PF1, HP | Perform RB selection (i.e., if SR is negative, then transmit HARQ-ACK on the HARQ-ACK resource. If SR is positive, transmit HARQ-ACK on the SR resource.) | Same as Rel-15 (i.e., RB selection). | Same as Rel-15 | Same as Rel-15 |   ***Proposal 11*: In NR Rel-17, for the case of multiplexing 1 bit SR and up to 2 bits HARQ-ACK with different priorities in a PUCCH format 0, adopt the multiplexed payload to CS indices mapping as shown in Fig 9 and Fig 10.**  ***Proposal 12*: In NR Rel-17, if a HARQ-ACK transmission on PUCCH format 2/3/4 collide with K SR transmissions including HP SRs and LP SRs, the UE append bits to the HARQ-ACK payload. Furthermore, if any of the HP SR is positive, thebits shall indicate a positive HP SR.** |
| E/// | [Proposal 10 When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1, for positive SR, transmit HARQ-ACK on the SR PUCCH resource.](#_Toc92834004)  [Proposal 11 When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1, for negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.](#_Toc92834005) |
| OPPO | ***Proposal 9: When a PUCCH carrying HP SR only with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1,***   * ***For positive SR, transmit HARQ-ACK on the SR PUCCH resource.*** * ***For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.***   ***Proposal 10: When a PUCCH carrying HP SR only with PF 0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF 2/3/4,***   * ***For positive SR, transmit HP SR on the SR PUCCH resource.*** * ***For negative SR, transmit LP HARQ-ACK on the HARQ-ACK PUCCH resource.***   ***Proposal 11: When a PUCCH carrying HP SR and HP HARQ-ACK overlaps with a PUCCH carrying LP HARQ-ACK,***   * ***Information bits for K HP SRs are appended to HP HARQ-ACK bits, and treat them as HP UCI;*** * ***The number of HP UCI bits is , same as Rel-15;*** * ***Reuse other procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource with PF 2/3/4, i.e. separate coding, PRB determination, rate matching and power control.***   ***Proposal 12: When a PUCCH carrying HP dynamic HARQ-ACK and HP SR overlaps with a PUCCH carrying LP HARQ-ACK, a PUCCH resource indicated by PRI is used for multiplexing.***  ***Proposal 13: When a PUCCH carrying HP SPS HARQ-ACK and HP SR, if any, overlaps with a PUCCH carrying LP HARQ-ACK, a PUCCH resource determined from the PUCCH resource(s) provided by sps-PUCCH-AN-List or n1PUCCH-AN is used for multiplexing.*** |
| DCM | **Proposal 5:**   * *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. | | |
| 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.** |
| IDC | ***Proposal 4: 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 5: 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 6: 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.*** |
| Intel | **Proposal 9: For collision between LP HARQ-ACK and HP SR with PUCCH format 0/1, LP HARQ-ACK is dropped.** |
| Quectel | **Proposal 13**: 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 14**: 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 15**: 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. |
| LG | **Proposal #10: Apply 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.**   + **On HP SR PF0, two CS values as m0 + {0, 6} or four CS values as m0 + {0, 3, 6, 9} is used for mapping of 1-bit or 2-bit LP HARQ-ACK respectively, where m0 is the CS value configured for SR only transmission in Rel-16.**   + **On HP SR PF1, BPSK or QPSK modulation is applied for LP HARQ-ACK of 1-bit or 2-bit respectively.** * **For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.** |
| Spreadtrum | 1. ***Support proposal 2.6***   ***When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1,***   * ***For positive SR, transmit HARQ-ACK on the SR PUCCH resource.*** * ***For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.***   ***Note: It was agreed to support multiplexing a LP HARQ-ACK and a HP SR into a PUCCH for some HARQ-ACK/SR PF combinations in Rel-17.*** |
| CTC | **Proposal 3: Resource selection is adopted in Rel-17 when a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1:**   * **When HP SR is positive, SR resource is used for the transmission.**   + **If SR resource corresponds to PF0, positive HP SR and LP HARQ-ACK are multiplexed using the cyclic shift values the same as in Rel-15.**   + **If SR resource corresponds to PF1, HARQ-ACK is transmitted on the SR resource to indicate the positive SR.** * **When HP SR is negative, the UE transmits only LP HARQ-ACK on the HARQ-ACK resource.** |
| Sharp | **Proposal 1: A LP HARQ-ACK with up to 2 bits is transmitted on a LP HARQ-ACK PUCCH resource with PF0/1 as scheduled in case of negative HP SR only.**  **Proposal 2: For overlapping of a HP SR PUCCH with a positive HP SR using PF1 and a PUCCH with LP HARQ-ACK using PF0/1, report LP HARQ-ACK on the HP SR PUCCH resource using PF1.**  **Proposal 3: For overlapping of a HP SR PUCCH with a positive HP SR using PF0 and a PUCCH with LP HARQ-ACK using PF0/1, report LP HARQ-ACK on the HP SR PUCCH resource if multiple CS values are configured.**  **Proposal 4: For overlapping between HP SR PUCCH(s) and a LP PUCCH for HARQ-ACK with PF 2/3/4, HP SR bits are generated and reported together with LP HARQ-ACK on the LP HARQ-ACK PUCCH resource.**  **Proposal 5: For multiplexing of HP HARQ-ACK, LP HARQ-ACK and SR, a HP PUCCH resource with PF 2/3/4 is used with multiplexing order of HARQ-ACK + HP SR + LP HARQ-ACK.** |
| Leno/Moto | **Proposal 1: Support multiplexing of HP SR (i.e. SR with a PUCCH resource of priority index 1) with LP HARQ-ACK in a PUCCH of priority index 1.**  **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 PUCCH resource of priority index 1 for the LP HARQ-ACK, and apply Rel-15 SR/HARQ-ACK multiplexing rules based on the determined PUCCH resource of priority index 1.**  **Proposal 5: Support multiplexing of HP SR bits in a PUSCH of priority index 0, where the HP SR bits and HP HARQ-ACK bits (if any) are jointly encoded.** |
| WILUS | * ***Proposal 5:*** *We propose to support Option 2b for multiplexing 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 6:*** *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

Proposal for 1st round discussion:

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

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

Note: It was agreed to support multiplexing a LP HARQ-ACK and a HP SR into a PUCCH for some HARQ-ACK/SR PF combinations in Rel-17.

* Support : Nokia/NSB, Huawei/Hisi, Sony, InterDigital, Sharp, Panasonic, DOCOMO, QC, New H3C, ITRI, NEC, ZTE, CATT, vivo (can accept), Quectel, CTC, E///, OPPO
* Not support: Samsung, Intel

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| Company | Comments |
| Nokia/NSB | Support the FL proposal. |
| Huawei/Hisi | Support.  Specifically, if the HP SR is PF0, and if HP SR is positive:   * 1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using {CS 0, CS 6} representing {NACK, ACK} respectively; * 2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using {CS 0, CS 3, CS 6, CS 9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.   If the HP SR is PF1, and if the HP SR is positive, the 1 bit LP HARQ-ACK can be transmitted on the same SR resource with BPSK, while 2 bits LP HARQ-ACK can be transmitted with QPSK |
| Sony | Support the proposal. |
| InterDigital | Support. |
| Sharp | Support the proposal.  This assumes that multiple CS resources can be reserved for a PF0 PUCCH resources for HP SR, in order to multiplex the LP HARQ-ACK. |
| Panasonic | We can accept the proposal of unified solution for progress. However, when a PUCCH carrying HP SR with PF0 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1, for positive SR, HARQ-ACK is transmitted on the SR PUCCH resource. However, SR PUCCH resource has only 1 cyclic shift. How to transmit ACK and NACK on SR PUCCH resource should be clarified. |
| DOCOMO | Support |
| Spreadtrum | Support. |
| Samsung | Not support.  The solution is not clear for positive SR.  For SR PF 0, it is not supported in Rel-15/16 to multiplex HARQ-ACK in the SR resource. How to transmit HARQ-ACK on the SR PF0 is not clear.  For SR PF 1, if there is already multiplexed with HP HARQ-ACK (for an overlapping HP HARQ-ACK PF1, HP HARQ-ACK will be multiplexed in the HP SR PF1), LP HARQ-ACK may not be multiplexed in the SR resource if the total payload of HP and LP HARQ-ACK is larger than 2. The details on this case are not clear.  In addition, if the proposal is supported, when a LP HARQ-ACK overlaps with both positive SR PF0 and positive SR PF1, how to handle the case needs further discussion. We don’t have such case in Rel-15/16.  Finally, this is not a typical case, it requires several conditions satisfied at the same time (positive SR and A/N with PF 0/1). The consequece of “no support” is marginal (smaller than typical UCI errors). PDSCH/HARQ-ACK retransmission can also solve the issue. |
| QC | Support the proposal. |
| New H3C | Support |
| ITRI | Support. |
| NEC | Support the proposal. |
| ZTE | Support. The detailed explanation from Huawei aligns the legacy way in current specification. |
| CATT | Support the proposal and agree with the details provided by Huawei. |
| Intel | No.  In our understanding, it is very important to avoid HP UCI performance degradation caused by multiplexing with LP UCI. For HP SR with PF0, it is unclear to us, how to determine a proper CS for HARQ-ACK+SR to ensure HP SR performance is well-protected, e.g., no worse than the case without LP HARQ-ACK.  And also, though HP SR resource would be quite frequent, but the probability of positive SR is low, and the probability of positive HP SR with PF 0/1 overlapping with LP HARQ-ACK with PF 0/1 is futher reduced, as also pointed out by Samsung. Therefore, we think dropping LP HARQ-ACK in such rare case should be acceptable.  Furthermore, a unified solution for all LP PUCCH format (0/1/2/3/4) is also desirable to keep reasonable standard effort in this late stage. |
| vivo | It is not our first preference, but we can accept the proposal for progress. |
| Quectel | Support |
| CTC | Support. The details for how to transmit HARQ-ACK on the SR PUCCH resource is FFS. |
| Ericsson | Support |
| OPPO | Support |
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Proposal for 1st round discussion:

When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF2/3/4:

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

Note: It was agreed to support multiplexing a LP HARQ-ACK and a HP SR into a PUCCH for some HARQ-ACK/SR PF combinations in Rel-17.

