3GPP TSG RAN WG1 #108-e R1-220xxxx

e-Meeting, February 21 – March 3, 2022

Source: Moderator (OPPO)

Title: Summary#3 of email thread [108-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#108 are summarized.

[108-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: February 25
* Final check point: March 3

# 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.*

Agreement

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.

**Agreement**

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.

**Agreement**

When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 2/3/4 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;
  + FFS: PF0, PF1
* 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 is used for multiplexing.

**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

* 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. Apply the Rel-15 placeholder bit handling procedure for PUSCH together with Rel-15 PUCCH scrambling sequence.

## Remaining issues on coding and resource determination

## Inputs from Tdocs

**Issue 2.2-1: 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].

* + HW, Nokia, CTC, DCM, Intel, Samsung

**Issue 2.2-2: 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
  + Option 2: Drop CSI part 2 if CSI would multiplex on a PUCCH which has HP A/N.
    - DCM

**Issue 2.2-3: 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 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,
  + 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.
* Note: If the new T-DAI field is not RRC configured, 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.
* FFS whether/how to multiplex LP HARQ-ACK sub-codebook for CBG-based PDSCH on HP PUCCH or HP PUSCH with single new T-DAI field.
* Support: Huawei/Hisi, Nokia/NSB, ZTE, CATT, DCM, IDC, Intel, NEC, Samsung, LG
* Not support: vivo, Ericsson, OPPO

**HW proposal:**

* Whether/how to handle the LP HARQ-ACK ambiguity in case of overlapping with HP SPS HARQ-ACK is up to gNB implementation.
* **Other options:**
  + Option 1: Configure a dedicated PUCCH resource for HP and LP HARQ-ACK in the second PUCCH-Config.
    - 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.
    - LG
  + Option 5:
    - 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 
    - CTC

|  |  |  |  |
| --- | --- | --- | --- |
| 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 2.2-4: Overlapping handling for Type 3 codebook HARQ-ACK**

**HW proposal:**

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.

**Issue 2.2-5: Multiplexing for SPS HARQ-ACK**

**Status in running specification:**

UE determines the PUCCH resource from the second *sps-PUCCH-AN-List* using

**Samsung proposal:**

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

**Issue 2.2-6: PRI selection for HP A/N and LP A/N multiplexing**

**QC proposal:**

For multiplexing HP HARQ-ACKs and LP HARQ-ACKs, the PRI in the lastly received DCI (if exist), which schedules a HP HARQ-ACK involved in the multiplexing, is used to select the PUCCH resource to transmit the multiplexed payload.

**LG proposal:**

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.

**Issue 2.2-7: Details on transmission power**

**Apple proposal:**

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.

**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 |
| HW | ***Proposal 9: 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 10: 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.***    + ***The UE should not transmit LP Type 1 HARQ-ACK on HP PUCCH in case of the LP T-DAI = 0 regardless of the fallback cases of receiving only a SPS release of fallback DCI with C-DAI=1 or only a PDSCH scheduled by fallback DCI on PCell with C-DAI=1.***   ***Proposal 11: 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 12: Whether/how to handle the LP HARQ-ACK ambiguity in case of overlapping with HP SPS HARQ-ACK is up to gNB implementation.***  ***Observation: 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 13: 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.*** |
| E/// | [Proposal 5 Do not introduce an additional LP DAI in DCI formats scheduling PUSCH and PDSCH.](#_Toc95752009) |
| Nokia | * **Proposal 3.1: 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 3.2: 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 3.3: For the ambiguity on LP HARQ-ACK type-1 codebook existence or LP HARQ-ACK type-2 codebook size due to DCI misdetection, a new T-DAI field can be RRC configured:**   + **For multiplexing HP HARQ-ACK and Type-2/Type-1 LP HARQ-ACK codebook,**     - **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.** |
| vivo | ***Proposal 6: It is up to gNB implementation to resolve the ambiguity on LP HARQ-ACK type-1 codebook existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection.*** |
| ZTE | ***Proposal 10:*** *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 11:*** *Modify the agreement in RAN1#106-e in RED:*  *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 12****: For the case that the total number of bits is no more than 2 bits, the PRI+x in the HP DCI is used to implicitly determine an extended PUCCH resource from the same PUCCH set in the PUCCH-config with high priority for the multiplexed UCI.*   * *x is predefined, e.g., x=1.* |
| OPPO | ***Proposal 7: Additional enhancement to avoid ambiguity caused by LP DCI missing is not supported.*** |
| CATT | ***Proposal 7: To avoid the impact on HP PUCCH/PUSCH due to missing DCIs corresponding to LP HARQ-ACK codebook, it is proposed to indicate the number of LP HARQ-ACK bits by a new T-DAI field in DCI corresponding to HP PUCCH/PUSCH.*** |
| Pana | Proposal 3: 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.** |
| CTC | **Proposal 1: For the scenario where a PUCCH carrying HP HARQ-ACK overlaps with another PUCCH carrying LP HARQ-ACK and the total payload size is 2 bits, the order of the multiplexed two bits could be [HP HARQ-ACK bit, LP HARQ-ACK bit].**  **Proposal 2: 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 |
| DCM | **Proposal 1:**   * *The bit order of HP HARQ-ACK and LP HARQ-ACK can be [HP HARQ-ACK bit, LP HARQ-ACK bit] in case the total number of LP and HP HARQ-ACK bits is 2.*   **Proposal 2:**   * *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 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* |
| IDC | ***Proposal 4: 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 5: DCI indicating HP HARQ-ACK includes an indication of the DAI of LP HARQ-ACK.***  ***Proposal 6: RRC can configure 2-bits field combining priority indication and DAI of LP HARQ-ACK.*** |
| Intel | **Proposal 6: 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 is [high-priority HARQ-ACK bit, low-priority HARQ-ACK bit].**  **Proposal 8: For multiplexing a HP HARQ-ACK and LP HARQ-ACK into a PUCCH or PUSCH, additional T-DAI for LP HARQ-ACK can be indicated by the DCI scheduling HP HARQ-ACK/HP PUSCH for type-2 HARQ-ACK codebook.**  **Proposal 8: For multiplexing a HP HARQ-ACK and LP HARQ-ACK into a PUCCH or PUSCH, additional T-DAI for LP HARQ-ACK can be indicated by the DCI scheduling HP HARQ-ACK/HP PUSCH for type-2 HARQ-ACK codebook.** |
| Apple | **Observation 3-1: in Rel-16, for PRB number adjustment/interlace number adjustment, the configured PRB number of the selected PUCCH resource (if it is at PF2 or PF3), , , maxCodeRate according to the PUCCH format of the selected PUCCH resource, , , maxCodeRate according to the PUCCH format of the selected PUCCH resource are used as inputs, and the same coding rate is used for two CSI parts.**  **Proposal 3-1: 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 4-1: leverage the Rel-15 design, LP HARQ-ACK is mapped to UCI Part II in separate encoding, adopt the UCI mapping in Figures 4-3a/4-3b.**  **Proposal 6-1: 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.** |
| NEC | ***Proposal1:*** *When multiplexing both low-priority HARQ-ACK and high-priority HARQ-ACK on a high priority PUSCH scheduled by an UL non-fallback DCI,*   * *Support introducing an additional DAI field in UL DCI associated with high priority PUSCH for determining the total number of low priority HARQ-ACK.*   ***Proposal2:*** *When multiplexing both low-priority HARQ-ACK and high-priority HARQ-ACK on a low priority PUSCH scheduled by an UL non-fallback DCI,*   * *The one DAI field in UL DCI associated with low priority PUSCH for determining the total number of low priority HARQ-ACK as Rel-16.*   ***Proposal 3:***  *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* |
| Samsung | **Proposal 2: 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.**  **Proposal 4: RRC configures presence of a T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.** |
| QC | **Proposal 9: For HP UCI and LP HARQ-ACK (in type 2 codebook) multiplexing on a PUCCH, round up LP HARQ-ACK size to a nearest reference size, in the calculation of total number of RBs for HP and LP UCI and in the PUCCH resource set determination.** |
| LG | **Proposal #6: 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 #7: 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.**   **Proposal #9: 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.** |
| WILUS | * ***Proposal 4:*** *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.* |

## 1st round discussion

Proposal for 1st round discussion:

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].

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support. |
| Huawei/Hisi | Support |
| ZTE | Support |
| OPPO | Support |
| LG | Support FL’s proposal. |
| Sony | Support |
| Sharp | Support |
| Samsung | Support |
| Intel | Support |
| DOCOMO | Support |
| Spreadtrum | Support |
| ITRI | Support |
| CATT | Support the proposal with minor editorial suggestion to change “could be” to “is” as follows. Otherwise, it may lead to confusion that other ordering is not precluded either.  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~~ is [high-priority HARQ-ACK bit, low-priority HARQ-ACK bit]. |
| Panasonic | We support the proposal. |
| WILUS | Support |
| vivo | support |
| CTC | Support |
| Lenovo | Support |
| QC | Support. CATT’s revision is better. |
|  |  |
|  |  |
|  |  |
|  |  |

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,
  + 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.
* Note: If the new T-DAI field is not RRC configured, 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.
* FFS whether/how to multiplex LP HARQ-ACK sub-codebook for CBG-based PDSCH on HP PUCCH or HP PUSCH with single new T-DAI field.
* Support: Nokia/NSB, Huawei/Hisi, ZTE, Samsung, Intel, DOCOMO, ITRI, Panasonic, WILUS
* Concerned about the existence of the solution for the FFS point: OPPO, Apple, Spreadtrum

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support the FL proposal. |
| Huawei/Hisi | Support. |
| ZTE | Support |
| OPPO | It is an optimized issue and there is still an open issue at this stage, we prefer that this issue is left to gNB scheduling. If an complete solution can be achived and supported by majority companies, we could compromise to majority view. |
| LG | Support FL’s proposal. |
| Apple | It’s an optimization, should not be taken. |
| Sharp | It is an optimization, can be considered after all critical issues are solved. |
| Samsung | Support.  We don’t agree that the proposal is an optimization, it is essential to ensure the reliability of HP HARQ-ACK. |
| Intel | We’re fine with FL’s proposal. |
| DOCOMO | Fine with the proposal. |
| Spreadtrum | From our understanding, when there are two LP HARQ-ACK sub-CBs, both of those two HARQ-ACK CBs are multiplexed on HP PUSCH/PUCCH. So if only one sub-CB is multiplexed is not acceptable. e.g. only LP TB level sub-CB is multiplexed, but LP CBG based sub-CB is not.  Furthermore, the new LP T-DAI also need to indicate the TB and CBG sub-CBs if it is supported. We don’t think it is a complete solution for only indicating TB sub-CB, without CBG sub-CB. Since those two CBs have same impact to HP HARQ-ACK when considering the reliability impact of LP HARQ-ACK to HP PUSCH.  So the “whether” in the last FFS means this proposal applies to one HARQ-ACK CB based case, or only first HARQ-ACK sub-CB is multiplexed without CBG sub-CB? We do not have a clear picture for how to indicate the LP HARQ-ACK T-DAI using up to 2bits, when it is configured with two sub-CBs. |
| ITRI | Fine with the proposal |
| CATT | We also think it is important to ensure the reliability of HP UCI so we support the proposal in principle.  We also would like to clarify the FFS part which seems to be an issue due to the restriction of at most 2 bits for T-DAI of LP HARQ-ACK. Is there any specific reason to set the restriction and then discuss potential solution or in other words, why the restriction is needed? |
| Panasonic | We are fine with the proposal. |
| WILUS | We support FL’s proposal |
| CTC | If it is the majority view, we can support it.  If the proposal can not be agreed finally due to the additional DCI overhead, we prefer to slove for HP+LP HARQ-ACK 2 bits case the LP DTX to ACK error when LP DCI missing happens. Even gNB decides to not configure the new T-DAI, LP DCI missing may also happen. For HP+LP HARQ-ACK 2 bits case, almost all of the time the HP HARQ feedback is ACK, LP HARQ feedback would be regarded as ACK. This is even worse than Rel-16 as PDSCH can not be retransmitted. We prefer adjusting the HP and LP HARQ-ACK bits to the CS or modulated symbol mapping for the 2 bits case. |
| Lenovo | This was discussed for enough time in previous meetings, without consensus on benefits.  The proposal would degrade URLLC PDCCH detection performance. |
| QC | We support the proposal in general, although we also share the same view as CATT the restriction of 2 bits is unnecessary. Suggest to remove the restriction of 2 bits in the proposal. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal for 1st round discussion:

Whether/how to handle the LP HARQ-ACK ambiguity in case of overlapping with HP SPS HARQ-ACK is up to gNB implementation.

* Support: Huawei/Hisi, ZTE, OPPO, LG, Apple, Sharp, Samsung, Intel, DOCOMO, Spreadtrum, ITRI, CATT, Panasonic, WILUS, vivo
* Not support: Samsung, CTC
* Not need the agreement: Nokia/NSB, Intel, Lenovo

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | First we prefer the indication above. But if this is left to gNB implementation, then we don’t see what we would specify here (as left to gNB implementation obviously)? |
| Huawei/Hisi | Support. Since the occurrence of HP SPS HARQ-ACK is predictable and deterministic, the gNB can avoid the collision by careful scheduling if the HP reliability would be specifically protected. |
| ZTE | Support |
| OPPO | Support |
| LG | Fine with FL’s proposal. |
| Apple | Support |
| Sharp | Support. The same can be applied for non-SPS case. |
| Samsung | Not support.  The reliability of HP HARQ-ACK should be ensured at least by RRC disabling multiplexing of HP SPS HARQ-ACK and LP HARQ-ACK. |
| Intel | We share same view with NOKIA that this is left to gNB implementation, no standard impact. |
| DOCOMO | Support |
| Spreadtrum | Support. |
| ITRI | Support |
| CATT | Support |
| Panasonic | We are fine with the proposal. |
| WILUS | Support FL’s proposal with no specification change. |
| vivo | Support FL’s proposal with no specification change. |
| CTC | We prefer adjusting the HP and LP HARQ-ACK bits to the CS or modulated symbol mapping for the 2 bits case, it can also be applied for SPS HARQ-ACK case. |
| Lenovo | No agreement is needed, since it is up to gNB implementation. |
| QC | No agreement is needed, since it is up to gNB implementation. Maybe a conclusion is enough. |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal for 1st round discussion:

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

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Do not support the proposal in principle.  We prefer to have a common RRC parameter regardless of whether HP HARQ-ACK is SPS or not. |
| Huawei/Hisi | It looks this proposal is contradictory with the proposal above (they should be two orthogonal options for handling the same issue) so we do not support this proposal. |
| ZTE | The intention should be clarified. |
| OPPO | Not support. Share view as Nokia/NSB |
| LG | Not support FL’s proposal, same view with Nokia. |
| Sony | Intention is unclear. |
| Sharp | Not support. There are also deferred HARQ-ACKs, do we need separate RRC for each case? It is better to use one RRC parameter on all cases. |
| Samsung | Support |
| Intel | Not support, sharing the same view with NOKIA. |
| DOCOMO | Not support. Share the same view as Nokia/NSB. A common RRC parameter is preferred. |
| Spreadtrum | Not support. It complicates the UE behavious towards intra-UE multiplexing, considering dynamic and SPS PDSCH HARQ-ACK have different rules. |
| ITRI | The intention is unclear. |
| CATT | Not support. We agree with Nokia. |
| Panasonic | We are fine with the proposal. |
| WILUS | Not support, share the same view with Nokia. |
| vivo | Not support, share the same view with Nokia. |
| CTC | Not support, share the same view with Nokia. |
| Lenovo | Not support. We don’t see benefit/need for separate configuration for SPS and dynamic HARQ-ACK. |
| QC | Not support. There is no motivation to introduce RRC parameter at this late stage just for this issue. |
|  |  |
|  |  |
|  |  |
|  |  |

## 2nd round discussion

Proposal for email approval:

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 is [high-priority HARQ-ACK bit, low-priority HARQ-ACK bit].

|  |  |
| --- | --- |
| Supporting companies: | Sony, Lenovo, Nokia/NSB, Ericsson, Panasonic, Samsung, LG, InterDigital Huawei/Hisi, NEC, Sharp, CATT, DOCOMO, New H3C, ITRI,OPPO, ZTE,vivo, Spreadtrum, Intel |
| Objecting companies: |  |
| Company | Reason for objection |
| QC | Not objecting. This is a very straightforward proposal. Suggest to remove the [] to settle it down completely. |
| CATT | If the square bracket means FFS, we agree with the comment from QC to remove the []. |

Question for 2nd round discussion:

Since this is the last meeting of Rel-17 and this proposal is related to RRC configuration which needs to be confirmed and sent to RAN2, the existence of a complete solution behind this approach should be clarified, although the group may need more time for consensus on the solution. Please provide the solution in your mind for the question below?