* Support : Nokia/NSB, Huawei/Hisi (can accept), InterDigital, Panasonic, DOCOMO, Spreadtrum, Samsung, New H3C, ITRI, ZTE (can accept), CATT, Intel, Quectel, E///, OPPO
* Not support : QC

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| Company | Comments |
| Nokia/NSB | Support the proposal. |
| Huawei/Hisi | It is not our first preference, but we are fine with the proposal. |
| InterDigital | Support. |
| Panasonic | We are fine with the proposal. |
| DOCOMO | Support |
| Spreadtrum | Support. |
| Samsung | Support in principle.  We assume the proposal is for two overlapping channels, for more than two overlapping channels, further discussion is necessary. We suggest the following update.  For two overlapping channels, when a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF2/3/4:   * For positive SR, transmit SR on the SR PUCCH resource and drop HARQ-ACK. * For negative SR, transmit HARQ-ACK only on the HARQ-ACK PUCCH resource.   Note: It was agreed to support multiplexing a LP HARQ-ACK and a HP SR into a PUCCH for some HARQ-ACK/SR PF combinations in Rel-17. |
| QC | Don’t support. This proposal seems a Rel-16 prioritization type of proposal. We could multiplex SR with HARQ-ACK, following Rel-15 approach by simply append SR to the end of HARQ-ACK bits.  Please note that here LP HARQ-ACK codebook size is relatively large as it is in PF2/3/4. Dropping a large number of HAQR-ACK bits just because 1 bit HP SR might not be well justified.  With above, we suggest consider the following alternative which following Rel-15 principle.  ***Proposal*: 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.** |
| New H3C | Support |
| ITRI | Support. |
| ZTE | We can accept the proposal if majority companies support. Alternative is following the Rel-15 multiplexing principle if SR is positive. |
| CATT | Support the proposal. |
| Intel | Support the proposal. |
| Quectel | Support |
| Ericsson | Support |
| OPPO | Support |
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Proposal for 1st round discussion:

When a PUCCH carrying HP SR and HP HARQ-ACK overlaps with a PUCCH carrying LP HARQ-ACK, information bits for K HP SRs are appended to HP HARQ-ACK bits, and treat them as HP UCI, where K (K≥1) PUCCHs semi-statically configured for K HP SRs overlap with the original PUCCH carrying the HP HARQ-ACK.

* The number of HP UCI bits is , same as Rel-15;
* Reuse other procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource with PF 2/3/4, i.e. separate coding, PRB determination, rate matching and power control.
* If the HP HARQ-ACK is a dynamic HARQ-ACK, a PUCCH resource indicated by PRI is used for multiplexing.
* If the HP HARQ-ACK is a SPS HARQ-ACK, a PUCCH resource determined from the PUCCH resource(s) provided by sps-PUCCH-AN-List or n1PUCCH-AN is used for multiplexing.
* Support: Nokia/NSB, Huawei/Hisi, Sony, InterDigital, Panasonic, DOCOMO, QC, New H3C, ITRI, NEC, ZTE, CATT, Quectel, E///, OPPO
* Not support PUCCH format 2: Sumsung, Intel

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| Company | Comments |
| Nokia/NSB | Support the proposal.  This proposal seems essentially just a clarification on the handling agreed with Steps 1 and 2. |
| Huawei/Hisi | We support the principle. One suggestion for description:  For the last three bullets, we think it is simple to summarize them as “Adopt the same rule as the handling of multiplexing the LP HARQ-ACK and HP HARQ-ACK on PUCCH resource with PF [2]/3/4, including separate coding, PRB determination, PUCCH resource determination, rate matching and power control, where the HP HARQ-ACK is replaced with the HP UCI” |
| Sony | Support the proposal.  Good to have a general behaviour for HP UCI + LP HARQ-ACK. |
| InterDigital | Support. |
| Panasonic | We are fine with the proposal. |
| DOCOMO | Support |
| Samsung | Not support.  The proposal is not clear and considers only PF 2/3/4 but PF2 is not supported yet. PF0/1 should also be considered.  If the intention is to reuse the same rules for multiplexing HP HARQ-ACK and LP HARQ-ACK, we suggest the following proposal  **Proposal**:  Multiplexing HP HARQ-ACK, HP SR and LP HARQ-ACK in a same PUCCH reuses the same rule as for multiplexing 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, PUCCH power control, rate matching and RE mapping. |
| QC | Fine with the proposal |
| New H3C | Support |
| ITRI | Support. |
| NEC | Support |
| ZTE | Fine with the proposal. This case is a common case, and the solution reuses the legacy way as much as possible. |
| CATT | Support the proposal. |
| Intel | We’re fine with the proposal, if format 2 is removed.  We want to clarify one scenario for HP PUCCH with PF 0/1. In Rel-15/16, for same priority, if multiple SR PUCCH overlaps with HARQ-ACK with 1 or 2 bits, UE determines HP PUCCH containing HARQ-ACK with only one HP SR. Then, for intra-UE multiplexing, if the resultant HP PUCCH overlaps with a LP PUCCH, do we assume multiple HP SR or single HP SR is transmitted together with LP and HP HARQ-ACK? If multiple HP SR is assumed, which HP PUCCH resource is used as input for step 2.1, the HP PUCCH resource with single HP SR, or any other HP PUCCH resource? |
| Quectel | Support. |
| Ericsson | Support in principle  Agree with Intel point that the multi-bit SR attachment should be limited to HP HARQ-ACK with PF 2/3/4 |
| OPPO | Support |
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## 2nd round discussion

Proposal for 1st round discussion:

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

* For positive SR, transmit HARQ-ACK on the SR PUCCH resource.
* For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.
* If the HP SR is PF0 and HP SR is positive,
  + 1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using {CS 0, CS 6} representing {NACK, ACK} respectively;
  + 2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using {CS 0, CS 3, CS 6, CS 9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.

Note: It was agreed to support multiplexing a LP HARQ-ACK and a HP SR into a PUCCH for some HARQ-ACK/SR PF combinations in Rel-17.

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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.*

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, 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.*

*Note: Apple raised concern on CSI being dropped unnecessarily which could cause performance and degrade usefulness of URLLC enhancement.*

## Remaining issues on coding and resource determination

## Inputs from Tdocs

**Issue 3.2-1: Remaining combinations of HP/LP HARQ-ACK + CSI on PUSCH:**

* If HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI including two parts would be transmitted on HP PUSCH,
  + Option 1: 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.
    - Nokia, HW, CATT, QC, E///, OPPO, DCM, Intel, Quectel, Spreadtrum, ETRI
  + 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.
    - ZTE, Samsung, LG
  + Option 3: LP HARQ-ACK is jointly encoded with CSI part 1 or CSI part 2.
    - vivo, Apple
  + Proposed conclusion by Samsung in case of no consensus: It is not supported to multiplex a LP HARQ-ACK in a HP PUSCH with HP HARQ-ACK, HP CSI Part 1 and HP CSI Part 2 in Rel-17.
* If HP HARQ-ACK, LP HARQ-ACK, and LP A-CSI including two parts would be transmitted on HP PUSCH, the LP A-CSI is dropped. (Not supported according to previous agreement)
  + - ZTE,
* If HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI including two parts would be transmitted on LP PUSCH, follow the same multiplexing principle in the scenario where HP HARQ-ACK, LP HARQ-ACK, and HP CSI consisting of two parts are transmitted on HP PUSCH. (Not supported according to previous agreement)
  + - ZTE,
* 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.
  + - Quectel

**Issue 3.2-2: PUSCH not conveying UL-SCH**

* If HP HARQ-ACK, LP HARQ-ACK, and HP/LP CSI 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.
  + - ZTE, CATT

**Issue 3.2-3: Single-part LP CSI:**

* If HP HARQ-ACK, LP HARQ-ACK, and HP CSI including a single part would be transmitted on HP PUSCH,
  + Reuse Rel-15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK.
  + Reuse Rel-15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK.
  + Reuse Rel-15 CSI part 2 rate matching and RE mapping for the single part of LP CSI.
  + LG, ETRI
* If HP HARQ-ACK, LP HARQ-ACK, and LP CSI including a single part would be transmitted on LP PUSCH,
  + Reuse Rel-15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK.
  + Reuse Rel-15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK.
  + For CSI:
    - Option 1: Reuse Rel-15 CSI part 2 rate matching and RE mapping for the single part of LP CSI.
      * Nokia, CATT, Intel, Quectel, LG, Spreadtrum, ETRI
    - Option 2: Drop the single part of LP CSI.
      * H3C

**Issue 3.2-4: Single-priority HARQ-ACK multiplexed with PUSCH**

* If HP HARQ-ACK without LP HARQ-ACK would be transmitted on LP PUSCH, HP HARQ-ACK should be multiplexed on the LP PUSCH by reusing the encoding chain for the legacy HARQ-ACK. It applies to the LP PUSCH with/without UL-SCH.
* If LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH, LP HARQ-ACK should be multiplexed on the HP PUSCH by reusing the encoding chain for the legacy HARQ-ACK. It applies to the HP PUSCH with/without UL-SCH.
  + - HW, Quectel

**Issue 3.2-5: LP CSI only**

* For the scenarios where a high-priority PUSCH overlaps with a PUCCH carrying low-priority CSI, the low-priority CSI is always dropped. (Not supported according to previous agreement)
  + - Nokia, HW

**Issue 3.2-6: The problem of ambiguous LP HARQ-ACK payload size**

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.