If a new T-DAI field can be RRC configured for solving the ambiguity on LP HARQ-ACK type-1 codebook existence or LP HARQ-ACK type-2 codebook size due to DCI mis-detection, what is your solution on how to multiplex LP HARQ-ACK sub-codebook for CBG-based PDSCH on HP PUCCH or HP PUSCH with single new T-DAI field? If

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | We don’t see that as showstopper, as different approaches could be adopted in this case.  - One approach would be to configure the UE via RRC if the 2-bit indication is associated with the first or the second sub-codebook. Therefore, the gNB can configure if only the first or the second sub-codebook could be multiplexed.  - Another approach would be that the 2-bit indication only indicates the codebook size of the first (TB-based) sub-codebook of LP HARQ-ACK and only the first sub-codebook is to be multiplexed (i.e., the second HARQ-ACK codebook for CBG based PDSCH with much larger size due to CBG HARQ-ACK feedback is neglected, having higher potential to create worse decoding performance due to overall higher UCI payload sizes).  - A third approach would be to not support the scenario with two LP subcodebooks at all. |
| Ericsson | Do not support this direction. We see many issues with introducing a new T-DAI field. |
| Samsung | The T-DAI can apply to both sub-codebooks. This scheme has been implemented in Rel-16 NRU enhanced Type-2 HARQ-ACK codebook. |
| QC | We don’t see TB + CGB is a critical issue. Since whether configuring this the new UL-TDAI is up to gNB, we are open to extend this new UL-TDAI to up to 4 bits, then the problem is solved. Of course this will increase DL overhead, but it is gNB’s choice between DL overhead and UL realiability. Basically, we think the limitation of 2 bits for the new UL-TDAI is unnecessary. |
| LG | We share similar view with Nokia.  In case with CBG for LP HARQ-ACK with Type-2 codebook, the new 2-bit T-DAI can only indicate the size of TB sub-codebook and only the TB sub-codebook of LP is multiplexed on HP PUCCH/PUSCH.  In case with CBG for LP HARQ-ACK with Type-1 codebook, there is no issue.  @Samsung,  In our understanding on Rel-16 NR-U, single T-DAI can be configured in UL DCI for two PDSCH groups, but the T-DAI is applied to only one of two PDSCH groups according to actual scheduling for each PDSCH group. |
| InterDigital | It does not seem critical to support this case. Otherwise, one of the solutions outlined by Nokia can work. |
| Huawei/Hisi | The 2bits T-DAI field applies to both sub-codebooks, as applied in e-Type 2 HARQ CB in the legacy spec. Introducing more than 2 bits T-DAI leads to too much additional overhead for HP DCI and should not be considered.   |  | | --- | | * if , after the completion of the and loops for the pseudo-code for the second HARQ-ACK codebook generation in clause 9.1.3.1, set . If the UE is provided *PDSCH-CodeBlockGroupTransmission* for serving cells, set for both sub-codebooks before appending the second sub-codebook to the first sub-codebook. | |
| NEC | If a new T-DAI field is configured by RRC for multiplexing LP Type-2 HARQ-ACK codebook including two sub-codebooks on HP PUCCH/PUSCH, we prefer that the DAI filed is only for multiplexing TB-based sub-codebook on HP PUCCH/PUSCH,the CBG-based sub-codebook which would degrede the reliability performance of HP PUCCH/PUSCH can be dropped. |
| Sharp | We don’t see this as a critical feature to ne introduced in the last moment.  In case of LP TB + CBG codebooks, it is betterr to compress the CBG to TB level to reduce the payload. |
| CATT | We share the same view as Qualcomm. |
| DOCOMO | Share similar view with InterDigital. It does not seem critical to support this case. Otherwise, one of the solutions outlined by Nokia can work. |
| New H3C | We think that 2bits are enough for T-DAI field because more than 2 bits T-DAI increase too much DL overhead. |
| ZTE | It is not critical to support this case. One of the solutions by Nokia can work. 2 bits are enough. |
| vivo | We agree with other companies that the CBG-based sub-codebook which would degrede the reliability performance of HP PUCCH/PUSCH, 4 bits T-DAI may increase too much DL overhead. Compress the CBG to TB level as Sharp proposed may be a better way. |
| Intel | Two sub-codebooks for CBG and TB-codeobok does not impact Type-1 codebook. So the question is only for type-2 codeobok.  For type-2 codebook, we prefer to apply single DAI to both codebooks. As mentioned by Samsung, it is already supported in Rel-16. Otherwise, we’re fine with not support two sub-codebook with T-DAI as suggested by NOKIA. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 3rd round discussion

Proposal for 3rd 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,
  + A T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.
  + Working assumption: 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.
  + Working assumption: 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.
* Note: If the new T-DAI field is not RRC configured, 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.
* FFS whether/how to multiplex LP HARQ-ACK sub-codebook for CBG-based PDSCH on HP PUCCH or HP PUSCH with single new T-DAI field.
* Support: New H3C, LG, vivo (can accept), Nokia/NSB, Samsung, ZTE, Sony, DOCOMO, Intel, NEC, QC, Spreadtrum, Huawei/Hisi, ITRI, Panasonic, WILUS, InterDigital, CATT
* Not support: Apple, Ericsson, OPPO (can compromise if is the only objecting company)

|  |  |
| --- | --- |
| Company | Comments |
| New H3C | We support this proposal in principal |
| LG | We are fine with the update.  Regarding the FFS part in case with CBG for Type-2 codebook, as commented in 2nd round, the new 2-bit T-DAI only indicates the size of TB sub-codebook for LP and only the TB sub-codebook of LP is multiplexed on HP PUCCH/PUSCH, with consideration of kepping the robustness of T-DAI signaling as in Rel-15. |
| vivo | Although we have concern on the overhead of DCI for HP, considering it is RRC configurable, we can live with the proposal for progress. |
| Nokia/NSB | Support the proposal.  For the FFS point, if a single additional T-DAI field is used (according to the current working asusmptions), then any of the approaches we outlined in the previous round of discussion could be adopted. |
| OPPO | We still think it is not an essential issue and can be handled by gNB. If we are the only one objecting company, we can live with the proposal for progress. |
| Samsung | Support.  The realiability issue of URLLC is essential and should be addressed.  Regarding the concern on PDCCH resource waste, we think at least in some cases adding two bits won’t require larger AL and can ensure the reliability of PDCCH considering the size of DCI at least for DCI 1\_1/0\_1. If gNB thinks it is an issue in some other cases, the feature can be disabled. |
| ZTE | Fine with the update. Regarding the concern, at least the ambiguity issue for PUSCH is very severe. We all know the reason why some REs are reserved for HP HARQ-ACK when multiplexing with PUSCH. The same reason is for LP HARQ-ACK as if no any solution here, there is the ambiguity of judging the location of RE for CSI-part or UL-SCH which will cause gNB processing much difficult. |
| Sony | We are fine with this proposal. We think the 2 extra bits is no big deal considering that the alternative is that the gNB needs to use high Aggregation Level on the LP DCI, which would end up costing more bits.  Also this is configurable and so is a tool for the gNB to use to handle misdetection. |
| Apple | As discussed multiple times, there are problems with the proposal. Implementation base solutions are present. Second adding more bits in HP DCI for LOW PRIORTIY traffic is totally against the design intention behind 0\_2/1\_2, yet if the proposed additions are limited to 1\_1/0\_1 only, then there can be quite many situations, to handle.  We don’t support this proposal. |
| Sharp | We also think it is not an essential problem. Anyway, UE/gNB implementaitons should be supported if extra DAI is not configured. |
| Ericsson | Do not support. The reasons have been provided before.  One new issue to be addressed is, the new T-DAI field is present if the DCI field priority\_indicator = 1, but not present if priority\_indicator = 0. Then the UE need to blind decode which version of DCI is sent. This doubles the blind decoding cost of UE, or degrade the DCI reception reliability. Since all four DCI formats are affected (0\_1, 0\_2, 1\_1, 1\_2), this degrades system performance, and not acceptable. |
| DOCOMO | We are fine with the updated proposal. |
| Intel | We support the proposal.  Regarding blind detection issue asked by Ericsson, in our understanding, DCI size should be fixed. It is same as Rel-16. For example, in Rel-16, for a DCI with a priroity indication bit field, if type-1 codewbook is configured for LP and type-2 codebook is configured for HP, then, the size of DAI bit field in the DCI is determined by the largest size of LP and HP. The same principle is applied for Rel-17.  Regarding the impact to all DCI format, to address Ericsson’s concern, we think at least T-DAI for DL and UL DCI format can be supported. |
| NEC | We are fine with the proposal. |
| QC | We can support this proposal, although the 2 bits restriction is not our preference.  To Ericsson: DCI size alignment is the practice we did many times in Rel-16 URLLC DCI design. Not sure why it is a critical issue.  If the concern is DCI overhead, can FL and the group consider the following proposal, which can solve the issue without extra DL overhead. Nevertheless, we don’t think this is a critical issue and a solution in spec is needed.  **Proposal**  **The existing T-DAI field is double interpreted to indicate both T-DAI of HP HARQ-ACK and LP HARQ-ACK.** |
| Spreadtrum | We support the proposal. |
| InterDigital | We support the proposal.  Regarding the issue on different DCI size depending on priority, another possibility is to not configure the HP T-DAI at all in the HP DCI. The LP T-DAI is more important than the HP T-DAI because the PDCCH of HP DCI anyway must be very robust to meet the HP reliability requirement. |
| Ericsson2 | Regarding blind decoding of DCI size:  @ QC and InterDigital: the issue can not be addressed by the existing size alignment procedure. The problem here is, the DCI size varies according to the field value of the DCI, i.e., priority indicator. The DCI size is not determined by RRC configuration only. Thus the UE has to perform additional blind decoding.  @ InterDigital: your suggestion seems to contradict with the proposal? |
| InterDigital2 | @Ericsson:  Yes, this suggestion would require change to the FL proposal, for example as follows: note that this could potentially reduce additional RRC signaling as well, since all that may be required is a flag to indicate if the configured T-DAI field is for LP HARQ-ACK or HP HARQ-ACK when in a HP DCI.  We still support original FL proposal but would be ok with the update below as well.  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,   + A T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.   + ~~Working assumption: 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.~~   + If the new T-DAI field is configured, the DL DCI format associated with HP HARQ-ACK does not include T-DAI field for the T-DAI of HP HARQ-ACK. * 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.   + ~~Working assumption: 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 configured, the DL DCI format associated with the UL DCI format scheduling the HP PUSCH does not include T-DAI field for the T-DAI of HP HARQ-ACK. * Note: If the new T-DAI field is not RRC configured, 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. * FFS whether/how to multiplex LP HARQ-ACK sub-codebook for CBG-based PDSCH on HP PUCCH or HP PUSCH with single new T-DAI field. |
| Samsung | To E///, regarding the DAI size alignment issue, we have the similar ones in Rel-16, and the DAI size is aligned as described in 38.212 below.   |  | | --- | | If higher layer parameter *priorityIndicatorDCI-1-1* is configured, if the bit width of the Downlink assignment index in DCI format 1\_1 for one HARQ-ACK codebook is not equal to that of the Downlink assignment index in DCI format 1\_1 for the other HARQ-ACK codebook, a number of most significant bits with value set to '0' are inserted to smaller Downlink assignment index until the bit width of the Downlink assignment index in DCI format 1\_1 for the two HARQ-ACK codebooks are the same. |   Could you help clarify a bit about the difference from Rel-16? |
|  |  |
|  |  |

## Multiplexing HARQ-ACK and SR with different priorities

## Inputs from Tdocs

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

**Proposals from last meeting:**

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 the HP SR is positive,
  + 1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=6} representing {NACK, ACK} respectively;
  + 2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=3, mCS=6, mCS=9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.
  + Where m0 is configured by initialCyclicShift in the configuration of the HP SR PF0 resource in Rel-16.
* 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 on the same SR resource with QPSK.
* Support: Huawei/Hisi, vivo, ZTE, OPPO, CATT, Panasonic, Spreadtrum, Lenovo (HP UCI bits of ), Sharp, LG, WILUS
* Not support: Samsung

**Nokia proposal:**

* When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK:
  + If there is 1bit HP HARQ-ACK and 1 bit LP HARQ-ACK: LP HARQ-ACK bit can be simply treated as a second HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
  + If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2:
    - the 1-bit SR is appended to the HP HARQ-ACK bits, and these bits are treated as HP UCI/HARQ-ACK bits;
    - the number of HP UCI bits is *O*uci = *O*ACK + 1, where *O*ACK is the (original) number of HP HARQ-ACK bits;
    - reuse the (agreed) procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource with PF 2/3/4, i.e., PUCCH resource selection, separate coding, PRB determination, rate matching, power control, etc.

**Issue 2.3-2: HP SR + HP HARQ-ACK with PF0/1 multiplexed with LP HARQ-ACK**

**Extending agreement in last meeting to PF0/1:**

* When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 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
    - Option 1: , same as Rel-15;
      * OPPO, QC
    - Option 2:
      * Ericsson, CATT, Spreadtrum, Sharp, Intel
  + 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 is used for multiplexing.

**Intel proposal:**

* Proposal 7: When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, HP UCI bits can be multiplexed with LP HARQ-ACK in step 2, if the resultant HP PUCCH in step 1 uses HP HARQ-ACK PUCCH resource, otherwise, LP HARQ-ACK is dropped. , where M is the number of HP SRs carried by resulant HP PUCCH in step 1.

**Lenovo proposal:**

* For overlapping PUCCH transmissions of a HP SR (i.e. positive SR), 1-bit HP HARQ-ACK, and 1-bit LP HARQ-ACK, UE multiplexes LP HARQ-ACK into a PUCCH resource for the HP SR and the HP HARQ-ACK by treating the LP HARQ-ACK as a HP HARQ-ACK bit.

**LG proposal:**

Consider following 6 cases when HP PUCCH format 0/1 carrying HP SR and HP HARQ-ACK overlaps with LP PUCCH carrying LP HARQ-ACK.

* Case 1: HP HARQ-ACK + LP HARQ-ACK = 2 bits, and the HP HARQ-ACK is based on PUCCH format 0
  + The LP HARQ-ACK is to be dropped to avoid performance loss of HP UCI mapping on HP HARQ-ACK PF0 resource.
* Case 2: HP HARQ-ACK + LP HARQ-ACK = 2 bits, and the HP HARQ-ACK and HP SR are based on PF1 and PF1, respectively
  + The LP HARQ-ACK can be multiplexed with the HP HARQ-ACK on HP SR PF1 resource.
* Case 3: HP HARQ-ACK + LP HARQ-ACK = 2 bits, and the HP HARQ-ACK and HP SR are based on PF1 and PF0, respectively
  + After dropping the HP SR, the LP HARQ-ACK is multiplexed with HP HARQ-ACK on HP HARQ-ACK PF1 resource.
* Case 4: HP HARQ-ACK + LP HARQ-ACK > 2 bits, and the HP HARQ-ACK has dynamic HARQ-ACK
  + The LP HARQ-ACK is multiplexed with the HP UCI on HP HARQ-ACK PF2/3/4 resource determined by PRI indicated in HP DCI.
* Case 5: HP HARQ-ACK + LP HARQ-ACK > 2 bits, and the HP HARQ-ACK is SPS HARQ-ACK with sps-PUCCH-AN-List
  + The LP HARQ-ACK is multiplexed with the HP UCI on HP HARQ-ACK PF2/3/4 resource determined by PRI indicated in LP DCI (if exists).
  + Alternatively (or if there is no LP DCI), the LP HARQ-ACK can be multiplexed with the HP UCI on HP SPS PF2/3/4 resource provided by sps-PUCCH-AN-List.
    - FFS on the case when total payload size of HP UCI + LP UCI exceeds the maximum payload size configured in sps-PUCCH-AN-List
* Case 6: HP HARQ-ACK + LP HARQ-ACK > 2 bits, and the HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN
  + The LP HARQ-ACK is multiplexed with the HP UCI on HP HARQ-ACK PF2/3/4 resource determined by PRI indicated in LP DCI (if exists).
  + Alternatively (or if there is no LP DCI), the LP HARQ-ACK can be dropped.

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 14: 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.*** * ***If the HP SR is PF0 and the HP SR is positive,***    + ***1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=6} representing {NACK, ACK} respectively;***   + ***2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=3, mCS=6, mCS=9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.***   + ***Where m0 is configured by initialCyclicShift in the configuration of the HP SR PF0 resource in Rel-16.*** * ***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 on the same SR resource with QPSK.***   ***Proposal 16: 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.*** |
| E/// | [Proposal 4 When a PUCCH carrying both HP HARQ ACK and SR (explicitly or implicitly) overlaps with a PUCCH carrying LP HARQ-ACK, treat the SR as a HP HARQ-ACK bit and reuse multiplexing solutions for PUCCH carrying HP HARQ-ACK overlapping with PUCCH carrying LP HARQ-ACK.](#_Toc95752008) |
| Nokia | * **Proposal 3.4: When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1:**   + **For positive SR, transmit LP HARQ-ACK on the SR PUCCH resource.**   + **For negative SR, transmit LP HARQ-ACK on the HARQ-ACK PUCCH resource.** * **Proposal 3.5: When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK:**   + **If there is 1 bit HP HARQ-ACK and 1 bit LP HARQ-ACK: LP HARQ-ACK bit can be simply treated as a second HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.**   + **If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2:**      - **the 1-bit SR is appended to the HP HARQ-ACK bits, and these bits are treated as HP UCI/HARQ-ACK bits;**     - **the number of HP UCI bits is *O*uci = *O*ACK + 1, where *O*ACK is the (original) number of HP HARQ-ACK bits;**     - **reuse the (agreed) procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource with PF 2/3/4, i.e., PUCCH resource selection, separate coding, PRB determination, rate matching, power control, etc.** |
| vivo | ***Proposal 5: 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 the HP SR is positive,***    + ***1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=6} representing {NACK, ACK} respectively;***   + ***2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=3, mCS=6, mCS=9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.***   + ***Where m0 is configured by initialCyclicShift in the configuration of the HP SR PF0 resource in Rel-16.*** * ***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 on the same SR resource with QPSK.*** |
| ZTE | ***Proposal 13:*** *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 the HP SR is positive,*    + *1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=6} representing {NACK, ACK} respectively;*   + *2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=3, mCS=6, mCS=9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.*   + *Where m0 is configured by initialCyclicShift in the configuration of the HP SR PF0 resource in Rel-16.* * *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 on the same SR resource with QPSK.* |
| OPPO | ***Proposal 5: 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 6: When a PUCCH with PF 0/1 carrying HP SR and HP HARQ-ACK overlaps with a PUCCH carrying LP HARQ-ACK, information bits for K (K≥1) HP SRs are appended to HP HARQ-ACK bits, and treat them as HP UCI, where K PUCCHs semi-statically configured for K HP SRs overlap with the original PUCCH with PF 0/1 carrying the HP HARQ-ACK.*** |
| CATT | ***Proposal 5: For multiplexing of HP SR with PF0/1 and 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 the HP SR is positive,***    + ***1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=6} representing {NACK, ACK} respectively;***   + ***2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=3, mCS=6, mCS=9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.***   + ***Where m0 is configured by initialCyclicShift in the configuration of the HP SR PF0 resource in Rel-16.*** * ***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 on the same SR resource with QPSK.***   ***Proposal 6: If a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, 1 bit HP SR is appended to HP HARQ-ACK bits, and treated as HP UCI.*** |
| Pana | Proposal 4: 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 5:   * **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 6: 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 7:   * **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.** |
| DCM | **Proposal 4:**   * *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. | | |
| Spreadtrum | 1. **Support the *Proposal for 3rd 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 the HP SR is positive,***    + ***1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=6} representing {NACK, ACK} respectively;***   + ***2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=3, mCS=6, mCS=9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.***   + ***Where m0 is configured by initialCyclicShift in the configuration of the HP SR PF0 resource in Rel-16.*** * ***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 on the same SR resource with QPSK.***  1. ***When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, information 1 bit for the single HP SR is appended to HP HARQ-ACK bits, which is selected by UE.*** |
| Samsung | **Proposal 1: Maintain Rel-16 operation and drop LP HARQ-ACK PUCCH when a LP HARQ-ACK PUCCH PF 0/1 overlaps with a HP SR PUCCH with positive SR.** |
| Intel | **Proposal 7: When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, HP UCI bits can be multiplexed with LP HARQ-ACK in step 2, if the resultant HP PUCCH in step 1 uses HP HARQ-ACK PUCCH resource, otherwise, LP HARQ-ACK is dropped. , where *M* is the number of HP SRs carried by resulant HP PUCCH in step 1.** |
| Lenovo | **Proposal 2: For overlapping PUCCH transmissions of a HP SR (i.e. positive SR), 1-bit HP HARQ-ACK, and 1-bit LP HARQ-ACK, UE multiplexes LP HARQ-ACK into a PUCCH resource for the HP SR and the HP HARQ-ACK by treating the LP HARQ-ACK as a HP HARQ-ACK bit.**  **Proposal 3:** **When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1, similar to the case of LP HARQ-ACK with PF2/3/4, a UE can transmit SR on the SR PUCCH resource for positive SR and drop HARQ-ACK.**  **Proposal 4: When a PUCCH carrying HP SR and HP HARQ-ACK with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK and when the total number of HARQ-ACK bits including HP HARQ-ACK bits and LP HARQ-ACK bits is larger than 2, UE determines a PUCCH resource of priority index 1 based on HP UCI bits of (i.e. 1 bit for SR) and LP HARQ-ACK bits.** |
| Sharp | **Proposal 1: 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 the HP SR is positive,**    + **1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=6} representing {NACK, ACK} respectively;**   + **2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=3, mCS=6, mCS=9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.**   + **Where m0 is configured by initialCyclicShift in the configuration of the HP SR PF0 resource in Rel-16.**   **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 on the same SR resource with QPSK.** |
| LG | **Proposal #5: Consider following 6 cases when HP PUCCH format 0/1 carrying HP SR and HP HARQ-ACK overlaps with LP PUCCH carrying LP HARQ-ACK.**   * **Case 1: HP HARQ-ACK + LP HARQ-ACK = 2 bits, and the HP HARQ-ACK is based on PUCCH format 0**   + **The LP HARQ-ACK is to be dropped to avoid performance loss of HP UCI mapping on HP HARQ-ACK PF0 resource.** * **Case 2: HP HARQ-ACK + LP HARQ-ACK = 2 bits, and the HP HARQ-ACK and HP SR are based on PF1 and PF1, respectively**   + **The LP HARQ-ACK can be multiplexed with the HP HARQ-ACK on HP SR PF1 resource.** * **Case 3: HP HARQ-ACK + LP HARQ-ACK = 2 bits, and the HP HARQ-ACK and HP SR are based on PF1 and PF0, respectively**   + **After dropping the HP SR, the LP HARQ-ACK is multiplexed with HP HARQ-ACK on HP HARQ-ACK PF1 resource.** * **Case 4: HP HARQ-ACK + LP HARQ-ACK > 2 bits, and the HP HARQ-ACK has dynamic HARQ-ACK**   + **The LP HARQ-ACK is multiplexed with the HP UCI on HP HARQ-ACK PF2/3/4 resource determined by PRI indicated in HP DCI.** * **Case 5: HP HARQ-ACK + LP HARQ-ACK > 2 bits, and the HP HARQ-ACK is SPS HARQ-ACK with sps-PUCCH-AN-List**   + **The LP HARQ-ACK is multiplexed with the HP UCI on HP HARQ-ACK PF2/3/4 resource determined by PRI indicated in LP DCI (if exists).**   + **Alternatively (or if there is no LP DCI), the LP HARQ-ACK can be multiplexed with the HP UCI on HP SPS PF2/3/4 resource provided by sps-PUCCH-AN-List.**     - **FFS on the case when total payload size of HP UCI + LP UCI exceeds the maximum payload size configured in sps-PUCCH-AN-List** * **Case 6: HP HARQ-ACK + LP HARQ-ACK > 2 bits, and the HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN**   + **The LP HARQ-ACK is multiplexed with the HP UCI on HP HARQ-ACK PF2/3/4 resource determined by PRI indicated in LP DCI (if exists).**   + **Alternatively (or if there is no LP DCI), the LP HARQ-ACK can be dropped.** |
| WILUS | * ***Proposal 1: To multiplex HP-SR with PF0 and LP HARQ-ACK with PF0, we propose***    + *If HP-SR is negative, then transmit LP HARQ-ACK on HARQ-ACK resource.*     - *In case of 1-bit LP HARQ-ACK, use 2 CSs, i.e., {0, 6} CS index*     - *In case of 2-bit LP HARQ-ACK, use 4 CSs, i.e., {0, 3, 6, 9} CS index*   + *If HP-SR is positive, then transmit LP HARQ-ACK and HP-SR on HARQ-ACK resource*     - *In case of 1-bit LP HARQ-ACK, use 2 CSs, i.e., {3, 9} CS index*     - *In case of 2-bit LP HARQ-ACK, use 4 CSs, i.e., {1, 4, 7, 11} CS index*        * *To enhance HP-SR reliability, 2-bit LP HARQ-ACK can be bundled to 1-bit and then the 1-bit bundled LP HARQ-ACK is treated as 1-bit LP HARQ-ACK, i.e., use 2 CSs, {3, 9} CS index.* * ***Proposal 2:*** *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 3:*** *To multiplex HP-SR with PF1 and LP HARQ-ACK with PF0, reuse multiplexing rule for HP-SR with PF0 and LP HARQ-ACK with PF0.* |

## 1st round discussion

Proposal for 1st round discussion:

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

* For positive SR, transmit HARQ-ACK on the SR PUCCH resource.
* For negative SR, transmit HARQ-ACK on the HARQ-ACK PUCCH resource.
* If the HP SR is PF0 and the HP SR is positive,
  + 1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=6} representing {NACK, ACK} respectively;
  + 2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=3, mCS=6, mCS=9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.
  + Where m0 is configured by initialCyclicShift in the configuration of the HP SR PF0 resource in Rel-16.
* 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 on the same SR resource with QPSK.
* Support: Nokia/NSB, Huawei/Hisi, LG, Sony, Sharp, DOCOMO, Spreadtrum, ITRI, CATT, Panasonic, New H3C, WILUS, vivo, CTC, QC
* Not support: Samsung, Intel