* + HW, ZTE, Samsung

RE reservation is performed based on the beta-offset value configured for LP HARQ-ACK on the PUSCH when there is no HP HARQ-ACK on the PUSCH and *UCI-MuxWithDifferentPriority* is configured.

* + Quectel

**Issue 3.2-7: Power control:**

* 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
* Update the transmission power allocation order for Rel-17 by considering inter-priority UCI-on-PUSCH cases:
  + LP PUSCH with HP HARQ-ACK should be of the same priority as HP PUSCH with HP HARQ-ACK, i.e., higher than HP PUSCH with CSI, as well as HP PUSCH only.
  + LP HARQ-ACK on HP PUSCH should of the same priority as HP PUSCH only, i.e., lower than HP PUSCH with HP HARQ-ACK, as well as HP PUSCH with CSI.
  + HW
* 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 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
* 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.
  + DCM

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| Company | Proposals/observations from Tdocs |
| H3C | **Proposal 4: For multiplexing HP HARQ-ACK, LP HARQ-ACK, and LP CSI in one PUSCH, if LP CSI consists of single part, the LP CSI is dropped; R15 HARQ-ACK rate matching/puncturing and RE mapping is reused for HP HARQ-ACK in principle and R15 CSI rate matching and RE mapping is reused for LP HARQ-ACK.** |
| Nokia | **Proposal 3.13: For multiplexing high-priority HARQ-ACK, low-priority HARQ-ACK and low-priority CSI (consisting of a single part) into a low-priority PUSCH in Rel-17,**  **• Reuse Rel-15 HARQ-ACK rate matching and RE mapping for high-priority HARQ-ACK.**  **• Reuse Rel-15 CSI part 1 rate matching and RE mapping for low-priority HARQ-ACK.**  **• Reuse Rel-15 CSI part 2 rate matching and RE mapping for the single part of low-priority CSI.**  **Proposal 3.14: For the scenarios where a high-priority PUSCH overlaps with a PUCCH carrying low-priority CSI, the low-priority CSI is always dropped.**  **Proposal 3.15: 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 3.16: For the scenario of the multiplexing of HARQ-ACK into 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 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.** |
| HW | ***Proposal 22: If HP HARQ-ACK without LP HARQ-ACK would be transmitted on LP PUSCH, HP HARQ-ACK should be multiplexed on the LP PUSCH by reusing the encoding chain for the legacy HARQ-ACK.***   * ***It applies to the LP PUSCH with/without UL-SCH.***   ***Proposal 23: If LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH, LP HARQ-ACK should be multiplexed on the HP PUSCH by reusing the encoding chain for the legacy HARQ-ACK.***   * ***It applies to the HP PUSCH with/without UL-SCH.***   ***Proposal 24: LP CSI only should be dropped when colliding with HP PUSCH .***  ***Proposal 25: 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.***   * ***If the A-CSI is of a single part, the LP HARQ-ACK can be multiplexed on the HP PUSCH by reusing the legacy CSI part 2 encoding chain.*** * ***It applies to the HP PUSCH with/without UL-SCH.***   ***Proposal 26: 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.***   ***Proposal 27: UE does not expect the overlapping between HP PUSCH and LP HARQ-ACK subject to Type 3 codebook/enh. Type 3 codebook/one shot retransmission.***  ***Proposal 28: Update the transmission power allocation order for Rel-17 by considering inter-priority UCI-on-PUSCH cases:***   * ***LP PUSCH with HP HARQ-ACK should be of the same priority as HP PUSCH with HP HARQ-ACK, i.e., higher than HP PUSCH with CSI, as well as HP PUSCH only.*** * ***LP HARQ-ACK on HP PUSCH should of the same priority as HP PUSCH only, i.e., lower than HP PUSCH with HP HARQ-ACK, as well as HP PUSCH with CSI.*** |
| vivo | ***Proposal 9: 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.*** |
| ZTE | ***Proposal 10:*** *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 11:*** *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 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 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 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 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 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 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/LP CSI consisting of two parts would be transmitted on HP/LP PUSCH not conveying UL-SCH, UE follows the same behaviour as that in case of PUSCH conveying UL-SCH.* |
| Samsung | **Proposal 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.**   **Proposal 20: For multiplexing LP/HP HARQ-ACK and CSI in a HP PUSCH, LP HARQ-ACK is treated as CSI part 1, CSI part 1 is treated as CSI part 2, and CSI part 2, if any, is dropped.**  **Proposal 21: 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 22: 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.**   * **FFS: LP DG PUSCH > HP CG PUSCH**   **Proposal 23: 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.** |
| CATT | ***Proposal 14: For multiplexing HP HARQ-ACK, LP HARQ-ACK and HP A/SP-CSI on PUSCH with UL-SCH, LP HARQ-ACK can be dropped in case the HP A/SP-CSI includes two parts.***  ***Proposal 15: For multiplexing HP HARQ-ACK, LP HARQ-ACK and HP/LP CSI including one part on PUSCH with UL-SCH,***   * ***Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK.*** * ***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 HP/LP CSI.***   ***Proposal 16: For multiplexing HP HARQ-ACK or LP HARQ-ACK, and HP/LP CSI (if any) on PUSCH with UL-SCH,***   * ***Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK or LP HARQ-ACK.*** * ***Reuse R15 CSI part 1 rate matching and RE mapping for HP/LP CSI part 1.*** * ***Reuse R15 CSI part 2 rate matching and RE mapping for HP/LP CSI part 2.***   ***Proposal 17: For multiplexing any combination of HP HARQ-ACK, LP HARQ-ACK, and HP/LP CSI on PUSCH without UL-SCH, reuses the same UCI mapping rule as multiplexing in PUSCH with UL-SCH.*** |
| QC | ***Proposal 14*: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP/LP PUSCH without CSI, 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 15*: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH (either HP or LP) 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.**    + QC **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 16*: 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.** |
| E/// | [Proposal 12 When an LP HARQ-ACK overlaps with a HP PUSCH, and the HP PUSCH contains HP HARQ-ACK and HP CSI, then: the HP PUSCH is transmitted as is, the LP HARQ-ACK is dropped.](#_Toc92834006) |
| OPPO | ***Proposal 16: For multiplexing HP HARQ-ACK and LP HARQ-ACK into a PUSCH, if HP HARQ-ACK, LP HARQ-ACK and HP A-CSI would be transmitted on HP PUSCH,***   * ***LP HARQ-ACK is dropped.*** * ***Reuse R15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK in principle.*** * ***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, if any.*** |
| DCM | **Proposal 7:**   * *If HP HARQ-ACK and LP HARQ-ACK would be transmitted on HP PUSCH with HP CSI, LP HARQ-ACK is dropped.*   **Proposal 10: 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.** |
| Intel | **Proposal 10: For multiplexing a HP HARQ-ACK and LP HARQ-ACK onto a HP PUSCH with A-CSI**   * **If HP CSI consists of two parts, LP HARQ-ACK is dropped. Reuse R15 rate matching and RE mapping for HP HARQ-ACK and HP CSI.** * **If HP CSI consists of one part, reuse R15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK, Rel-15 CSI part 1 for HP CSI part 1 and Rel-15 CSI part 2 for LP HARQ-ACK.**   + **In case of insufficient number of REs, LP HARQ-ACK is dropped as legacy CSI part 2.** |
| 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.**  **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. |
| Quectel | **Proposal 6**: Multiplexing of LP HARQ-ACK in a HP PUSCH is not supported when HP A/N and HP CSI consisting of two parts simultaneously exist in the HP PUSCH.  **Proposal 7**: 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 9**: Reuse Rel-15 HARQ-ACK channel coding, rate matching/puncturing and RE mapping for LP HARQ-ACK in case LP HARQ-ACK is multiplexed on a HP PUSCH conveying UL-SCH only.  **Proposal 10**: LP HARQ-ACK uses R15 HARQ-ACK rate matching and RE mapping when there is no HP HARQ-ACK on the PUSCH and *UCI-MuxWithDifferentPriority* is configured.  **Proposal 11**: RE reservation is performed based on the beta-offset value configured for LP HARQ-ACK on the PUSCH when there is no HP HARQ-ACK on the PUSCH and *UCI-MuxWithDifferentPriority* is configured.  **Proposal 12**: for Type-1 HARQ-ACK codebook or for Type-2 HARQ-ACK codebook disables multiplexing of HARQ-ACK in PUSCH with different priorities. |
| LG | **Proposal #11: Support following four cases 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.**     - **Alternatively, whether to drop HP CSI part 2 or LP HARQ-ACK can be configurable by RRC according to gNB’s situation and scheduling policy.** * **Case 2: Overlapping of {HP HARQ-ACK, LP HARQ-ACK, HP single-part CSI} and HP PUSCH with UL SCH**   + **{HP HARQ-ACK, LP HARQ-ACK, HP single-part CSI} are all multiplexed on HP PUSCH, without UCI dropping.** * **Case 3: 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 LP PUSCH, by dropping LP CSI part 2.**     - **Note: the above Case 3 was already agreed, but the part “dropping LP CSI part 2” was not captured yet in the specification.** * **Case 4: Overlapping of {HP HARQ-ACK, LP HARQ-ACK, LP single-part CSI} and LP PUSCH with UL SCH**   + **{HP HARQ-ACK, LP HARQ-ACK, LP single-part CSI} are all multiplexed on LP PUSCH, without UCI dropping.**   **Proposal #12: 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 on LP PUSCH as well as HP PUSCH, even in case when there is no HP HARQ-ACK from UE perspective.**   **Proposal #13: Consider to handle the case where the required number of REs for HP HARQ-ACK mapping exceeds the maximum number of REs allowed for UCI mapping on LP PUSCH.**  **Proposal #14: Support following four cases for the multiplexing of CG-UCI and HARQ-ACK on CG PUSCH.**   * **Case 1: {HP CG-UCI, HP HARQ-ACK, LP HARQ-ACK} on HP CG PUSCH**   + **HP CG-UCI and HP HARQ-ACK are jointly encoded, and LP HARQ-ACK is separately encoded from the jointly-encoded HP UCIs.** * **Case 2: {HP CG-UCI, LP HARQ-ACK} on HP CG PUSCH**   + **HP CG-UCI and LP HARQ-ACK are separately encoded.** * **Case 3: {HP HARQ-ACK, LP CG-UCI, LP HARQ-ACK} on LP CG PUSCH**   + **LP CG-UCI and LP HARQ-ACK are jointly encoded, and HP HARQ-ACK is separately encoded from the jointly-encoded LP UCIs.** * **Case 4: {HP HARQ-ACK, LP CG-UCI} on LP CG PUSCH**   + **HP HARQ-ACK and LP CG-UCI are separately encoded.** |
| Spreadtrum | 1. ***For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of single part would be transmitted on LP PUSCH conveying UL-SCH,***  * ***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. ***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 one/two parts would be transmitted on HP PUSCH w/o 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.*** |
| ETRI | **Proposal 10: The scheduling UL-DCI has an additional field whether or not to allow multiplex HP UCI and LP UCI**  **Proposal 11: UCI into a PUSCH with different priorities can be applied to any type, provided that the number of encoding chains kept not increased.**  **Proposal 12: Introduce an additional field in CG-UCI to indicate whether or not to multiplex HP UCI and LP UCI.**  **Proposal 13: For HARQ-ACK codebook construction, sub-slot based HARQ-ACK codebooks are concatenated, and may be transmitted for PUSCH repetition.**  **Proposal 14: LP CSI is rate matched and mapped as Rel-15 CSI part2 when HARQ and CSI reports are multiplexed onto PUSCH.**  **Proposal 15: The LP HARQ can be dropped from PUSCH in the combination HP HARQ + LP HARQ + HP CSI of two parts.**  **Proposal 16: The LP HARQ may not be not dropped from PUSCH in the combination HP HARQ + LP HARQ + HP CSI of one part.**  **Proposal 17: The UL-SCH may not affect the UCI dropping from PUSCH in the combination HP HARQ + LP HARQ + HP CSI**  **Proposal 18: If HP UCI is included in LP PUSCH, the ULCI may not cancel the PUSCH transmission.** |
| Leno/Moto | **Proposal 3: If UE would transmit HP UCI and LP UCI in overlapping PUSCH(s) and PUCCH(s) of different priorities or in overlapping PUSCHs of different priorities after resolving overlapping PUCCHs and/or PUSCHs with priority index 1,** **a PUSCH to multiplex the HP UCI and the LP UCI is selected from**   * **HP PUSCH(s) if the PUSCH(s) includes at least one HP PUSCH,** * **LP PUSCH(s) if the PUSCH(s) only includes LP PUSCH(s).**   **The PUSCH to multiplex the HP UCI and the LP UCI is selected from multiple HP PUSCHs (or from multiple LP PUSCHs) according to Rel-15 PUSCH selection rules.**  **Proposal 4: If UE is provided *cg-UCI-Multiplexing* and multiplexes HARQ-ACK of different priorities in a CG PUSCH, CG-UCI is jointly encoded with HP HARQ-ACK for the CG PUSCH of priority index 1, and CG-UCI is jointly encoded with LP HARQ-ACK for the CG PUSCH of priority index 0.** |
| Lenovo/Moto | **Proposal 6: If a UE would transmit HP CSI on a PUSCH of priority index 1 determined for multiplexing UCI of different priorities, the UE multiplexes HP CSI with UCI of different priorities by performing first encoding with HP HARQ-ACK, second encoding with HP CSI-part1, and third encoding jointly with HP CSI-part2 and LP HARQ-ACK.** |
| ITRI | **Proposal 6:**  The HP UCI should only be multiplexed on a single set of LP PUSCH resource even if the LP PUSCH is configured with frequency hoping. |
| WILUS | * ***Proposal 7:*** *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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## 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 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.
* Support: Nokia/NSB, Huawei/Hisi, Sony, InterDigital, Sharp, Panasonic, DOCOMO, Spreadtrum, QC, New H3C, ITRI, NEC, ZTE, CATT, Intel, vivo, Quectel, OPPO
* Improve the wording: Samsung

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| Company | Comments |
| Nokia/NSB | Support the FL proposal. |
| Huawei/Hisi | Support. |
| Sony | Support the proposal. |
| InterDigital | Support. |
| Sharp | Support |
| Panasonic | We are fine with the proposal. |
| DOCOMO | Support |
| Spreadtrum | Support. |
| Samsung | The proposal is not clear. The main bullet says “multiplexing” but the solution is prioritization. For the FFS, we are not clear about the remaining issues.  If the intention is drop LP HARQ-ACK, we would like to suggest the following  Proposal:  For resolving the two overlapping channels in Rel-17, when a LP HARQ-ACK PUCCH overlaps with a HP PUSCH with HP HARQ-ACK and HP A-CSI consisting of two parts, the LP HARQ-ACK PUCCH is dropped. |
| QC | Support |
| New H3C | Support |
| ITRI | Support. |
| NEC | Support. |
| ZTE | For sake of progress, we can compromise to this proposal. Actually, if the proposal is adopted, no specification effort is needed, it is legacy Rel-16 behavior. |
| CATT | Support the proposal. |
| Intel | Support the proposal. |
| vivo | Same view with ZTE. |
| Quectel | Support. |
| OPPO | Support |
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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/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.

* Support: Huawei/Hisi, Sony, InterDigital, Panasonic, DOCOMO, Spreadtrum, QC, New H3C, ITRI, NEC, ZTE, CATT, Intel, vivo, Quectel, OPPO
* Not support: Nokia/NSB (Separate proposals for scenarios)

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| Company | Comments |
| Nokia/NSB | Do not support the proposal as it is.  We agree with the intention that UE should follow the same behaviour for PUSCH conveying UL-SCH and PUSCH not conveying UL-SCH. However, we prefer to discuss HP PUSCH and LP PUSCH separately because we do not see the necessity to support multiplexing LP CSI on HP PUSCH. In addition, in case with LP PUSCH, where the HP CSI comes? Suggested modification:  “For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a low-priority (LP) 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.  For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a high-priority (HP) 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.” |
| Huawei/Hisi | Support. The same rule can simply be applied to PUSCH without UL-SCH since the encoding chain number for UCI-on-PUSCH is the same. |
| Sony | Support the principle. We agree to separate the HP CSI and LP CSI into separate proposals as per Nokia’s suggestion. |
| InterDigital | Support and fine with Nokia’s revision. |
| Panasonic | We are fine with the proposal. |
| DOCOMO | Support the Nokia’s revision. |
| Spreadtrum | Support. Also fine with Nokia’s version. |
| Samsung | Support for LP PUSCH, for HP PUSCH, the issue can be covered in our suggested proposal. |
| QC | Support FL proposal in principle and OK with Nokia’s revision. |
| New H3C | Support either of FL proposal or Nokia’s revision. |
| ITRI | Support Nokia’s version. |
| NEC | Support and fine with Nokia’s revision. |
| ZTE | Support. Also agree with Nokia’s revision as the case of CSI multiplexing with different priority of PUSCH doesn’t make sense. |
| CATT | Support the proposal in principle and agree with Nokia’s revision as CSI of a given priority is not expected to be multiplexed in a PUSCH of a different priority. |
| Intel | We support Nokia’s version. |
| vivo | Support in principle and are fine with Nokia’s revision. |
| Quectel | Fine with Nokia’s revision. |
| OPPO | Fine with Nokia’s version |
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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 CSI including a single part would be transmitted on PUSCH,
    - Reuse Rel-15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK.
    - Reuse Rel-15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK.
    - Reuse Rel-15 CSI part 2 rate matching and RE mapping for the single part of LP CSI.
    - Companies suggested to separate proposals. So the proposal will be discussed in the 2nd round.