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support the FL proposal. |
| Huawei/Hisi | Support. |
| ZTE | Support |
| LG | Support FL’s proposal. |
| Sony | Support |
| Sharp | Support |
| Samsung | Not support.  First, the motivation is not clear. This is a very corner case, it requires the following conditions satisfied at the same time and the combined probability is even smaller than the LP HARQ-ACK BLER.  (1) positive HP SR  (2) no overlapping HP HARQ-ACK PUCCH  (3) no overlapping HP PUSCH  (4) 1- or 2-bits LP HARQ-ACK  (5) LP PUCCH overlaps with HP PUCCH.  (6) LP HARQ-ACK PUCCH not overlapping with LP CSI PUCCH  (7) LP HARQ-ACK PUCCH not overlapping LP PUSCH.  Second, the performance of HP SR will be degraded at least for PF0.  Third, it complicates UE implementation, UE behaviour depends on different PUCCH formats.  Fourth, for more than 2 overlapping channels, the issue becomes very complicated. It requires quite a lot of spec work and complicates UE implementation. The following case is discussed under URLLC-03. If both SRs are positive, how to perform multiplexing is not clear.    Another case is the HP HARQ-ACK is transmitted on the HP SR PF1, the details are not clear in the proposal.  Finally, the consequece of “no support” is marginal (smaller than typical UCI errors). PDSCH/HARQ-ACK retransmission can also solve the issue. |
| Intel | Do not support the proposal.  We share same view with Samsung |
| DOCOMO | Support |
| Spreadtrum | Support |
| ITRI | Support |
| CATT | Support |
| New H3C | Support |
| Panasonic | We are fine with the proposal. |
| WILUS | Support FL’s proposal. |
| vivo | Support |
| CTC | Support |
| Lenovo | We agreed to drop LP HARQ-ACK with more than 2 bits when overlapping with HP SR. What is the reason not to drop LP HARQ-ACK up to 2 bits? The impact of LP HARQ-ACK dropping is more significant for PF2/3/4.  **Agreement**  To resolve overlapping between a HP PUCCH carrying positive SR only and a LP PUCCH carrying HARQ-ACK and CSI and/or SR, LP PUCCH with PF2/3/4 is dropped.  FFS LP PUCCH carrying LP HARQ-ACK and LP SR with PF 0/1 |
| QC | Support FL proposal.  HP URLLC SR in PF 0/1 overlap with LP eMBB HARQ-ACK in PF 0/1 might be the most typical use case. It is very surprised to see Samsung/Intel claim this is a corner case. Just imaging the following scenario in XR: UE has hevy DL eMBB traffic, while sparse UL traffic, but UL is URLLC. gNB very likely would configure HP SR with short periodcity, which would overlap with LP HARQ-ACK quite frequently. |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal for 1st round discussion:

* When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 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 (to be down-selected from the two options):
    - Option 1: , same as Rel-15;
    - Option 2:
  + 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 is used for multiplexing.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Do not support the proposal (at least not yet).  In our view, it would be good to first align companies’ views on the assumption whether K=1 or whether K could be >1 in this case. It’s our understanding that, in this case, only a single HP SR is assumed to overlap with the original PUCCH carrying HP HARQ-ACK with F0/F1.  Then, depending on the HP and LP HARQ-ACK payload sizes, two cases could be considered (with our understanding that K=1):   * If there is 1 bit HP HARQ-ACK and 1 bit LP HARQ-ACK: In our view, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules. * If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2: The agreement above would essentially be applicable in this case, where 1-bit SR is appended to the HP HARQ-ACK bits, i.e., the number of HP UCI bits is *O*uci = *O*ACK + 1, and then the multiplexing rule agreed for the case where a HP HARQ-ACK overlaps with LP HARQ-ACK can be applied. |
| Huawei/Hisi | We prefer Option 2. Option 1 requires the UE to re-determine the HP SR payload which somehow goes back to Step 1.1 for recalculating the HP UCI payload [and re-selecting the HP PUCCH resource]. In our understanding, such behavior is sort of recursive operation.  Minor editorial change for the two options:   * + - Option 1: , same as Rel-15;     - Option 2: |
| ZTE | It should be clarified that the PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 is the PUCCH with 0/1 for combined UCI of SR and HARQ-ACK, or only HARQ-ACK with PUCCH format 0/1. The different understanding means the K equals 1 or can larger than 1. |
| OPPO | Support with option 1. Option 1 applies the unfied solution for any PUCCH format case. Moreover, it provides more SR information. |
| LG | Not support FL’s proposal, it seems necessary to consider two cases as commented by Nokia in above, according to HARQ-ACK payload size as well as PUCCH format combination, PUCCH resource determination as below.  1) Case 1: HP AN is 1-bit and LP AN is 1-bit.   * If HP AN is with PF0, LP AN is dropped (in order to avoid performance loss of HP SR + HP AN mapping on the HP AN PF0) * If both HP SR and HP AN are with PF1, HP AN + LP AN are multiplexed/mapped on HP SR PF1. * If HP SR is with PF0 and HP AN is with PF1, after dropping HP SR in Step 1, HP AN + LP AN are multiplexed/mapped on HP AN PF1.   2) Case 2: at least one of HP AN and LP AN is larger than or equal to 2-bit.   * If HP AN is dynamic AN, HP SR + HP AN and LP AN are multiplexed on HP PF2/3/4 indicated by PRI in HP DCI. * If HP AN is SPS AN and sps-PUCCH-AN-List is provided, HP SR + HP AN and LP AN are multiplexed on HP PF2/3/4 provided by sps-PUCCH-AN-List.   - FFS on the case when there is no PUCCH resource configured in sps-PUCCH-AN-  List corresponding to the total payload size of HP SR + HP AN and LP AN  If HP AN is SPS AN and n1PUCCH-AN is provided for the HP SPS, LP AN is dropped. |
| Sony | Option 1 as per Rel-15. |
| Sharp | We prefer Option 2 since it provide the same SR information as HP UCI only case with a smaller SR payload.  However, Option 1 is also acceptable since it provides the index of the positive SR. |
| Samsung | Not support.  If the total bits are 2, we don’t see the reason why additional bits for SR should be appended. It is a different design from Rel-15/16 which is not acceptable at this late stage.  In addition, UE behaviour needs further clarification in some cases. For example, consider the case below. Two HP SR PUCCHs overlaps with a HP HARQ-ACK PUCCH PF 0, UE will multiplex the SR in the HP HARQ-ACK PUCCH if at least one SR is positive. When LP HARQ-ACK is multiplexed with HP HARQ-ACK and HP SR, HP PUCCH PF 0 cannot be used because the total payload is larger than 2. Therefore, a new PUCCH resource will be used instead, for example, a HP PUCCH PF 2. Multiplexing SR with HARQ-ACK in a PUCCH PF 0 and PUCCH PF 2 is different. How to handle such case needs clarification. Furthermore, if both SRs are negative, the case becomes overlapping HP HARQ-ACK PUCCH PF0 and LP HARQ-ACK PUCCH PF 2, the SR information will not be included in the resulting PUCCH. gNB needs to perform blind detection to check whether there is positive SR or not.    The LP HARQ-ACK can be dropped for simplicity. |
| Intel | For 1st sub-bullet (The number of HP UCI bits), we prefer option 2. We share same view with HW that only the SR information carried by PUCCH after step 1.1 should be considered in step 2 to avoid rescurise operation or requiring UE to store the information before step 1.1. Therefore, option 1 is not preferred.  Regarding the question asked by Nokia, in our understanding, K can be larger than 1. For example, in step 1.1, it is possible that a HP HARQ-ACK with PUCCH format 1 overlaps with K >1 HP SR resources with PUCCH format 1, but, UE only choses one HP SR resource with positive HP SR to transmit PUCCH format 1 with HP HARQ-ACK information. Simiarly, for the case of HP HARQ-ACK with PUCCH format 0 overlapping with 2 HP SR resources, UE only carry 1 bit HP SR information by CS on HP HARQ-ACK PUCCH resource. We prefer option 2 with only 1 bit HP SR information in step 2,  In addition, we’d like to clarify that, “When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1” does NOT include case that a HP HARQ-ACK with PUCCH format 1 overlaps with HP SR resources with PUCCH format 0 in step 1.1, because HP SR is dropped and the PUCCH only carries HP HARQ-ACK.  For 2nd sub-bullet (multiplexing procedure), we share similar view with NOKIA that we should consider different cases for different payload respectively.  Case 1: For 1 bit LP HARQ and 1 bit HP HARQ and 1 bit HP SR, we’re fine with dropping LP HARQ or treating LP HARQ as HP HARQ. For this case, PUCCH format 0/1 is used for resultant PUCCH. So, current 2nd sub-bullet is not proper for this case.  Case 2: For at least one of HP AN and LP AN is larger than or equal to 2-bit, we think current 2nd sub-bullet can be applied. |
| DOCOMO | For 1st sub-bullet, we prefer Option 2 with the same reason as HW/HiSi.  For 2nd sub-bullet, share the same view with Nokia/NSB and Intel that we should consider different cases for different payload sizes. |
| ITRI | Prefer option 2, re-determination of HP SR payload should be avoided. |
| CATT | We support the proposal in principle and also prefer Option 2 for the same reason as Huawei and Intel.  For 1 bit LP HARQ and 1 bit HP HARQ and 1 bit HP SR, we suppor the proposal to use PF 2/3/4 to transmit 3 bit UCIs. For the proposal from Nokia to treat 1 bit LP HARQ-ACK as 1 bit HP HARQ-ACK, there may be misunderstandings between gNB and UE if the DCI corresponding to LP HARQ-ACK is missed by the UE. For example, UE will transmit HP HARQ-ACK and positive SR using sequence cyclic shifts 3/9 when DCI corresponding to LP HARQ-ACK is missed by the UE, and gNB may consider UE receives the DCI corresponding to LP HARQ-ACK and the SR is negative. |
| Panasonic | We are fine with the proposal. |
| vivo | For 1st sub-bullet, we prefer Option 2 with the same reason as HW/HiSi.  For 2nd sub-bullet, share the same view with Nokia/NSB and Intel that we should consider different cases for different payload sizes. |
| QC | Support the spirit of this proposal. But agree with other company that the case of 3 bits (1 bit HP A/N, 1 bit LP A/N, 1 bit SR) should be treated differently. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 2nd round discussion

Question for 2nd round discussion:

When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, which case do you assume to study the solution? Why?

* + Assumption 1: Information bits for K (K≥1) HP SRs may overlap with the original PUCCH carrying HP HARQ-ACK with F0/F1.
  + Assumption 2: Only a single HP SR is assumed to overlap with the original PUCCH carrying HP HARQ-ACK with F0/F1.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | What is the intention of this proposal? If we take Assumption 2, are we saying that a HP PUCCH can overlap with more than 1 HP SR if Rel-17 intra-UE multiplexing is RRC enabled is an error case? |
| Lenovo | We think Assumption 1 includes all potential cases. |
| Nokia/NSB | We thank the Moderator for trying to clarify this aspect first.  Some companies including Intel have the understanding that K could be >1, meaning that there could be e.g. more than one HP SR overlapping with HP HARQ-ACK with PF0/PF1.  It’s true that the existing specs don’t seem to restrict K to 1, but we still actually wonder how the gNB would know which SR is positive if two SRs overlap with HARQ-ACK PF0 (or PF1)? Or did Rel-15 discuss this scenario and it was concluded that nothing additional needs to be captured in the specs? |
| Ericsson | Our understanding is different than both assumptions above. Our understanding of SR+HARQ-ACK of **PF0/1**:   * Multiple SR resources may overlap with the HARQ-ACK resources. * But the UE ensures that only one SR is triggered at most. Thus only one SR bit is to be considered in the multiplexing procedure.   + Correspondingly, the spec of 38.213 section 9.2.5.1 uses phrase like “If a UE would transmit a PUCCH with positive SR”, “If the UE would transmit negative SR”, “If a UE would transmit SR”. That is, the spec assumes a single SR bit. |
| Panasonic | We agree to Ericsson’s understanding. |
| Samsung | Assumption 1.  Assumption 2 is restrictive for HP (URLLC) scheduling. There can be multiple SR configurations and 1 or 2 bits HARQ-ACK is typical for URLLC.  Regarding Nokia’s question, at least for SR with PF 1 and HARQ-ACK with PF1, gNB is able to know which SR is positive.  The follow agreements were maded in RAN1#93   |  | | --- | | Agreements:   * If a HARQ-ACK transmission from a UE using PUCCH format 1 overlaps with SR transmission occasions corresponding to K SR PUCCH configurations each using PUCCH format 1 in a slot,   + In case of negative SR, the HARQ-ACK is transmitted on the HARQ-ACK resource. In case of positive SR, the HARQ-ACK is transmitted on the SR resource corresponding to the positive SR.   Agreements:   * If a HARQ-ACK transmission from a UE using PUCCH format 0 overlaps with SR transmission occasions corresponding to K SR PUCCH configurations, in a slot,   + If any SR is positive, indicate positive SR. Else indicate negative SR |   Consider the case below, after multiplexing, how gNB knows which SR is positive is not clear to us. |
| QC | We are not sure what is the intention of the questionnaire. Given the proposal is for the scenario of “When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK…”, is it clear the HP SR is only 1 bit, otherwise, how can step 1 multiplex 2 bits SR in a PUCCH resource with PF 0/1? |
| LG | Although we failed to completely understand the intention of this proposal, we think the Assumption 2 seems to be correct since the “HP SR and HP HARQ-ACK with PUCCH format 0/1” in above is the outcome of Step 1 where Rel-16 multiplexing is applied for a same priority. |
| InterDigital | In our understanding, MAC does not preclude transmission of more than one SR if they correspond to different SR configurations. Therefore, Assumption 1 would be correct.  It seems that R15 does not support differentiation between the multiple SRs in case of overlap with HARQ-ACK on PF0/1. The resulting transmission is the same if any of the SRs is positive. |
| NEC | Our understanding is Assumption 1. We share same understanding with InterDigital on Rel-15 multiplexing mechanism for SR and HARQ-ACK with PF0/1. |
| Sharp | We think assumption 1 is the assumption, which includes all cases. This same assumption is applied even for HP HARQ-ACK with PF0/1+ HP SR. |
| CATT | We are not sure about the intention of the proposal. Our understanding is that for the PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1, it is clear that only 1 bit SR is carried in the HP PUCCH. However, it is possible that the HP PUCCH with HARQ-ACK overlaps with multiple HP PUCCHs with SR and by applying Rel-15 multiplexing rule, HP SR and HP HARQ-ACK are multiplexed in a HP PUCCH with PF 0/1. |
| DOCOMO | We share the same understanding with InterDigital. |
| New H3C | We have the similar understanding with Samsung. |
| OPPO | Assumption 1. In our understanding, overlapping issue is for channel not information bit, so we suggest editorial modification for assumption 1.   * + Assumption 1: ~~Information bits for~~ K (K≥1) HP SR~~s~~ PUCCHs may overlap with the original PUCCH carrying HP HARQ-ACK with F0/F1.   Assumption 2 is too restrictive for scheduling  In addition, we share view as Samsung that at least for SR with PF 1 and HARQ-ACK with PF1, gNB is able to know which SR is positive. |
| ZTE | Assumption 1. It is allowed that multiple SR overlap with HP HARQ.  But we share the view from Ericsson and CATT that the spec assumes a single SR bit to be multiplexed. |
| vivo | We agree to Ericsson’s understanding. |
| Spreadtrum | Share the same view as Ericsson and CATT. |
| Intel | We prefer assumption 1 provided by OPPO, i.e., more than one HP SR PUCCH resources can overlap with one HP HARQ-ACK PUCCH and the resultant PUCCH after step 1 for HP SR and HP HARQ-ACK only carries 1 bit SR information, which is aligned with Rel-15 assumption and agreement shown by Samsung.  Regarding the case shown by Samsung, in our understanding, it is true that gNB can not know which SR is positive. But we think it’s fine, because for the case of PF 0, even without LP HARQ-ACK, gNB still does not know which SR is positive. |
| Huawei/Hisi | Assumption 1. There is no need to restrict the number of SRs to be overlapping with HP HARQ-ACK.  Echo with Nokia, that it seems in R15 it leaves the gNB implementation, that for HARQ-ACK PF0 overlapping with more than one SRs, either not to configure/schedule such collision case, or, if scheduled like this, the gNB does not distinguish the positive SR is from which SR resource, but schedules at will (e.g., by assuming the arrival of highest priority services). |
|  |  |
|  |  |
|  |  |

Proposal for 2nd round discussion:

When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, if only K=1 HP SR overlaps with the original PUCCH carrying HP HARQ-ACK,

* If there is 1 bit HP HARQ-ACK and 1 bit LP HARQ-ACK, down-select from the two options,
  + Option 1: 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is (i.e. ).
  + Option 2: LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
* If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2,
  + 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is (i.e. ).