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| Company | Comments |
| Nokia/NSB | Support in principle, but it only applies to LP PUSCH.  Suggested modification:  “For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a low-priority (LP) PUSCH in R17,   * + If HP HARQ-ACK, LP HARQ-ACK, and CSI including a single part would be transmitted on low-priority (LP) PUSCH,     - Reuse Rel-15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK.     - Reuse Rel-15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK.     - Reuse Rel-15 CSI part 2 rate matching and RE mapping for the single part of LP CSI.” |
| Huawei/Hisi | We are a bit confused with the intention of the proposal since the main bullet says CSI without mentioning the specific priority type, while the third subbullet specifically says LP CSI (as raised by Nokia); that means, for the case of HP HARQ-ACK, LP HARQ-ACK on HP PUSCH with (HP) A-CSI, the description is missed.  In our understanding, the spirit of designing the HP channel and LP channel prioritization/multiplexing is that any HP channel/signal, regardless of it is PUCCH/PUSCH, and regardless the UCI type it includes, should be absolutely higher than any LP channel/signal. E.g., if the gNB schedules the HP PUSCH with (HP) A-CSI of single part, it is still with higher priority than LP HARQ-ACK for the organizing of the encoder chain.  Therefore, the suggested modifications are:  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 including a single part would be transmitted on PUSCH,     - Reuse Rel-15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK.     - Reuse Rel-15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK.     - Reuse Rel-15 CSI part 2 rate matching and RE mapping for the single part of LP CSI.   + If HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI including a single part would be transmitted on HP PUSCH,     - Reuse Rel-15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK.     - Reuse Rel-15 CSI part 1 rate matching and RE mapping for the single part of HP A-CSI.     - Reuse Rel-15 CSI part 2 rate matching and RE mapping for LP HARQ-ACK. |
| Sony | Share similar view with Nokia & Huawei. We should separate the proposals for LP and HP CSI. |
| InterDigital | Suggest having separate proposals as well. For the case of HP CSI, the modification from Huawei seems reasonable. |
| Panasonic | We are fine with the proposal in principle. Nokia’s update is fine. |
| DOCOMO | Support the proposal in principle but we also prefer to have separate proposals for LP and HP CSI. The revision by Huawei/HiSi seems reasonable. |
| Spreadtrum | Support the version from Nokia.  According to HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI including a single part, it can be discussed separately, such as postponed until we achieve the consensus of HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI including two parts. |
| Samsung | Support the proposal and prefer Nokia’s update. |
| QC | Support FL proposal in principle. We also agree with other companies that reformulating separate proposals for HP and LP PUSCH seems better. |
| New H3C | We want to clarify if only one CSI part is included or not and why there are two CSI parts for rate matching if only one CSI part. |
| ITRI | Prefer Huawei’s update. |
| NEC | Support the proposal and prefer Nokia’s update. |
| ZTE | Fine with Nokia’s update. The case of HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI including a single part can be discussed separately. |
| CATT | We support Huawei’s update. |
| Intel | We also think separate proposal for HP and LP PUSCH is needed.  For the case of HP CSI on HP PUSCH, we support the proposal from HW.  For the case of LP CSI on PUSCH, we’d like to add LP before PUSCH, on top of the proposal provided by Huawei, otherwise, it reads like LP CSI can also be multiplexed onto a HP PUSCH, which was not agreed.   * + If HP HARQ-ACK, LP HARQ-ACK, and LP CSI including a single part would be transmitted on LP PUSCH, |
| vivo | Agree with other companies that for the case of HP CSI, the modification from Huawei seems reasonable. |
| Quectel | Share similar views with companies above. Separate proposals for HP and LP PUSCH would be clearer. |
| OPPO | Fine with Huawei’s version |
|  |  |

Proposal for 1st round discussion:

* If HP HARQ-ACK without LP HARQ-ACK would be transmitted on LP PUSCH, the HP HARQ-ACK should be multiplexed on the LP PUSCH by reusing the encoding chain for the legacy HARQ-ACK.
* If LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH, the LP HARQ-ACK should be multiplexed on the HP PUSCH by reusing the encoding chain for the legacy HARQ-ACK.
  + - Companies suggested to separate proposals. So the proposal will be discussed in the 2nd round.

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| Company | Comments |
| Nokia/NSB | Not support the proposal.  In our understanding, there is no UCI specific encoding chain and it is up to UE implementation to select which encoding chain to be used. Would it make better sense to discuss the following modified proposal:”   * If HP HARQ-ACK without LP HARQ-ACK would be transmitted on LP PUSCH, the HP HARQ-ACK should be multiplexed on the LP PUSCH by reusing the rate matching and RE mapping ~~encoding chain~~ for the legacy HARQ-ACK. * If LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH, the LP HARQ-ACK should be multiplexed on the HP PUSCH by reusing the rate matching and RE mapping ~~encoding chain~~ for the legacy HARQ-ACK.” |
| Huawei/Hisi | Support in principle. Also OK with Nokia’s version. Minor changes on top of that version:   * If HP HARQ-ACK without LP HARQ-ACK would be transmitted on LP PUSCH, the HP HARQ-ACK should be multiplexed on the LP PUSCH by reusing the rate matching/puncturing and RE mapping ~~encoding chain~~ for the legacy HARQ-ACK. * If LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH, the LP HARQ-ACK should be multiplexed on the HP PUSCH by reusing the rate matching/puncturing and RE mapping ~~encoding chain~~ for the legacy HARQ-ACK.” |
| InterDigital | Fine with Nokia’s and Huawei’s revisions. |
| Panasonic | We are fine with the proposal in principle. We are fine with Nokia’s and Huawei’s modifications. |
| DOCOMO | Fine with Nokia’s and Huawei’s revisions. |
| Spreadtrum | Support the first bullet from Nokia’s version.  For the second bullet, it can be discussed separately, such as postponed until we achieve the consensus of HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI including two parts or single part. Especially, considering the handling of LP HARQ-ACK and HP A-CSI is not clear now. Like when with HP A-CSI or without HP A-CSI, LP HARQ-ACK might be treated differently, just reusing the rate matching and RE mapping for the legacy HARQ-ACK is not exact. |
| Samsung | Fine with Huawei’s update |
| QC | Fine with Huawei’s revision. |
| New H3C | Fine with HW’s revision. |
| ITRI | Fine with Huawei’s update. |
| NEC | Fine with Huawei’s update. |
| ZTE | Fine with Huawei’s update |
| CATT | Support the proposal in principle and fine with Huawei’s revision. |
| Intel | We support the proposal for LP PUSCH case provided by NOKIA and Huawei.  For HP PUSCH case, we share similar view with Spreadtrum that we can come back after we achieve consensus of HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI on HP PUSCH. |
| vivo | Fine with Huawei’s revision. |
| Quectel | Fine with the first bullet. For the second bullet, it is not clear for us how to fully reuse Rel-15 HARQ-ACK rate matching/puncturing and RE mapping given a different beta\_offset value could be configured for LP HARQ-ACK on HP PUSCH. |
| OPPO | Fine with Huawei’s version |
|  |  |

## 2nd round discussion

Proposal (for email approval):

~~For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH i~~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.

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| Supporting companies: |  |
| Objecting companies: |  |
| Company | Reason for objection |
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Proposal (for email approval):

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

* + If HP HARQ-ACK, LP HARQ-ACK, and CSI including a single part would be transmitted on low-priority (LP) PUSCH,
    - Reuse Rel-15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK.
    - Reuse Rel-15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK.
    - Reuse Rel-15 CSI part 2 rate matching and RE mapping for the single part of LP CSI.”

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| Supporting companies: |  |
| Objecting companies: |  |
| Company | Reason for objection |
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Proposal for 2nd round discussion:

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

* + If HP HARQ-ACK, LP HARQ-ACK, and HP A-CSI including a single part would be transmitted on HP PUSCH,
    - Reuse Rel-15 HARQ-ACK rate matching/puncturing and RE mapping for HP HARQ-ACK.
    - Reuse Rel-15 CSI part 1 rate matching and RE mapping for the single part of HP A-CSI.
    - Reuse Rel-15 CSI part 2 rate matching and RE mapping for LP HARQ-ACK.

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Proposal for 2nd round discussion:

* If HP HARQ-ACK without LP HARQ-ACK would be transmitted on LP PUSCH, the HP HARQ-ACK should be multiplexed on the LP PUSCH by reusing the rate matching/puncturing and RE mapping for the legacy HARQ-ACK.
* If LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH, the LP HARQ-ACK should be multiplexed on the HP PUSCH by reusing the rate matching/puncturing and RE mapping for the legacy HARQ-ACK.”

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## Enhancements for multiplexing parameters

## Beta-offset value and configuration

#### Inputs from Tdocs

**Issue 3.3-1: Support Beta-offset =0?**

* Yes
  + Nokia, CATT, DCM, CTC
* No
  + ZTE

**Issue 3.3-2: Details for Bete-offset values**

* Option 1: New RRC configured scaling factors can be introduced and applied on top of the set of legacy beta-offset values to generate the inter-priority beta-offset values for UCI on PUSCH
  + Scaling factor X<1 can be introduced to determine the values of smaller beta-offset including the less than 1 values for LP HARQ-ACK on HP PUSCH
  + Scaling factor Y>1 can be introduced to determine the values of larger beta-offset for HP HARQ-ACK on LP PUSCH
  + HW
* Opion 2: Introduce 8 new values for Table 9.3-1 in TS38.213, as shown in Table 1.

Table 1: Mapping of beta\_offset values for HARQ-ACK information and the index signalled by higher layers

|  |  |
| --- | --- |
| or |  |
| 16 | 0.8 |
| 17 | 0.64 |
| 18 | 0.5 |
| 19 | 0.4 |
| 20 | 0.32 |
| 21 | 0.25 |
| 22 | 0.2 |
| 23 | 0.1 |

* + OPPO

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Nokia | **Proposal 3.11: 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 enabling/disabling multiplexing HARQ-ACK in DG PUSCH of different priority.**  **Proposal 3.18: For the scenarios where multiplexing low-priority HARQ-ACK in high-priority PUSCH, low-priority HARQ-ACK bits are dropped (e.g., via setting beta-offset=0) in case no sufficient resource to multiplex all low-priority HARQ-ACK bits.** |
| HW | ***Proposal 29: New RRC configured scaling factors can be introduced and applied on top of the set of legacy beta-offset values to generate the inter-priority beta-offset values for UCI on PUSCH***   * ***Scaling factor X<1 can be introduced to determine the values of smaller beta-offset including the less than 1 values for LP HARQ-ACK on HP PUSCH*** * ***Scaling factor Y>1 can be introduced to determine the values of larger beta-offset for HP HARQ-ACK on LP PUSCH*** |
| vivo | ***Proposal 8: In Rel-17, the same set of beta-offset value is used for UCI multiplexing with the same priority on PUSCH.*** |
| ZTE | ***Proposal 17****: The beta\_offset should not be used to disable the intra-UE multiplexing UCI with data*.  ***Proposal 18:*** *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* |
| CATT | ***Proposal 13: A value of zero for beta-offset in a DCI can be used to indicate that LP UCI is not multiplexed on the HP PUSCH scheduled by the DCI.*** |
| DCM | **Proposal 8:**   * *Support beta-offset =0 or a value disabling the UCI multiplexing on PUSCH of different priorities* |
| 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.** |
| 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*** |
| CTC | **Proposal 2: For LP HARQ-ACK multiplexed on HP PUSCH, beta-offset =0 can be configured in the value set.** |
|  |  |

#### 1st round discussion

Proposal for 1st round discussion:

Down-select from the belows:

* + Option 1: New RRC configured scaling factors can be introduced and applied on top of the set of legacy beta-offset values to generate the inter-priority beta-offset values for UCI on PUSCH
    - Scaling factor X<1 can be introduced to determine the values of smaller beta-offset including the less than 1 values for LP HARQ-ACK on HP PUSCH
    - Scaling factor Y>1 can be introduced to determine the values of larger beta-offset for HP HARQ-ACK on LP PUSCH
    - Huawei/Hisi, Sharp, Apple
  + Option 2: Introduce 8 new values for Table 9.3-1 in TS38.213, as shown in Table 1.