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Option 1 |
| Lenovo | Support the proposal with option 2 in the first bullet. |
| Nokia/NSB | We support the proposal (for the case K=1) and Option 2.  As explained in the previous round, we prefer Option 2 for the case with 1 bit HP HARQ-ACK and 1 bit LP HARQ-ACK; under this option, the resulting PUCCH is with PF0/PF1. |
| Ericsson | First, we’d like to clarify that “PUCCH carrying HP SR and HP HARQ-ACK” includes HP SR being carried implicitly. For example, for the case of negative HP SR, where HP HARQ-ACK is transmitted on HP HARQ-ACK resources.  Second, Option 1 is preferred for a unified solution.  Third, cross out “if only K=1 HP SR”. As explained earlier, it’s always the case that only one SR bit is triggered for PF0/1.  The proposed edits are below:  When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, ~~if only K=1 HP SR overlaps with the original PUCCH carrying HP HARQ-ACK~~,  …  NOTE: the HP SR may be carried implicitly or explicitly on the PUCCH of format 0/1. |
| Panasonic | Option 1 is preferred for a unified solution. |
| Samsung | NOT support.  We are not clear about the intention. Does UE have different behaviour with different number of SR?  We prefer a simple and unified solution, for example, drop LP HARQ-ACK. |
| QC | Agree with Ericsson the K=1 HP SR should be crossed out, as the proposal is clear: the HP SR and HP HARQ-ACK are multiplexed into PF 0/1. Then HP SR has to be only 1 bit.  Secondly, the formulation of the proposal looks not clear to us.  We think the partition of the two bullets should not be based on payload size but should be based on the PUCCH format of the final PUCCH resource to transmit the payload. I assume the first bullet is for the case where total payload size (HP A/N + LP A/N + 1 bit SR) = 3, while the second bullet is for the case where total payload size >3. But for the first bullet when total payload = 3bits, depend on it is transmitted in PF0 or PF 2/3/4, the way to transmit it is very different.  So we think the clean partition the first bullet and second bullet should be based on final PUCCH format to transmit the total payload, instead of based on the payload size. We suggest to reformate the proposal as following. Basically the major change is to lump option 1 in the first bullet into the second bullet, because it seems they share a same solution. With this change, the partition of the two bullets is based on PF, which seems cleaner.  **When a PUCCH carrying HP SR and HP HARQ-ACK in PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, based on total number of HP HARQ-ACK bits, LP HARQ-ACK bit, and SR bit, determine a resulting PUCCH resource in the configured HP PUCCH resources, either following PRI or sps-PUCCH-AN-List.**   * **If the resulting PUCCH is in PF0, treat the 1-bit LP A/N as if it is HP and reuse Rel-15 procedure to multiplex the three bits in the PF0 PUCCH.**   **If the resulting PUCCH is in PF2/3/4, append the HP SR to HP HARQ-ACK bits, then multiplex with LP HARQ-ACK by reusing the procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource in PF 2/3/4.** |
| LG | Regarding the above proposal, we have some question/comments as below.  If there is 1 bit HP HARQ-ACK and 1 bit LP HARQ-ACK,   1. Question: With Option 1, the HP SR and 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK would be 3-bit and thus would be multiplexed on PF2/3/4. Is this correct understanding? 2. Comment: With Option 2, the CS mapping for HP SR and 1-bit HP HARQ-ACK on PF0 would be degraded due to LP HARQ-ACK. The gap between adjacent CSs on PF0 is 3 in Step 1, but the gap would be decreased to 1 with Option 2 in Step 2.   For this reason, it is better to drop the LP HARQ-ACK in above case where HP UCI would be multiplxed on PF0. But in other case where HP UCI would be multiplexed on PF1, there might be no degradation with Option 2.  If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2,   1. Comment: If the HP HARQ-ACK is 1-bit SPS HARQ-ACK and the corresponding SPS PUCCH resource is provided by n1PUCCH-AN, the LP HARQ-ACK may not be multiplexed with HP UCI. |
| InterDigital | It should be clarified if the above proposal is also applicable to negative SR?  If HP SR is positive, prefer to drop LP HARQ-ACK for simplicity and to ensure robustness of the HP HARQ-ACK and SR. |
| Sharp | We support option 1.  And the same approach should be applied for all HARQ-ACK payload cases since even 1-bit HP HARQ-ACK + 1-bit HP SR + 1-bit LP HARQ-ACK is 3 bits. Thus, a PUCCH format 2/3/4 should be used to multiplex them. |
| CATT | We agree with the comment from Ericssion and Qualcomm that the proposal should apply to K=1 and K>1 cases.  Between Option 1 and 2, we prefer Option 1 which is a unifed solution and can avoid potential misunderstanding between gNB and UE as we commented in the 1st round. |
| DOCOMO | Prefer Option 1. |
| New H3C | Prefer Option 1. |
| OPPO | We prefer to Option 1 due to it is a unified solution.  In proposal, and are the same, so K should be limited to 1.  If we take K>1 into account, we need to select one forluma between and , we prefer to the latter one, ,which provide more accurate SR information.  In Rel15, when PUCCH for SR and HARQ-ACK is PUCCH format 2/3/4, K bits is reserved for SR. Similarly, when PUCCH for HP SR, HP HARQ-ACK and LP HARQ-ACK is PUCCH format 2/3/4, it is nature to reserve K bits for SR. Kindly note that although PUCCH for HP SR and HARQ-ACK is PUCCH format 0/1, PUCCH for HP SR, HP HARQ-ACK and LP HARQ-ACK is selected from PUCCH-Config for HP HARQ-ACK and it can be PUCCH format 2/3/4. |
| ZTE | Support Option 1. And share the comments from Ericssion, CATTand Qualcomm that the proposal should apply to K=1 and K>1 cases. For the target PUCCH format, PF2/3/4 is the better choice to avoid more specification work or unpredicted performance loss. |
| vivo | For option 1, we have the same question as LG. If the HP SR and 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK would be multiplexed on PF2/3/4. It may be a new behavior. Currently, for two bits HARQ-ACK and SR, it is transmitted in a PUCCH with PF0/1. |
| Intel | We share the same view with CATT, Ericssion and Qualcomm that the proposal should apply to K=1 and K>1 cases.  For option 1 and option 2, we prefer option 2, considering we already agreed to treat 1 bit LP as HP HARQ-ACK for 1 bit LP and 1 bit HP case, and it is natural to resue Rel-15 solution for 2 bits HARQ-ACK + 1 bit SR case, i.e., using PF 0/1. |
| Huawei/Hisi | Option 1 is preferred as a unified solution. Considering we have an ongoing discussion on whether to support HP SR with LP HARQ-ACK of PF 0/1, it is safe to take the 3 bits using PF 2/3/4 instead of using SR resources. The same principle can be applied for K>1 cases. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 3rd round discussion

Proposal for 3rd round discussion:

When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK (NOTE: the HP SR may be carried implicitly or explicitly on the PUCCH of format 0/1),

* Option 1: When one HP SR overlaps with the original PUCCH carrying HP HARQ-ACK, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is ~~(i.e. )~~.
  + New H3C, OPPO, ZTE, Sony, Apple, Ericsson, DOCOMO, NEC, Huawei/Hisi, Spreadtrum
* Option 2: When one HP SR overlaps with the original PUCCH carrying HP HARQ-ACK,
  + If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
  + If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is ~~(i.e. )~~.
  + Nokia/NSB, Intel, vivo
* Option 2a: When one HP SR overlaps with the original PUCCH carrying HP HARQ-ACK, down-select from the two options,
  + If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK,
* If HP SR and HP HARQ-ACK are on PUCCH format 1, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
* If HP SR and HP HARQ-ACK are on PUCCH format 0, LP HARQ-ACK is dropped.
  + If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2,
* If HP HARQ-ACK is dynamic HARQ-ACK or SPS HARQ-ACK with sps-PUCCH-AN-List, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is (i.e. ).
* If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped.
  + LG
* Option 3: Based on total number of HP HARQ-ACK bits, LP HARQ-ACK bit, and SR bit, determine a resulting PUCCH resource in the configured HP PUCCH resources, either following PRI or sps-PUCCH-AN-List.
  + If the resulting PUCCH is in PF0, treat the 1-bit LP A/N as if it is HP and reuse Rel-15 procedure to multiplex the three bits in the PF0 PUCCH.
  + If the resulting PUCCH is in PF2/3/4, append the HP SR to HP HARQ-ACK bits, then multiplex with LP HARQ-ACK by reusing the procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource in PF 2/3/4.
  + QC
* Not support: Samsung

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | We are fine with the proposal and prefer Option 2. |
| New H3C | We support Option 1 |
| OPPO | Support Option 1 due to it is a unified solution. |
| Samsung | Not support.  We prefer a simple unified solution. For example, drop LP HARQ-ACK.  The two proposals should be jointly discussed. |
| LG | Not support both Option 1 and Option 2 as it is.  We already provided/explained some related comments and HP performance concern in 2nd round (please check those in above), so based on those, the following update is suggested for Option 2.   * Updated Option 2:   + If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK, * If HP SR and HP HARQ-ACK are on PUCCH format 1, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules. * If HP SR and HP HARQ-ACK are on PUCCH format 0, LP HARQ-ACK is dropped.   + If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2, * If HP HARQ-ACK is dynamic HARQ-ACK or SPS HARQ-ACK with sps-PUCCH-AN-List, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is (i.e. ). * If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped. |
| ZTE | We slightly prefer Option 1 as it can be unified to the case of K>1, if any. |
| Sony | Option 1 |
| Apple | Option 1, the situation is totally different from HP SR only + LP HARQ. Option 1 is simple |
| Sharp | Optoin 1 is preferred as a unified solution. Since HP HARQ-ACK + HP SR + LP HARQ-ACK is at least 3 bits, a HP PUCCH with PF2/3/4 should be used in all cases. |
| Ericsson | First, we’d like to clarify that “PUCCH carrying HP SR and HP HARQ-ACK” includes HP SR being carried implicitly. For example, for the case of negative HP SR, where HP HARQ-ACK is transmitted on HP HARQ-ACK resources. ‘Implicit’ means: SR is not explicity carried as 1 bit.  Second, Option 1 is preferred for a unified solution.  Third, cross out “if only K=1 HP SR”. As explained earlier, it’s always the case that only one SR bit is triggered for PF0/1.  Fourth: cross out log2(K+1). What’s the reason to have this? In Rel-15, log2(K+1) was to indicate which SR was triggered. But this intention is not relevant in this context.  The proposed edits are below:  **Modified proposal:**  When a PUCCH carrying HP SR (implicitly or explicitly) and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, ~~if only K=1 HP SR overlaps with the original PUCCH carrying HP HARQ-ACK~~,  …  ~~(i.e. )~~  …  NOTE: the HP SR may be carried implicitly or explicitly on the PUCCH of format 0/1. |
| DOCOMO | Fine with the proposal and Option 1 is slightly preferred as it is a unified solution regardless of the SR bit size. |
| Intel | We share the same understanding with Ericssion’s 1st, 3rd and 4th comments.  For option 1 and option 2, we prefer option 2.  Regarding the comment for unified solution, option 2 is also a unfied solution, i.e., LP HARQ-ACK, HP HARQ-ACK and HP SR are multiplexed, regardless of the payload. Regarding how to multiplex, it is natural to use different way for different payload, as in Rel-15/16. Considering we already agreed to treat 1 bit LP as HP HARQ-ACK for 1 bit LP and 1 bit HP case, and it is natural to resue Rel-15 solution for 2 bits HARQ-ACK + 1 bit SR case, i.e., using PF 0/1. |
| NEC | Option 1 is preferred since it is a unified solution. |
| QC | We don’t support the proposal as it is, although the spirit of the proposal is fine.  We have a similar comment as LG, the partition of the bullet should be based on PUCCH format, not based payload size. Given 3 bits payload, resulting PUCCH resource in PF1 vs resulting PUCCH resource in PF2/3/4 lead to totally different solution.  We hope FL can consider the following reformulation of the proposal.  **Proposal:**  **When a PUCCH carrying HP SR and HP HARQ-ACK in PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, based on total number of HP HARQ-ACK bits, LP HARQ-ACK bit, and SR bit, determine a resulting PUCCH resource in the configured HP PUCCH resources, either following PRI or sps-PUCCH-AN-List.**   * **If the resulting PUCCH is in PF0, treat the 1-bit LP A/N as if it is HP and reuse Rel-15 procedure to multiplex the three bits in the PF0 PUCCH.**   **If the resulting PUCCH is in PF2/3/4, append the HP SR to HP HARQ-ACK bits, then multiplex with LP HARQ-ACK by reusing the procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource in PF 2/3/4.** |
| Huawei/Hisi | Option 1 is preferred as a unified solution. For Option 2, it is weird that we do not support multiplexing of 1bit LP HARQ-ACK with HP SR on SR, but support multiplexing of 1bit LP HARQ-ACK, 1 bit HP HARQ-ACK and HP SR on SR.  **Agreement**  When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1, the LP HARQ ACK is dropped when colliding with positive SR |
| LG2 | @ QC (& Intel): I’d like to clarify one thing.  In case where HP SR and 1-bit HP AN in PF0 overlaps with 1-bit LP AN PUCCH, are you proposing to treat 1-bit LP AN as HP and then to map 3-bit on PF0? If so, as we provided concern in 2nd round (captured below), it cause performance loss of HP UCI reliability.   |  | | --- | | 1. Comment: With Option 2, the CS mapping for HP SR and 1-bit HP HARQ-ACK on PF0 would be degraded due to LP HARQ-ACK. The gap between adjacent CSs on PF0 is 3 for HP SR + HP HARQ-ACK, but the gap would be decreased to 1 with Option 2 due to LP HARQ-ACK. |   For this reason, it is reasonable to drop the LP AN in the above case where HP SR + HP AN would be multiplxed on PF0. But in other case where HP SR + HP AN would be multiplexed on PF1, there would be no degradation even with Option 2. |
| vivo | we prefer option 2. Regarding unified solution, we agree with Intel’s view. |
| Spreadtrum | We support Option 1, due to unified solution is preferred. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal for 3rd round discussion:

When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, if K>1 HP SR overlaps with the original PUCCH carrying HP HARQ-ACK,

* In Step 1, 1-bit HP SR is multiplexed to HP HARQ-ACK bits for determining the resultant PUCCH resource of Step 1.
* In Step 2, down-select from the two options,
  + Option 1: The K HP SRs are appended.
    - OPPO
  + Option 2: The 1 HP SR is appended.
    - Nokia/NSB, LG, ZTE, DOCOMO, Intel, NEC, Huawei/Hisi, vivo
* Not support: Samsung,

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Fine with the proposal in principle. And we support the intention of Option 2 since anyhow a single HP SR is considered in Step 1.  We suggest the following updates (in red) on the proposal:  When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, if ~~only~~ K>1 HP SR overlaps with the original PUCCH carrying HP HARQ-ACK, ~~down-select from the two options~~,   * In Step 1, 1-bit HP SR is multiplexed to HP HARQ-ACK bits (based on Rel-15 rules) for determining the resultant PUCCH resource of Step 1. * In Step 2, down-select from the two options   + Option 1: The K HP SRs are appended.   + Option 2: The 1 HP SR is appended. |
| OPPO | Fine with proposal and prefer to option 1.  Option 1 provides more SR status information, i.e. which SR is positive. It allows fast scheduling for URLLC due to gNB knows logic channel corresponding to positive SR. In Rel-15, when PUCCH format 2/3/4 is used for SR and HARQ-ACK multiplexing, K bits are reserved for K SR. Option 1 is line with Rel-15 operation. |
| Samsung | Not support.  We prefer a simple unified solution. For example, drop LP HARQ-ACK.  The two proposals should be jointly discussed. |
| LG | Similar view with Nokia.  In step 1, only one among K HP SR PUCCHs is multiplexed with HP HARQ-ACK PUCCH as in Rel-15, and then in Step 2, the resultant PUCCH with the one HP SR and HP HARQ-ACK would be multiplexed with LP PUCCH. |
| ZTE | To align with the current specification, Option 2 is preferred. |
| Sharp | Option 2 is preferred. |
| Apple | We don’t understanding the intention behind the proposal, Step 1.1 is supposed to be used for handling intra-L1 priority processing. What is the reason to modify that? E.g. if SR requires 3 bits, why only a single bit is required for SR in resultant PUCCH lookup in step 1.1?  When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, if only K>1 HP SR overlaps with the original PUCCH carrying HP HARQ-ACK, down-select from the two options,   * In Step 1, 1-bit HP SR is multiplexed to HP HARQ-ACK bits for determining the resultant PUCCH resource of Step 1. |
| Ericsson | In Rel-15, for SR overlapping with HARQ-ACK of PF0/1, UE triggers one SR at most, i.e., only 1 SR bit is to be considered. Thus Option 1 does not make sense.  Also, with the Rel-15 understanding, there is no need to differentiate “1 SR overlap with HARQ-ACK” or “K>1 SR overlap with HARQ-ACK”. Thus the above proposal is not needed. The modified proposal can cover both.  **Modified proposal:**  When a PUCCH carrying HP SR (implicitly or explicitly) and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, ~~if only K=1 HP SR overlaps with the original PUCCH carrying HP HARQ-ACK~~,  …  ~~(i.e. )~~  …  NOTE: the HP SR may be carried implicitly or explicitly on the PUCCH of format 0/1. |
| DOCOMO | Fine with the proposal and Option 2 is preferred to align with the spec. |
| Intel | Step 1 in this proposal is exactly the same UE behaviour in Rel-15. No need to agree on it again. For step 2, we agree with option 2. But as Ericsson commented, there is no need to differentiate “1 SR overlp with HARQ-ACK” or “K>1 SR overlap with HARQ-ACK”.  Suggest to combine these two proposals into one, e.g,  When a PUCCH carrying HP SR (implicitly or explicitly) and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, ~~if only K=1 HP SR overlaps with the original PUCCH carrying HP HARQ-ACK~~, down-select from the two options,   * Option 1: 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is ~~(i.e. ).~~ * Option 2:   + If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.   If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is ~~(i.e. ).~~ |
| NEC | Option 2 is preferred. We don’t see the benefit to change current spec for multiplexing SR and HARQ-ACK with PF0/1 |
| QC | For step 1: whatever UE behavior defined in Rel-15 should be applied. We don’t need to have agreement covering step 1, although we agree 1 bit SR is the correct interpretation of Rel-15 spec for this case.  For step 2: listing two options are fine.  We suggest the following update on top of Nokia’s version.  Proposal: When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, if ~~only~~ K>1 HP SR overlaps with the original PUCCH carrying HP HARQ-ACK, ~~down-select from the two options~~,   * In Step 1, 1-bit HP SR is multiplexed to HP HARQ-ACK bits (based on Rel-15 rules) for determining the resultant PUCCH resource of Step 1. * In Step 2, down-select from the two options   + Option 1: ~~The K~~ bits of HP SRs are appended.   + Option 2: ~~The~~ 1 bit of HP SR is appended.   Note: the description of step 1 in this agreement is only for information purpose, which has no spec impact. |
| Huawei/Hisi | Option 2 is preferred as a unified solution. |
| vivo | Option 2 is preferred. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 4th round discussion

Thank you for the 3rd round discussion in which companies’ positions are better clarified. Based on that we can consider to combine the two proposals back to one.

Proposal for 4th round discussion:

When a PUCCH carrying explicit/implicit HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, where the original PUCCH carrying the HP HARQ-ACK before Step 1 overlaps with K HP SRs which are all negative or include at least one positive,

* In Step 1, 1-bit HP SR is multiplexed to HP HARQ-ACK bits (based on Rel-15 rules) for determining the resultant PUCCH resource.
  + Note: The description of Step 1 here is only for information purpose, which has no spec impact.
* In Step 2, down-select from the following options,
  + Option 1: bits of HP SRs are appended, 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 .
  + Option 2: 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is
  + Option 3:
    - If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
    - If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is
      * If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped.
  + Option 4 (LG):
    - If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK,
      * If HP SR and HP HARQ-ACK are on PUCCH format 1, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
      * If HP SR and HP HARQ-ACK are on PUCCH format 0, LP HARQ-ACK is dropped.
    - If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2,
      * If HP HARQ-ACK is dynamic HARQ-ACK or SPS HARQ-ACK with sps-PUCCH-AN-List, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is (i.e. ).
      * If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped.
  + Option 5 (QC): Based on total number of HP HARQ-ACK bits, LP HARQ-ACK bit, and SR bit, determine a resulting PUCCH resource in the configured HP PUCCH resources, either following PRI or sps-PUCCH-AN-List.
    - If the resulting PUCCH is in PF0, treat the 1-bit LP A/N as if it is HP and reuse Rel-15 procedure to multiplex the three bits in the PF0 PUCCH.
    - If the resulting PUCCH is in PF2/3/4, append the HP SR to HP HARQ-ACK bits, then multiplex with LP HARQ-ACK by reusing the procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource in PF 2/3/4.
  + Option 6 (Sony, Option 3 + 4):
    - If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK,
      * If HP SR and HP HARQ-ACK are on PUCCH format 1, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
      * If HP SR and HP HARQ-ACK are on PUCCH format 0, LP HARQ-ACK is dropped.
    - If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is

|  |  |
| --- | --- |
| Option 1 | OPPO |
| Option 2 | Ericsson, ZTE, Intel (can accept), CATT, DOCOMO, NEC, Lenovo, Sharp |
| Option 3 | Ericsson (can accept), ZTE, Intel, New H3C, Huawei/Hisi, vivo, Nokia/NSB |
| Option 4 | LG |
| Option 5 | QC, Lenovo |
| Option 6 | Sony, Samsung |

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Are Option 3, 4 and 5 further details of Option 2? Should they really be different options to Option 2?  On Option 4, it isin’t clear why we nee to diffenriate between dynamic HARQ-ACK and SPS HARQ-ACK. We prefer a combination of Option 3 and 4, i.e.:  Option 6 (Option 3 + 4):   * If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK,   + If HP SR and HP HARQ-ACK are on PUCCH format 1, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.   + If HP SR and HP HARQ-ACK are on PUCCH format 0, LP HARQ-ACK is dropped. * If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is |
| InterDigital | Sorry for missing 3rd round. A few questions/comments:  In the above options, is there a difference if SR is negative or positive?  In our understanding, in R15 there is no change of PUCCH resource set or format due to SR when the PUCCH with HARQ-ACK would be F0/1. It seems that Option 5 and perhaps Option 1 would deviate from that behaviour (the resource could be “upgraded” from F0/1 to F2/3/4). Is this ok from gNB perspective?  Considering that we will (most likely) drop LP HARQ-ACK when it overlaps with positive HP SR only, shouldn’t we have the Option that LP HARQ-ACK is dropped for that case too? Is it more important to avoid dropping when HP HARQ-ACK is also present? |
| Ericsson | Support Option 2 for simplicity. Can accept Option 3 for a bit more optimization.  For Option 5, it is not clear why the total of {HP A/N, LP A/N, SR} will be ever mapped to PF0/1, since PF0/1 can only carry 1-2 payload bits. Thus, only 2nd bullet of Option 5 is relevant? How many bits are assumed for SR in Option 5? |
| Apple | The only viable solution is Option 2:  Option 1 does not follow the processing flow of Step 1 and Step 2, whatever comes out of Step 1 is taken by Step 2; asking UE to remember the original MUX scenario is too much  Other options would multiple HP UCI/LP UCI on the same part. Companies argued doing that is undesirable, let us be consistent. |
| Samsung | NOT support.  Step 1 is misleading, there is no “1 bit SR” when multiplexing with HARQ-ACK PF0/1. Step 1 should be removed  We support Option 6, drop LP HARQ-ACK as we clarified in previous round. |
| LG | Support the proposal formulated by FL.  We have following comment/concern on each option.  On Option 1:  Given that one HP SR (among K HP SRs) is already selected to be multiplexed with HP HARQ-ACK on PF0/1 by following Rel-15 rule in Step 1, UE should reconsider/reprocess all K HP SRs (including already precluded {K-1} HP SRs) again in Step 2. Thus, it doesn’t seem to be aligned with basic design principle of Step 1/2 and would cause complication.  On Option 2:  In case with 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK, total UCI size becomes 3-bit (even though actual HARQ-ACK is 2-bit) and the 3-bit needs to be multiplexed on PF2/3/4, which is quite different from Rel-15/16 where SR and 2-bit HARQ-ACK are multiplexed on PF0/1. Thus, it would cause significant change/impact to UE/gNB implementation.  On Option 3 and 5:  As commented multiple times during 1st/2nd/3rd rounds, performance/reliability of HP SR + HP HARQ-ACK on PF0 would be quite degraded compared to Rel-16.  For HP SR + 1-bit HP HARQ-ACK, 4 CSs {0, 3, 6, 9} are used on PF0, so the gap between adjacent CSs is 3 which is sufficient to guatantee the HP UCI performance. But, if 1-bit LP HARQ-ACK is treated as HP HARQ-ACK with Option 3/5, 8 CSs {0, 1, 3, 4, 6, 7, 9, 10} would be used on PF0, then the gap between adjacent CSs would be decreased to 1 which cause performance degradation of HP UCI. Therefore, in order for ensuring Rel-16 HP UCI reliability, it is reasonable to drop the 1-bit LP HARQ-ACK in above case.  @ Sony:  Thank you for suggesting the combination. But as you also know, if HP HARQ-ACK is SPS HARQ-ACK and the corresponding PUCCH resource is provided by n1PUCCH-AN, the HP SPS PUCCH would be PF0/1, which could not accommodate m-bit LP HARQ-ACK. That’s the reason why we differentiated this case and other case with PF2/3/4. |
| ZTE | Support.  The Option 3 is more likely the extention or explanation of Option 2, we prefer Option 2 and Option 3.  For Option 4, I understand the reason why “If HP SR and HP HARQ-ACK are on PUCCH format 0, LP HARQ-ACK is dropped.” is proposed as the worry to the performance loss of 1 bit HP HARQ-ACK, but this violates the pricinple of reusing Rel-16/Rel-15 rules.  For the first comment for Interdigital on difference if SR is negative or positive? I think if Option 3 is adopted, the legacy Rel-16/Rel-15 rules are reused, and no impact on gNB implementation.  For the second comment for Interdigital, I think the PF format changing is anyway possible, as the total size may change if the LP HARQ-ACK is involved in the multiplexing  For the third comment for Interdigital, if we could achieve any agreement, we can just drop the LP HARQ-ACK, i.e., fallback to Rel-16. |
| Intel | Support Optoin 3. We can live with Option 2, if it is majority view.  Regarding the performance degradation mentioned by LG, yes, CS distance is smaller for multiplexing LP HARQ-ACK and HP HARQ-ACK+SR, compared with HP HARQ-ACK+SR only, but similar degradation also exists for the case of 1 bit LP HARQ-ACK + 1 bit HP HARQ-ACK case. If option 2 can address the concern for performance, we’re fine with option 2. |
| CATT | We support Option 2, which is a simple and unified solution and would not lead to LP HARQ-ACK dropping.  For Option 1, we think it complicates UE implementation since UE needs to go back to check the number of overlapping HP SRs in step 2.  We are not quite clear about the difference between Option 3 and Option 5. But to our understanding, both options may lead to misunderstandings between gNB and UE if the DCI corresponding to LP HARQ-ACK is missed by the UE as we commented in 1st round. To be more specific, for 1 bit LP HARQ and 1 bit HP HARQ and 1 bit HP SR, if DCI corresponding to LP HARQ-ACK is missed by the UE, UE will transmit HP HARQ-ACK and positive SR using sequence cyclic shifts 3/9. But from gNB’s perspectrive, gNB may consider UE receives the DCI corresponding to LP HARQ-ACK and the SR is negative. So these options should not be agreed to avoid impacting HP UCI.  Table 9.2.3-4: Mapping of values for two HARQ-ACK information bits to sequences for PUCCH format 0   |  |  |  |  |  | | --- | --- | --- | --- | --- | | HARQ-ACK Value | {0, 0} | {0, 1} | {1, 1} | {1, 0} | | **Sequence cyclic shift** |  |  |  |  |   Table 9.2.5-1: Mapping of values for one HARQ-ACK information bit and positive SR to sequences for PUCCH format 0   |  |  |  | | --- | --- | --- | | HARQ-ACK Value | 0 | 1 | | **Sequence cyclic shift** |  |  |   For Option 4, it leads to LP HARQ-ACK dropping if HP SR and HP HARQ-ACK are on PUCCH format 0 and also the option is too complicated depending on the payload size and PUCCH format. |
| QC | @Ericsson, PF0 can transmit up to 3 bits, in case of 2 bis A/N + 1 bit SR. We agree with you that most of the cases, only second bullet in option 5 is needed. However, the first bullet is also needed to handle this special case of 1 bit HP A/N + 1 bit LP A/N + 1 bit SR in PF0.  In general, in our proposal, we assume SR is ceil{log2(1+K)} bits. The first bullet is for the special case where K=1 so SR is 1 bit in the bullet bullet.  Again, our main point is that, except the special case of 1 bit HP A/N + 1 bit LP A/N + 1 bit SR in PF0, the rest of norminal cases should follow agreement we made for PF 2/3/4 in last meeting, which is the second bullet. But the special case needs a special handling. That is why we have the first bullet.  @Sony @FL, our understanding is option 3/4/5 indeed are filling more details for option 1 or 2. But we don’t support option 2. We think limitting K=1 is a little too restrictive. |
| New H3C | We prefer Option 2 as simple way, compared with other options. |
| Huawei/Hisi | Prefer Option 2 as a unified solution.  For Option 3/4, the UE behavior is the same as Option 2 if either HP HARQ-ACK of LP HARQ-ACK is >=2 bits (note the dropping of LP HARQ-ACK in case of n1PUCCH-AN should be be applied also for for Option 2 as well as HP HARQ-ACK only case). The only difference is when both HP HARQ-ACK and LP HARQ-ACK are 1 bit, which is not typical and not worth a different handling in our view. In addition, as the LP HARQ-ACK multiplexing with HP SR is not supported, it is weird to support the multiplexing of the two UCIs when HP HARQ-ACK is also involved.  For Option 5, it is not clear how to handle the case if the resulting PUCCH is PF1. In addition, it is not clear why the PF of the resulting HP/LP PUCCH is set as a condition; in R15, the PF of the resultant channel of multiple UCIs is a result of the multiplexing by taking the PF of the original PUCCHs as well as the total payload size as the input, e.g., if HARQ-ACK is PF1 and SR is PF1, the resultant channel is HARQ-ACK PF1/SR PF1 channel selection, while if HARQ-ACK is PF0 and SR is PF0/1, the resultant channel is HARQ-ACK PF0; with this in mind, it is still not clear how to derive the PF of the resultant PUCCH in Option 5.  In addition, for Option 2/3/4/5, we need to consider also the all negative SR case where the HP PUCCH does not includes explicit positive SR information, so the main text is changed as  When a PUCCH carrying explicit/implicit HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, where the original PUCCH carrying the HP HARQ-ACK before Step 1 overlaps with K HP SRs which are all negative or include at least one positive, |
| vivo | Support Optoin 3. PUCCH PF 0/1 should be used in case of 2 bis A/N + 1 bit SR. For option 5, we are wondering why the resulting PUCCH cann’t be PF1? |
| DOCOMO | We prefer Option 2, which is a simple and unified solution. Regarding Option 3/4/5, it is not clear why LP HARQ-ACK is multiplexed when it overlaps with HP HARQ-ACK and SR although the multiplexing of HP SR and LP HARQ-ACK is not supported. |
| Nokia/NSB | Support Option 3 – which is the Option proposed and explained in our Tdoc.  As suggested by LG, for the cases where at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is >=2 and HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, we could drop LP HARQ-ACK. Accordingly, we suggest some updates (in red) below on Option 3.  The option where LP HARQ-ACK is always dropped is not preferred, since this dropping could be avoided. Also, although we LP HARQ-ACK is dropped when overlapping with HP SR, when there is also HP HARQ-ACK there is no need to always drop LP HARQ-ACK as this could be avoided based on the agreed multiplexing for HP and LP HARQ-ACKs.  On having K>1 (e.g., under Option 1), we share other companies’ views that such is not needed and K=1 is enough.  Otherwise, we can compromise and be fine with Option 2 if supported by the majority. Note that although we understand its intention, maybe the current description of this option is not fully clear.  << When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK,   * In Step 1, 1-bit HP SR is multiplexed to HP HARQ-ACK bits (based on Rel-15 rules) for determining the resultant PUCCH resource.   + Note: The description of Step 1 here is only for information purpose, which has no spec impact. * In Step 2, down-select from the following options,   + …   + Option 3:     - If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.     - If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is .       * If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped.   + … |
| NEC | Option 2 is slightly preferred to provide a simple and unified solution. |
| Sharp | Option 2 is preferred as a simple and unified solution. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 5th round discussion