Table 1: Mapping of beta\_offset values for HARQ-ACK information and the index signalled by higher layers

|  |  |
| --- | --- |
| or |  |
| 16 | 0.8 |
| 17 | 0.64 |
| 18 | 0.5 |
| 19 | 0.4 |
| 20 | 0.32 |
| 21 | 0.25 |
| 22 | 0.2 |
| 23 | 0.1 |

* + - Support in principle: Nokia/NSB, InterDigital, DOCOMO, Samsung, QC, New H3C, NEC, ZTE, CATT, Intel, vivo, Quectel, OPPO

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | In principle we are fine with Option 2, but we would like to discuss further about the specific number of new beta-offset and their values.  In addition, we propose to introduce the value of “0” for beta-offset for the purpose of enabling gNB to flexibly enable/disable multiplexing of low-priority HARQ-ACK on high-priority PUSCH. This is a low-hanging fruit of RAN1. In this way, the flexibility is achieved without any additional signalling overhead and the impact on specification is almost negligible. |
| Huawei/Hisi | We prefer Option 1, with the concern that the specific beta-offset values can hardly converge in a haste. By introducing the RRC parameters, the optimization can be left for gNB implementation.  As an example, the beta-offset for LP HARQ-ACK on HP PUSCH could be:    The beta-offset for HP HARQ-ACK on LP PUSCH could be:    The specific set of X and Y can refer to the ratios of HP UCI code rate to LP UCI code rate where the set of HP/LP UCI code rate is from *PUCCH-MaxCodeRate*  PUCCH-MaxCodeRate ::= ENUMERATED {zeroDot08, zeroDot15, zeroDot25, zeroDot35, zeroDot45, zeroDot60, zeroDot80} |
| InterDigital | Slight preference for Option 2. |
| Sharp | Slightly prefer Option 1 for better flexibility. |
| Apple | We prefer Option 1. |
| DOCOMO | We slightly prefer Option 2. |
| Samsung | Option 2 but it should be a new Table and should not be mixed with legacy operation.  The values can be kept FFS for now until proper discussion – the issue can be deprioritized at this meeting. |
| QC | We are OK with either option 1 or option 2.  Regarding Nokia’s proposal to adding beta\_offset = 0, we object it. Adding beta\_offset =0 is just another way to implement dynamic switch between Rel-16 multiplexing and Rel-17 prioritization, which was concluded in last RAN-P. We prefer not reopening this discussion. |
| New H3C | We slight prefer Option 2 |
| NEC | We slightly prefer Option 2. |
| ZTE | Slightly prefer a new Table but the value=0 should not be introduced. As we have precluded the capability 3 with dynamic indication of enabling/disabling, the indication of beta-offset = 0 to disable the multiplexing is a dynamic solution which means it will revert the endorsed proposal made in RAN plenary. |
| CATT | We share the same view as Nokia. |
| Intel | We slightly prefer Option 2. |
| vivo | We slightly prefer Option 2 |
| Quectel | We slightly prefer Option 2. |
| OPPO | Option 2 |
|  |  |

#### 2nd round discussion

Proposal for 2nd round discussion:

Define a new table for beta-offset values <1.

* + FFS for the values with the starting point as below.

|  |
| --- |
|  |
| [0.8] |
| [0.64] |
| [0.5] |
| [0.4] |
| [0.32] |
| [0.25] |
| [0.2] |
| [0.1] |

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| Company | Comments |
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## Separate configurations of alpha values?

#### Inputs from Tdocs

* Yes
  + LG, Quectel
  + 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 3.12: For the scenarios of multiplexing HARQ-ACK bits in a PUSCH of different priorities, do not support separate configurations of the scaling factor “alpha”.** |
| Quectel | **Proposal 8**: Separate configuration of scaling factors (“alpha”) is supported for UCI-PUSCH multiplexing with different priority combinations. |
| LG | **Proposal #15: Support separate configuration of alpha factor as well as beta offset 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.** |
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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
* Option 2: The LP UCI is compressed/bundled.
  + ZTE, Apple

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| Company | Proposals/observations from Tdocs |
| ZTE | ***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, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,*   * *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 19:*** *LP UCI compression is slightly preferred in case there is no enough resource left for LP UCI.* |
| Apple | **Proposal 11-3: For a UCI part, UCI omission/compaction is applied to the right-most UCI first among UCIs in that UCI part as in Tables 11-1 and 11-2. Before all the later-placed UCIs are omitted, an early UCI is not omitted or compacted.** |
|  |  |

# 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*

Agreement

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

Agreement

*For the overlapping between LP CG and HP DG, if MAC delivers two MAC PDUs to PHY, 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 d3 is needed (which results N2+d1+d3 in total cancellation time) for LP CG-PUSCH and HP DG-PUSCH collision resolution.*
  + *(Working assumption) d3 = {0, }symbol(s) upon UE capability report, where for SCS=15/30/60/120kHz, respectively.*

Agreement

*For collision of HP DG-PUSCH and LP CG-PUSCH, the cancellation is applied per actual repetition, if HP DG-PUSCH and/or LP CG-PUSCH is repeated.*

## Remaining issues

## Inputs from Tdocs

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 31: Confirm the working assumption about the value of d3.*** |
| ZTE | ***Proposal 21:*** *Confirm the working assumption:*  *d3 = {0, 1,…,2^(μ+1)}symbol(s) upon UE capability report, where μ=0,1,2,3 for SCS=15/30/60/120kHz, respectively.* |
| Apple | **Proposal 14: confirm the working assumption from RAN1 #107-e so that additional time d3’s value range is {0, }symbol(s) upon UE capability report, where for SCS=15/30/60/120kHz, respectively** |
| Quectel | **Proposal 16**: d3 values resulting in a same set of absolute processing time values are preferred for PHY layer prioritization when there is overlapping between LP CG and HP DG and MAC delivers two MAC PDUs to PHY. |

## 1st round discussion

Proposal for 1st round discussion:

Confirm the working assumption as:

For the overlapping between LP CG and HP DG, if MAC delivers two MAC PDUs to PHY, 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 d3 is needed (which results N2+d1+d3 in total cancellation time) for LP CG-PUSCH and HP DG-PUSCH collision resolution.
  + d3 = {0, }symbol(s) upon UE capability report, where for SCS=15/30/60/120kHz, respectively.
* All companies support. Will try email approval in the 2nd round.

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| --- | --- |
| Company | Comments |
| Nokia/NSB | Support. |
| Huawei/Hisi | Support. |
| Sony | Support |
| InterDigital | Support. |
| Sharp | Support |
| Apple | Support |
| DOCOMO | Support |
| Samsung | Support |
| QC | Support |
| New H3C | Support |
| NEC | Support |
| ZTE | Support |
| CATT | Support |
| Intel | Fine |
| vivo | Support |
| Quectel | Fine |
| Ericsson | Support |
| OPPO | Support |
|  |  |

## 2nd round discussion

Proposal (for email approval):

Confirm the working assumption as:

For the overlapping between LP CG and HP DG, if MAC delivers two MAC PDUs to PHY, 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 d3 is needed (which results N2+d1+d3 in total cancellation time) for LP CG-PUSCH and HP DG-PUSCH collision resolution.
  + d3 = {0, }symbol(s) upon UE capability report, where for SCS=15/30/60/120kHz, respectively.

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| Supporting companies: |  |
| Objecting companies: |  |
| Company | Reason for objection |
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# Spec clarification

## Inputs from Tdocs

**HW proposals:**

***Proposal 32: RAN1 should adopt the following TP to explicitly address the UE behavior of dropping LP HARQ-ACK in case the rest RE on the resultant PUCCH for LP HARQ-ACK is 0.***

|  |
| --- |
| **------------------ Text Proposal for 38.213 Clause 9.2.5.3 ------------------**  If , the UE transmits the PUCCH over the PRBs. If , the HARQ-ACK information bits of priority 0 are dropped. If a UE transmits a PUCCH that includes HARQ-ACK information bits of priority 0 and 1 using PUCCH format 1, the UE determines a power for the PUCCH transmission, as described in clause 7.2.1, assuming that all HARQ-ACK information bits have priority 1. |

***Proposal 33: RAN1 should adopt the following TP to remove the restriction of disallowing the collision between HP SPS HARQ-ACK with LP PUCCH/PUSCH.***

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| --- |
| **------------------ Text Proposal for 38.213 Section 9 ------------------**  A UE does not expect to be scheduled to transmit a PUCCH or a PUSCH with smaller priority index that would overlap in time with a PUCCH of larger priority index with HARQ-ACK information only in response to a PDSCH reception without a corresponding PDCCH unless the UE is provided *UCI-MuxWithDifferentPriority*. A UE does not expect to be scheduled to transmit a PUCCH of smaller priority index that would overlap in time with a PUSCH of larger priority index with SP-CSI report(s) without a corresponding PDCCH. |

## 1st round discussion

Proposal for 1st round discussion:

Adopt the following TP to explicitly address the UE behavior of dropping LP HARQ-ACK in case the rest RE on the resultant PUCCH for LP HARQ-ACK is 0.

|  |
| --- |
| **------------------ Text Proposal for 38.213 Clause 9.2.5.3 ------------------**  If , the UE transmits the PUCCH over the PRBs. If , the HARQ-ACK information bits of priority 0 are dropped. If a UE transmits a PUCCH that includes HARQ-ACK information bits of priority 0 and 1 using PUCCH format 1, the UE determines a power for the PUCCH transmission, as described in clause 7.2.1, assuming that all HARQ-ACK information bits have priority 1. |

* Support: Nokia/NSB, Huawei/Hisi, Sharp, DOCOMO, QC, New H3C, NEC, CATT, Quectel, OPPO
* Not support: Samsung, ZTE, vivo, Ericsson

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support in principle |
| Huawei/Hisi | Support. The specific dropping behavior is better explicitly captured, so that the behaviors of HP only and HP+LP can be clearly distinguished. |
| InterDigital | The case of coding rate higher than 1 for LP HARQ-ACK may need to be handled (not just 0 RE). |
| Sharp | Support in principle |
| DOCOMO | Support in principle |
| Samsung | Not support.  Not an essential correction, the UE procedure is clear. |
| QC | Support in principle, although this seems a very corner case.  By the way, for the case InterDigital mentioned, if I recall correct, in case LP HARQ-ACK coding rate > configured code rate, it was agreed in RAN1 107 to transmit LP HARQ-ACK follow whatever code rate it ends up with – not dropping LP HARQ-ACK. It is is different than the case where the TP is addressing. |
| New H3C | Support in principle |
| NEC | Support in principle |
| ZTE | Not sure the TP is needed, from our understanding, the agreement of previous meeting implies the LP HARQ-ACK can have sufficient resource to transmission. |
| CATT | Support in principle |
| vivo | Not support  It is corner case and can be avoided by gNB. |
| Quectel | Support in principle |
| Ericsson | Do not support. Existing procedure is clear |
| OPPO | Support |
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Proposal for 1st round discussion:

Adopt the following TP to remove the restriction of disallowing the collision between HP SPS HARQ-ACK with LP PUCCH/PUSCH.

|  |
| --- |
| **------------------ Text Proposal for 38.213 Section 9 ------------------**  A UE does not expect to be scheduled to transmit a PUCCH or a PUSCH with smaller priority index that would overlap in time with a PUCCH of larger priority index with HARQ-ACK information only in response to a PDSCH reception without a corresponding PDCCH unless the UE is provided *UCI-MuxWithDifferentPriority*. A UE does not expect to be scheduled to transmit a PUCCH of smaller priority index that would overlap in time with a PUSCH of larger priority index with SP-CSI report(s) without a corresponding PDCCH. |

* Support: Nokia/NSB, Samsung, CATT

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Fine in principle with removing the Rel-16 restriction on HP SPS HARQ-ACK collision with LP PUCCH/PUSCH. |
| Samsung | Support. |
| CATT | Support |
|  |  |

## 2nd round discussion

Proposal (for email approval):

Adopt the following TP to remove the restriction of disallowing the collision between HP SPS HARQ-ACK with LP PUCCH/PUSCH.

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| --- |
| **------------------ Text Proposal for 38.213 Section 9 ------------------**  A UE does not expect to be scheduled to transmit a PUCCH or a PUSCH with smaller priority index that would overlap in time with a PUCCH of larger priority index with HARQ-ACK information only in response to a PDSCH reception without a corresponding PDCCH unless the UE is provided *UCI-MuxWithDifferentPriority*. A UE does not expect to be scheduled to transmit a PUCCH of smaller priority index that would overlap in time with a PUSCH of larger priority index with SP-CSI report(s) without a corresponding PDCCH. |

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| --- | --- |
| Supporting companies: |  |
| Objecting companies: |  |
| Company | Reason for objection |
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# About RRC parameter table

## Inputs from Tdocs

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| H3C | **Proposal 5: Dynamic indication of simultaneous PUCCH/PUSCH transmission of different PHY priorities over different cells isn’t supported. Detail signalling design on RRC configuration should be left to RAN2.** |
| Nokia | **Proposal 4.1: Resolve some RRC parameter related issues using also GTW time, such as if some RRC parameter is needed or not (while the details of the RRC parameter can be left to email discussions).**  **Proposal 4.2: RAN1 to decide (using GTW) if separate or joint RRC configuration of ‘Multiplexing UCIs of different priorities on PUCCH or PUSCH’ in the primary and secondary PUCCH cell group is to be adopted. Nokia preference is to have separate / independent RRC configuration for the primary and secondary PUCCH cell group.**  **Proposal 4.3: Align the sub-feature group name in column B for all RRC parameters in rows 50 to 61 as ‘*Multiplexing UCIs of different priorities in a PUCCH or PUSCH*’**  **Proposal 4.4: RAN1 to decide (using GTW) if separate or joint RRC configuration of simultaneous PUCCH / PUSCH operation in the primary and secondary PUCCH cell group is to be adopted. Nokia preference is to have separate / independent RRC configuration for the primary and secondary PUCCH cell group.**  **Proposal 4.5: Do not introduce RRC parameters to enable the UE handling for overlapping CG / DG PUSCH of different priorities, i.e., do not introduce the yellow marked related RRC parameters in rows 68 and 69 from the IIoT&URLLC RRC parameter sheet from R1-2112979.** |
| Samsung | **Proposal 4: A separate RRC parameter configures enabling/disabling multiplexing of LP HARQ-ACK and HP HARQ-ACK without a PDCCH.**  **Proposal 14: A separate RRC parameter configures enabling/disabling multiplexing of LP HARQ-ACK and HP CG PUSCH.**  **Proposal 19: A separate RRC parameter configures enabling/disabling multiplexing of HP HARQ-ACK and LP CG PUSCH.** |
|  |  |

## 1st round discussion

Proposal for 1st round discussion:

Down-select from belows:

* Option 1: One RRC parameter to configure ‘Multiplexing UCIs of different priorities on PUCCH or PUSCH’ in the primary and secondary PUCCH cell group.
  + Huawei/Hisi, QC
* Option 2: Separate RRC parameters to configure ‘Multiplexing UCIs of different priorities on PUCCH or PUSCH’ in the primary and secondary PUCCH cell group.
  + Nokia/NSB, InterDigital, Sharp, DOCOMO, Samsung, NEC, ZTE, CATT, Intel, vivo, Quectel, OPPO

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support Option 2 – as explained in our Tdoc (R1-2200018). |
| Huawei/Hisi | Option 1. No strong need to introduce mirroring parameters for the secondary PUCCH cell group. |
| InterDigital | Prefer Option 2. |
| Sharp | Prefer Option 2. |
| DOCOMO | Slightly prefer Option 2. |
| Samsung | Option 2.  PUCCH CGs use separate RRC configurations. The same should apply here. No need to optimize for 1 bit RRC signaling while compromising flexibility for deploying the feature. |
| QC | Support option 1. Such a flexibility of different operation for two PUCCH groups seems not needed in real deployment. On the other hand, requiring UE to run Rel-16 prioritization for one PUCCH group and Rel-17 mux for another PUCCH group seems a big burden. |
| NEC | Slightly prefer Option 2. |
| ZTE | Support Option 2. |
| CATT | Option 2 |
| Intel | We support Option 2 |
| vivo | We slightly prefer Option 2 |
| Quectel | Fine with Option 2 |
| OPPO | Fine with Option 2 |
|  |  |

Proposal for 1st round discussion:

Down-select from belows:

* Option 1: Introduce RRC parameters to enable the UE handling for overlapping CG/DG PUSCH of different priorities, i.e., keep the yellow marked related RRC parameters in rows 68 and 69 from the IIoT&URLLC RRC parameter sheet from R1-2112979.
  + QC
* Option 2: Not to introduce RRC parameters to enable the UE handling for overlapping CG/DG PUSCH of different priorities, i.e., remove the yellow marked related RRC parameters in rows 68 and 69 from the IIoT&URLLC RRC parameter sheet from R1-2112979.
  + Nokia/NSB, DOCOMO, Intel

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support Option 2 – as explained in our Tdoc (R1-2200018). |
| DOCOMO | Support Option 2 and agree with Nokia/NSB’s analysis in R1-2200018. |
| Samsung | We should discuss the solutions directly. |
| QC | Support option 1. Like other Rel-17 intra-UE Mux features which are enabled/disable by RRC, this one should follow the same procedure. If UE should autonomous enable/disable this based on UE capability, why we need to introduce RRC for other Rel-17 intra-UE mux features? Why not let UE autonomously enable/disable tall Rel-17 intra-UE mux features based on UE capability? |
| ZTE | One question, if thereis no RRC parameters to enable the UE handling for overlapping CG/DG PUSCH of different priorities, it means the function of handling for overlapping CG/DG PUSCH is mandatory for UE? |
| Intel | We support option 2. |
|  |  |

Proposal for 1st round discussion:

A separate RRC parameter configures enabling/disabling multiplexing of LP HARQ-ACK and HP CG PUSCH.

A separate RRC parameter configures enabling/disabling multiplexing of HP HARQ-ACK and LP CG PUSCH.

* + Support: Samsung
  + Not support: Nokia/NSB, Huawei/Hisi, DOCOMO, QC, CATT, Intel, Quectel, OPPO

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Do not support.  It would be preferrable/simpler to have the same RRC parameter applicable for both CG and DG PUSCHs. |
| Huawei/Hisi | Not support. No strong motivation to see the differentiated enable/disable flags. |
| DOCOMO | Not support. Share similar views with Nokia/NSB and Huawei/HiSi. |
| Samsung | Support.  For CG PUSCHs collision of the same priority, it is up to UE to decide which CG PUSCH is transmitted, gNB needs to perform blind detection for decoding the CG PUSCH. If a HP HARQ-ACK is multiplexed in a LP CG PUSCH, the reliability of the HP HARQ-ACK may not be ensured.  If a LP HARQ-ACK is multiplexed in a HP CG PUSCH, the reliability of CG PUSCH may be affected due to LP DCI missing.  The gNB should be able to disable multiplexing on CG PUSCH. |
| QC | Not support. Same with as above companies. |
| ZTE | Not clear the intention to discuss the CG separately. Is there any difference between CG and DG on inter-priority multiplexing? |
| CATT | Do not support. |
| Intel | Not support. |
| Quectel | Not support |
| OPPO | Not support |
|  |  |

## 2nd round discussion

Proposal (for email approval):

Separate RRC parameters to configure ‘Multiplexing UCIs of different priorities on PUCCH or PUSCH’ in the primary and secondary PUCCH cell group.