The wording of the proposal and some options are improved. Please finally check your positions before the GTW session.

Proposal for 5th round discussion:

When a PUCCH carrying explicit/implicit HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, where the original PUCCH carrying the HP HARQ-ACK before Step 1 overlaps with K HP SRs which are all negative or include at least one positive,

* In Step 1, 1-bit HP SR is multiplexed to HP HARQ-ACK bits (based on Rel-15 rules) for determining the resultant PUCCH resource.
  + Note: The description of Step 1 here is only for information purpose, which has no spec impact.
* In Step 2, down-select from the following options,
  + Option 1: bits of HP SRs are appended, 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 .
  + Option 2: 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is
  + Option 3:
    - If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
    - If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is
      * If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped.
  + Option 4 (LG):
    - If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK,
      * If HP SR and HP HARQ-ACK are on PUCCH format 1, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
      * If HP SR and HP HARQ-ACK are on PUCCH format 0, LP HARQ-ACK is dropped.
    - If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2,
      * If HP HARQ-ACK is dynamic HARQ-ACK or SPS HARQ-ACK with sps-PUCCH-AN-List, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is (i.e. ).
      * If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped.
  + Option 5 (QC): Based on total number of HP HARQ-ACK bits, LP HARQ-ACK bit, and SR bit, determine a resulting PUCCH resource in the configured HP PUCCH resources, either following PRI or sps-PUCCH-AN-List.
    - If the resulting PUCCH is in PF0, treat the 1-bit LP A/N as if it is HP and reuse Rel-15 procedure to multiplex the three bits in the PF0 PUCCH.
    - If the resulting PUCCH is in PF2/3/4, append the HP SR to HP HARQ-ACK bits, then multiplex with LP HARQ-ACK by reusing the procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource in PF 2/3/4.
  + Option 6 (Sony, Option 3 + 4):
    - If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK,
      * If HP SR and HP HARQ-ACK are on PUCCH format 1, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
      * If HP SR and HP HARQ-ACK are on PUCCH format 0, LP HARQ-ACK is dropped.
    - If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is

|  |  |
| --- | --- |
| Company | Comments |
| Lenovo | Support joint operation of option 2 and option 5.  In Step 2, it is not desired to change the HP UCI bits which was determined in step 1. Thus, a resultant PUCCH resource should determined based on the total UCI bits, i.e. sum of HP UCI bits and LP HARQ-ACK bits. |
| Sony | Support the proposal but are we suppose to downselect one of these options? If not when are we supposed to do this.  For downselecting purpose, we prefer Option 6.  We can also support Option 2 but believe Option 2 needs a bit more details which are provided in Option 6. |
| Nokia/NSB | As we explained in the previous round of discussion, Option 3 is our first preference.  To provide further alacrity on Option 3, in the following we detail the handling rule depending on the PUCCH format combination for the case where there 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK (and obviously 1-bit HP SR).   * If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules. Specifically:   + **For HP SR with PF0/PF1 and HP HARQ-ACK with PF0**, the 1-bit HP HARQ-ACK + 1-bit HP SR + 1-bit LP HARQ-ACK are multiplexed on the PUCCH resource (with PF0) of HP HARQ-ACK by treating the LP HARQ-ACK as HP bit and following Rel-15/Rel-16 mux rules.   + **For HP SR with PF0 and HP HARQ-ACK with PF1**, according to Rel-15/Rel-16 rules, the SR is dropped. Then, the 1-bit LP HARQ-ACK is treated as HP bit and multiplexed with the HP HARQ-ACK bit on the PUCCH resource (with PF1) of HP HARQ-ACK.   + **For HP SR with PF1 and HP HARQ-ACK with PF1**, the 1-bit HP HARQ-ACK + 1-bit HP SR are multiplexed based on Rel-15/Rel-16 by ‘transmitting’ HP HARQ-ACK on the SR resource when the SR is positive; and ‘transmitting’ HP HARQ-ACK on the HP HARQ-ACK resource when the SR is negative. Then, the 1-bit LP HARQ-ACK is treated as HP bit and multiplexed with the HP HARQ-ACK bit (and thus implicitly with the HP SR) on the resulting PUCCH resource (with PF1) containing the HP HARQ-ACK bit.   Otherwise, as we previously mentioned, we can compromise and be fine with Option 2 if supported by the majority. Note that although we understand its intention, maybe the current description of this option is still not fully clear. Under Option 2, at least based on our understanding, it seems that the resulting PUCCH resource for multiplexing HP SR + HP HARQ-ACK + LP HARQ-ACK is either of PF2, PF3, or PF4 (i.e., cannot be PF0 or PF1) as the SR bit is appended to the HP HARQ-ACK. |
| Sharp | Option 2 is preferred as a simple and unified solution. |
| LG | Option 4 is preferred to gurantee Rel-16 performance/reliability for multiplexing of HP SR + HP HARQ-ACK.  @ Nokia:  Thank you for providing the detailed behaviors for the case with 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK. We are supportive to the 2nd sub-bullet “For HP SR with PF0 and HP HARQ-ACK with PF1” and the 3rd sub-bullet “For HP SR with PF1 and HP HARQ-ACK with PF1” in above. However, we are NOT supportive to the 1st sub-bullet “For HP SR with PF0/PF1 and HP HARQ-ACK with PF0” since it causes performance/reliability degradation of HP SR + HP HARQ-ACK on PF0 compared to Rel-16, as already commented in 4th round as below.   |  | | --- | | *For HP SR + 1-bit HP HARQ-ACK, 4 CSs {0, 3, 6, 9} are used on PF0, so the gap between adjacent CSs is 3 which is sufficient to guatantee the HP UCI performance. But, if 1-bit LP HARQ-ACK is treated as HP HARQ-ACK with Option 3/5, 8 CSs {0, 1, 3, 4, 6, 7, 9, 10} would be used on PF0, then the gap between adjacent CSs would be decreased to 1 which cause performance degradation of HP UCI. Therefore, in order for ensuring Rel-16 HP UCI reliability, it is reasonable to drop the 1-bit LP HARQ-ACK in above case.* |   @ Intel:  Regarding your comment in 4th round “similar degradation also exists for the case of 1 bit LP HARQ-ACK + 1 bit HP HARQ-ACK case”, in case with 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK, 4 CSs {0, 3, 6, 9} are used on PF0, so there is no performance issue since the CS gap is sufficient. But, in case with HP SR + 1-bit HP HARQ-ACK and 1-bit LP HARQ-ACK, 8 CSs {0, 1, 3, 4, 6, 7, 9, 10} which cause performance degradation of HP SR + HP HARQ-ACK, have to be used due to the LP HARQ-ACK (even though 4 CSs {0, 3, 6, 9} can be used for HP SR + 1-bit HP HARQ-ACK if there was not LP HARQ-ACK), therefore it is reasonable to drop the LP HARQ-ACK in this case so that 4 CSs {0, 3, 6, 9} can be used for HP SR + 1-bit HP HARQ-ACK as in Rel-16. |
| DOCOMO | We prefer Option 2, which is a simple and unified solution. Also, we can accept Option 3 as it is a detailed solution with better performance. |
| New H3C | We still prefer Option 2 as a simple way. |
| ZTE | Support Option 3 as first preference.  Option 2 is not a complete solution as the PUCCH format is not determined yet, it could be PF0/1 or PF 2/3/4? This should be clarified. From the reason of unified solution, I guess the PF would be 2/3/4?  If Option 2 can be fixed by some details, we may accept Option 2 for sake of progress. |
| InterDigital | Do not support.  What does “explicit/implicit HP SR” mean?  As mentioned by Samsung in earlier round, in R15 the 1-bit SR is not multiplexed with HARQ-ACK on PF0 unless the SR is positive. Thus, “Step 1” description does not seem accurate.  All Options appear to always add the SR bit(s) in the UCI when it would be multiplexed with HP PUCCH F0/1, even when all overlapping SR’s are negative. Since HP SR is expected to be configured with very small periodicity, this may result in overhead in every single slot.  In addition, solutions (e.g. Options 3,4,5,6) where LP HARQ-ACK is treated the same as HP HARQ-ACK may impact HP SR/HARQ-ACK reliability in power-limited cases.  A simpler solution may be to drop LP HARQ-ACK if it overlaps with a positive HP SR (as in R16), regardless of whether there is overlap with HP HARQ-ACK resource. This would be consistent with the absence of support for multiplexing positive HP SR with LP PUSCH, or multiplexing positive HP SR with LP HARQ-ACK alone. |
| OPPO | Option 2 is a compromised solution, which is simple and unified. If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped.  For other options, we do think optimization for each sub-case is too much. |
| Huawei/Hisi | Prefer Option 2 as a unified solution.  @InterDigital ‘implicit’ means the HP PUCCH includes HARQ-ACK bits only as all K overlapping SRs are negative SR. In that sense, 1 bit SR is also needed to denote ‘negative’ in the resultant PUCCH of HP and LP in Step 2. |
| Ericsson | Support Option 2 for simplicity. Can accept Option 3 for a bit more optimization.  We don’t support options that compute ceil(log2(K+1)) bits at Step 2. Step 2 happens after Step 1. In Step 1, the outcome is 1 bit SR+ HARQ-ACK regardless of K. We don’t see the benefit of memorizing in step 1 that K SRs overlp with HARQ-ACK, and the SR resource ID of the triggered SR is ceil(log2(K+1)). Why is this info stored in Step 1 but not used, then used in Step 2? |
| CATT | Same as our reply in 4th round.  We support Option 2, which is a simple and unified solution and would not lead to LP HARQ-ACK dropping.  For Option 1, we think it complicates UE implementation since UE needs to go back to check the number of overlapping HP SRs in step 2.  We are not quite clear about the difference between Option 3 and Option 5. But to our understanding, both options may lead to misunderstandings between gNB and UE if the DCI corresponding to LP HARQ-ACK is missed by the UE as we commented in 1st round. To be more specific, for 1 bit LP HARQ and 1 bit HP HARQ and 1 bit HP SR, if DCI corresponding to LP HARQ-ACK is missed by the UE, UE will transmit HP HARQ-ACK and positive SR using sequence cyclic shifts 3/9. But from gNB’s perspectrive, gNB may consider UE receives the DCI corresponding to LP HARQ-ACK and the SR is negative. So these options should not be agreed to avoid impacting HP UCI.  Table 9.2.3-4: Mapping of values for two HARQ-ACK information bits to sequences for PUCCH format 0   |  |  |  |  |  | | --- | --- | --- | --- | --- | | HARQ-ACK Value | {0, 0} | {0, 1} | {1, 1} | {1, 0} | | **Sequence cyclic shift** |  |  |  |  |   Table 9.2.5-1: Mapping of values for one HARQ-ACK information bit and positive SR to sequences for PUCCH format 0   |  |  |  | | --- | --- | --- | | HARQ-ACK Value | 0 | 1 | | **Sequence cyclic shift** |  |  |   For Option 4, it leads to LP HARQ-ACK dropping if HP SR and HP HARQ-ACK are on PUCCH format 0 and also the option is too complicated depending on the payload size and PUCCH format. |
| Intel | Our 1st preference is option 3, and we share same understanding with Nokia for option 3.  We can live with option 2, to address the performance issue mentioned by LG and CATT, though we think option 2 requires more standard effort (Rel-15/16 does not support using PF 2/3/4 for such case) and option 3 still outperforms option 2, if HP PUCCH is PF 1. |
| QC | We are fine with the proposal to list all options. But we think some options need clarification.  Option 2 is not clear to us at all. We don’t know how to transmit the HP bits and the LP HARQ-ACK bits. I think details need to be added.  For option 3, the clarification added by Nokia is needed. But we have a question regarding the following sub-case. In this case, 1 bit SR is dropped in step 1. Does it still included in the scope of this proposal “When a PUCCH carrying explicit/implicit HP SR and HP HARQ-ACK with PUCCH format 0/1…”?   * + **For HP SR with PF0 and HP HARQ-ACK with PF1**, according to Rel-15/Rel-16 rules, the SR is dropped. Then, the 1-bit LP HARQ-ACK is treated as HP bit and multiplexed with the HP HARQ-ACK bit on the PUCCH resource (with PF1) of HP HARQ-ACK.   @LG, regarding the performance loss you mentioned on mux 1 bit HP A/N, 1 bit LP A/N and 1 bit SR on PUCCH format 0, the performance loss can be taken care of by power boost. But the adtantage of this scheme is that we saved the LP A/N bit, which is the main purpose of Rel-17 enhancement. You solution is basically fall back to Rel-16 for this sub-case.  @all, to clarify why option 5 does not end on a PF1 resource: The reason is that there are at least 3 bits in the payload (HP A/N, LP A/N, 1 bit SR). So it never end on PF1 in resource selection. |
| LG2 | It seems hard for the group to converge into one of the options as ther are.  On Option 2, we have concern (so cannot accept) on increase of PUCCH resource overhead with PF2/3/4 and impacts to Rel-15/16 PUCCH framework (where SR + 2-bit HARQ-ACK are multiplexed on PF0/1) as well as relevant UE/gNB implementations.  On Option 3, we have concern (so cannot accept) on the performance degradation of HP SR + HP HARQ-ACK on PF0 due to LP HARQ-ACK as we commented.  Moreover, some companies don’t want to support the multiplexing for this case at all and the consequence would be to drop LP HARQ-ACK (but it seems too extreme).  Given this situation, we may be able to find (so we suggest) a middle-ground or compromise Option A below, based on similar logic as for the multiplexing of HP SR + LP HARQ-ACK on PF0/1 which was agreed not to be supported.   * + **Option A:**      - **If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK, LP HARQ-ACK is dropped.**     - **If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2,**        * **If HP HARQ-ACK is dynamic HARQ-ACK or SPS HARQ-ACK with sps-PUCCH-AN-List, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is .**       * **If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped.** |
| Samsung | Support Option 7, drop LP HARQ-ACK.  Same comment as previous round. |
| vivo | Our 1st preference is option 3, and we share same understanding with Nokia and Intel for option 3. Option 2 is not clear to us. How to tranmist 1-bit LP HARQ-ACK + 1-bit HP HARQ-ACK needs further clarification. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 6th round discussion