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| Supporting companies: |  |
| Objecting companies: |  |
| Company | Reason for objection |
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# Proposals for GTW sessions

## GTW session on 18th Jan (Tuesday).

Proposal 1:

Support multiplexing of high-priority HARQ-ACK and low-priority HARQ-ACK on PUCCH Format 2.

* Extend legacy agreements on PRB number determination for Rel-17 (RAN1#106bis-e and RAN1#107-e) to cover PUCCH Format 2.
* Use the HP UCI bit number and HP RE number for ∆TF,b,f,c(i) formula selection and calculation (as for PUCCH formats 3 & 4).
* Concatenate the coded HP HARQ-ACK bits and the coded LP HARQ-ACK bits sequentially and apply the procedures described in R15 TS 38.211 to the concatenated coded HARQ-ACK bit sequence ~~in principle~~.

Note: It was agreed to support multiplexing a high-priority HARQ-ACK and a low-priority HARQ-ACK into a PUCCH in R17.

* Support: Nokia/NSB, Huawei/Hisi, Sony, InterDigital, Apple, Panasonic, DOCOMO, Spreadtrum, QC, ITRI, ZTE, CATT, Quectel, E///, OPPO
* Not support: Samsung, Intel
  + Increase the number of coding chains for PUCCH format 2 and complicate the UE/gNB implementation.
  + PUCCH format 2 is only 1 or 2 symbols, with Rel-15 timeline, it is likely that gNB can properly schedule a PUCCH resource for both LP and HP to avoid overlapping for such case.

Proposal 2:

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

* For positive SR, transmit HARQ-ACK on the SR PUCCH resource.
* For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.
* If the HP SR is PF0 and HP SR is positive,
  + 1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using {CS 0, CS 6} representing {NACK, ACK} respectively;
  + 2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using {CS 0, CS 3, CS 6, CS 9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.
* Or, agree on the detailed sequence allocation for the case where the HP SR is PF0 and HP SR is positive in RAN1#107bis-e.

Note: It was agreed to support multiplexing a LP HARQ-ACK and a HP SR into a PUCCH for some HARQ-ACK/SR PF combinations in Rel-17.

* Support : Nokia/NSB, Huawei/Hisi, Sony, InterDigital, Sharp, Panasonic, DOCOMO, QC, New H3C, ITRI, NEC, ZTE, CATT, vivo (can accept), Quectel, CTC
* Not support: Samsung, Intel

Proposal 3:

When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF2/3/4:

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

Note: It was agreed to support multiplexing a LP HARQ-ACK and a HP SR into a PUCCH for some HARQ-ACK/SR PF combinations in Rel-17.

* Support : Nokia/NSB, Huawei/Hisi (can accept), InterDigital, Panasonic, DOCOMO, Spreadtrum, Samsung, New H3C, ITRI, ZTE (can accept), CATT, Intel, Quectel, E///, OPPO
* Not support : QC

Proposal 4:

When a PUCCH carrying HP SR and HP HARQ-ACK overlaps with a PUCCH carrying LP HARQ-ACK, information bits for K HP SRs are appended to HP HARQ-ACK bits, and treat them as HP UCI, where K (K≥1) PUCCHs semi-statically configured for K HP SRs overlap with the original PUCCH carrying the HP HARQ-ACK.

* The number of HP UCI bits is , same as Rel-15;
* Reuse other procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource with PF 2/3/4, i.e. separate coding, PRB determination, rate matching and power control.
* If the HP HARQ-ACK is a dynamic HARQ-ACK, a PUCCH resource indicated by PRI is used for multiplexing.
* If the HP HARQ-ACK is a SPS HARQ-ACK, a PUCCH resource determined from the PUCCH resource(s) provided by sps-PUCCH-AN-List or n1PUCCH-AN is used for multiplexing.
* Support: Nokia/NSB, Huawei/Hisi, Sony, InterDigital, Panasonic, DOCOMO, QC, New H3C, ITRI, NEC, ZTE, CATT, Quectel, E///, OPPO
* Not support PUCCH format 2: Sumsung, Intel

Proposal 5:

~~For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH i~~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.
* Support: Nokia/NSB, Huawei/Hisi, Sony, InterDigital, Sharp, Panasonic, DOCOMO, Spreadtrum, QC, New H3C, ITRI, NEC, ZTE, CATT, Intel, vivo, Quectel, OPPO
* Improve the wording: Samsung

Proposal 6:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a low-priority (LP) 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.

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a high-priority (HP) 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.

* Support: Huawei/Hisi, Sony, InterDigital, Panasonic, DOCOMO, Spreadtrum, QC, New H3C, ITRI, NEC, ZTE, CATT, Intel, vivo, Quectel, OPPO
* Not support: Nokia/NSB (Separate proposals for scenarios)

# References

1. [R1-2200012](file:///D:/work/3GPP/Docs/R1-2200012.zip) Intra-UE multiplexing and prioritization New H3C Technologies Co., Ltd.
2. [R1-2200018](file:///D:/work/3GPP/Docs/R1-2200018.zip) On UL intra-UE prioritization and multiplexing enhancements Nokia, Nokia Shanghai Bell
3. [R1-2200039](file:///D:/work/3GPP/Docs/R1-2200039.zip) Intra-UE multiplexing enhancements Huawei, HiSilicon
4. [R1-2200082](file:///D:/work/3GPP/Docs/R1-2200082.zip) Remaining issues on intra-UE Multiplexing/Prioritization for Rel-17 URLLC vivo
5. [R1-2200109](file:///D:/work/3GPP/Docs/R1-2200109.zip) Discussion on enhanced intra-UE multiplexing ZTE
6. [R1-2200148](file:///D:/work/3GPP/Docs/R1-2200148.zip) Remaining issues on intra-UE multiplexing and prioritization CATT
7. [R1-2200180](file:///D:/work/3GPP/Docs/R1-2200180.zip) Remaining issues in intra-UE multiplexing & prioritisation Sony
8. [R1-2200199](file:///D:/work/3GPP/Docs/R1-2200199.zip) Remaining issues for Intra-UE Multiplexing/Prioritization Samsung
9. [R1-2200233](file:///D:/work/3GPP/Docs/R1-2200233.zip) Discussion on intra-UE multiplexing/prioritization for Rel.17 URLLC NTT DOCOMO, INC.
10. [R1-2200275](file:///D:/work/3GPP/Docs/R1-2200275.zip) Discussion on intra-UE multiplexing/prioritization Spreadtrum Communications
11. [R1-2200296](file:///D:/work/3GPP/Docs/R1-2200296.zip) Intra-UE multiplexing and prioritization for IOT and URLLC Qualcomm Incorporated
12. [R1-2200320](file:///D:/work/3GPP/Docs/R1-2200320.zip) Discussion on intra-UE multiplexing with different priorities Panasonic Corporation
13. [R1-2200344](file:///D:/work/3GPP/Docs/R1-2200344.zip) Enhancements on intra-UE multiplexing/prioritization OPPO
14. [R1-2200358](file:///D:/work/3GPP/Docs/R1-2200358.zip) Intra-UE Multiplexing/Prioritization ETRI
15. [R1-2200365](file:///D:/work/3GPP/Docs/R1-2200365.zip) Intra-UE multiplexing and prioritization InterDigital, Inc.
16. [R1-2200374](file:///D:/work/3GPP/Docs/R1-2200374.zip) Remaining Open Details of Intra-UE Uplink Channel Multiplexing and Prioritization Intel Corporation
17. [R1-2200416](file:///D:/work/3GPP/Docs/R1-2200416.zip) Rel-17 intra-UE Multiplexing/Prioritization Apple
18. [R1-2200442](file:///D:/work/3GPP/Docs/R1-2200442.zip) Intra-UE Multiplexing/Prioritization Enhancements for IIoT/URLLC Ericsson
19. [R1-2200485](file:///D:/work/3GPP/Docs/R1-2200485.zip) Discussion on some remaining issues for intra-UE multiplexing and prioritization China Telecom
20. [R1-2200492](file:///D:/work/3GPP/Docs/R1-2200492.zip) Remaining Issues on Intra-UE Multiplexing/Prioritization Quectel, Langbo
21. [R1-2200497](file:///D:/work/3GPP/Docs/R1-2200497.zip) Intra-UE UCI multiplexing and channel collision resolution with different priorities Sharp
22. [R1-2200517](file:///D:/work/3GPP/Docs/R1-2200517.zip) Discussion on Intra-UE prioritization and multiplexing NEC
23. [R1-2200531](file:///D:/work/3GPP/Docs/R1-2200531.zip) Intra-UE multiplexing enhancement for IIoT/URLLC Lenovo, Motorola Mobility
24. [R1-2200562](file:///D:/work/3GPP/Docs/R1-2200562.zip) Discussion on intra-UE multiplexing and prioritization ITRI
25. [R1-2200573](file:///D:/work/3GPP/Docs/R1-2200573.zip) Discussion on Intra-UE multiplexing/prioritization LG Electronics
26. [R1-2200635](file:///D:/work/3GPP/Docs/R1-2200635.zip) Remainng issues on intra-UE multiplexing/prioritization for URLLC/IIoT WILUS Inc.