According to the chairman’s guidance, this round focuses on Option 0 and 2 for the proposal.

Proposal for 6th round discussion:

When a PUCCH carrying explicit/implicit HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, where the original PUCCH carrying the HP HARQ-ACK before Step 1 overlaps with K HP SRs which are all negative or include at least one positive,

* In Step 1, 1-bit HP SR is multiplexed to HP HARQ-ACK bits (based on Rel-15 rules) for determining the resultant PUCCH resource.
  + Note: The description of Step 1 here is only for information purpose, which has no spec impact.
* In Step 2, down-select from the two options:
  + Option 0: LP HARQ-ACK is dropped.
  + Option 2: 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is
    - The resultant PUCCH resource for multiplexing HP SR + HP HARQ-ACK + LP HARQ-ACK is either of PF2, PF3, or PF4.

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Comments | | |
| Samsung | We support Option 0.  For Option 2, we have strong concerns.  First, the HP SR performance may degrade after multiplexing with LP HARQ-ACK.  Consider the case below,  In Step 1, after multiplexing, HP HARQ-ACK will be multiplexed in a HP SR PF1, if the multiplexed HP UCI is transmitted, gNB can tell which SR is positive based on the transmitted SR resource.  In Step 2.1, after multiplexing, gNB cannot tell with SR is positive, gNB may not schedule a propor UL resource for the HP traffic.  Clearly, Option 2 can cause HP SR information loss and degrade the performance of HP.    It is not acceptable a LP HARQ-ACK degrades the performance of HP.  Second, Option 2 is optimization and brings additional complexity  If the total bits are 2, we don’t see the reason why additional bit for SR should be added. It is a different design from Rel-15/16 which is not acceptable at this late stage.  Third, Option 2 can degrade the SE.  If the total bits are 2, a PF0/1 can carry the multiplexed UCI, however, Option 2 increases the payload and may require more resources.  Fourth, LP HARQ-ACK can be dropped when colliding with HP SR, the principle can apply here.  Based on the obove reasons, we object Option 2.  Regarding the main bullet, “are all negative or” should be removed, for all negative SR, HP PUCCH only includes HARQ-ACK. | | |
| LG | First of all, we think current Option 2 seems incomplete if we consider the case where HP HARQ-ACK is SPS HARQ-ACK provided by n1PUCCH-AN, so it needs to be updated as the following.   * + Option 2 (update):   If HP HARQ-ACK is dynamic HARQ-ACK or SPS HARQ-ACK with sps-PUCCH-AN-List, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is   * + - The resultant PUCCH resource for multiplexing HP SR + HP HARQ-ACK + LP HARQ-ACK is either of PF2, PF3, or PF4.   If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped. | | |
| Sony | **Support Option 0**, with clarification that LP HARQ-ACK is dropped only if the HP SR is positive.  Option 2 needs further details which is lacking. We think the extra complexity for this slight optimization does not justify the additional complexity required to support it. | | |
| Nokia/NSB | We prefer Option 2, and we are fine with the updates by LG.  Actually, although Option 2 is not our first preference, we still prefer it over Option 0 since under this latter option LP HARQ-ACK is always dropped. | | |
| Intel | Though we think option 2 can reduce LP HARQ-ACK dropping probability and reduce blind detection (whether positive HP SR + HP HARQ-ACK or HP HARQ-ACK +LP HARQ-ACK), we also worry whether all details for option 2 can be fixed within 2 days in this meeting. To ensure we can finish Rel-17 intra-UE on time, we slightly prefer option 0 for a simple design.  For *n1PUCCH-AN*, we share same view with LG that LP HARQ-ACK should be dropped, if HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN. Just to clarify, if the UE is configured with *SPS-PUCCH-AN-List*, LP HARQ-ACK can be multiplexed with HP UCI using the PUCCH resource from *SPS-PUCCH-AN-List*, right? | | |
| ZTE | Support Option 2. It is naturally align the previous meeting agreement on PF 2/3/4.  We are fine with LG’s revision. With this revision, I think there is no other severe open issue left.  For SR determination by gNB, I think no problem in step2, as the SR concept is not changed from step 1 to step 2.  For Intel’s question, indeed the n1PUCCH-AN can not support PF 2/3/4, so dropping is needed. But *SPS-PUCCH-AN-List* can support PF 2/3/4, then dropping is not needed. | | |
| DOCOMO | Prefer Option 2 with the clarification updated provided by LG.  Regarding Intel’s question, we share the same understanding as ZTE. LP HARQ-ACK can be multiplexed with HP UCI using the PUCCH resource from *SPS-PUCCH-AN-List* if its format is PF2/3/4. | | |
| CATT | We support Option 2.  In this case, there are both HP SR and HP HARQ-ACK in the HP PUCCH overlapping with LP PUCCH with HARQ-ACK. It seems that companies supporting Option 0 and Option 2 come from different angles, i.e. HP SR and HP HARQ-ACK respectively.  From our perspective, the case is almost the same as the case of HP PUCCH with 2 bits HARQ-ACK overlapping with LP HARQ-ACK and Option 2 basically follows the same rule by treating the HP SR the same as HP HARQ-ACK. Option 2 is also aligned with the previous agreement for HP PUCCH with HP SR and HP HARQ-ACK with PF 2/3/4. If Option 2 is adopted, then for a HP PUCCH with HP SR and HP HARQ-ACK regardless of the PUCCH format, LP HARQ-ACK is multiplexed with HP UCI by treating both HP SR and HP HARQ-ACK and HP UCI.  For LG’s update, I understand it is technically correct. But I would like to understand companies’ view that whether companies think that gNB may configure n1PUCCH-AN only in case intra-UE multiplexing across different priorities is supported. In this case, it means that in case HP SPS HARQ-ACK overlaps with LP HARQ-ACK, at least LP HARQ-ACK with 2 or more bits would be dropped. | | |
| OPPO | Support Option 2. It aligns with PF2/3/4 case and it reduce LP PUCCH dropping.  I share view as LG on SPS HARQ-ACK case and fine with Update Option 2 by LG. Update Option 2 is complete solution and no open issue needs to be discussed further. |
| QC | Support option 2, which alignes with previous agreement. We don’t understand the logic of option 0, it seems we are trying to punish PF 0/1 😊. Always dropping LP A/N in case overlap with HP A/N+SR in PF 0/1, but OK to multiplex with HP A/N+SR in PF 2/3/4 seems not convincing. PF 0/1 is baseline, HP A/N+SR in PF 0/1 is very common. How come RAN1 choose to not enhance a baseline, but enhance a non-baseline?  **Agreement in RAN1 107bis**  When a PUCCH carrying HP SR and HP HARQ-ACK with PUCCH format 2/3/4 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;   + FFS: PF0, PF1 * 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 is used for multiplexing.   A few comment to option 2:   * Regarding to this: “The resultant PUCCH resource for multiplexing HP SR + HP HARQ-ACK + LP HARQ-ACK is either of PF2, PF3, or PF4”, why PF 0 is excluded? PF 0 can transmit 1 bit SR+ 1bit HP A/N + 1 bit LP A/N. If the consider is the performance as LG commented in previous round. We disagree and we think gNB can use power control to solve the performance loss issue.   In summary, we don’t agree to exclude PF0 in option 2. We can accept option 2 with the following sub-bullet removed.   * + ~~The resultant PUCCH resource for multiplexing HP SR + HP HARQ-ACK + LP HARQ-ACK is either of PF2, PF3, or PF4.~~ * We are fine with LG’s update related to n1PUCCH-AN. | |
| Samsung2 | Regarding the argument of “dropping LP HARQ-ACK” by the proponents of Option 2, we cannot agree. When we were discussing PUCCH repetitions, alt 1 can avoid LP HARQ-ACK dropping but all the companies support alt 2, it seems dropping LP HARQ-ACK is not a big issue there. When we were discussing the LP PUCCH association with HP time unit, a clear majority companies support Alt 1 enven though Alt 2 can avoid LP HARQ-ACK dropping, it seems dropping LP HARQ-ACK is not problem in that case either. We hope companies can be consistent on LP HARQ-ACK dropping. If the consequence of dropping LP HARQ-ACK can be ignored when discussing thoses issues, same principle should apply here.  Regarding CATT’s comment “the case is almost the same as the case of HP PUCCH with 2 bits HARQ-ACK overlapping with LP HARQ-ACK”, we cannot agree. The difference here is the HP SR information loss which is not acceptable for us because of prioritizing LP HARQ-ACK transmission.  Regarding LG’s update, LP HARQ-ACK can be dropped in Option 2 as well, and now Option 2 is becoming more complicated.  Regarding the comments on “aligning with PF 2/3/4”, we don’t think this is a valid point, we have different design for PF 0/1 and PF 2/3/4 since Rel-15, why in Rel-17 we should align the design?  Regarding QC’s comment, it seems the details of Option 2 is not converged which makes Option2 cannot be adopted.  We cannot accept Option 2 unless all our concerns are addressed, it seems no company replies to any of our concern yet. | | |
| Apple | We support Option 2, LGE’s update on Option 2 is acceptable. | | |
|  |  | | |
|  |  | | |
|  |  | | |
|  |  | | |
|  |  | | |
|  |  | | |
|  |  | | |
|  |  | | |
|  |  | | |
|  |  | | |
|  |  | | |

## Agreements in this meeting

**Agreement**

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 is:

* high-priority HARQ-ACK bit, low-priority HARQ-ACK bit.

**Agreement**

When a PUCCH carrying HP SR with PF0/1 overlaps with a PUCCH carrying LP HARQ-ACK with PF0/1, the LP HARQ ACK is dropped when colliding with positive SR

# 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.*

**Agreement**

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.

**Agreement**

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] |

**Agreement**

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

* If HP HARQ-ACK, LP HARQ-ACK, and LP CSI including a single part would be transmitted on 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.

**Agreement**

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 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 CSI.
  + Reuse Rel-15 CSI part 2 rate matching and RE mapping for LP HARQ-ACK.

**Agreement**

In R17, if HP HARQ-ACK, LP HARQ-ACK and HP CSI consisting of two parts 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.

## Remaining issues on coding and resource determination

## Inputs from Tdocs

**Issue 3.2-1: Single-priority HARQ-ACK multiplexed with PUSCH**

* 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.
  + Huawei/Hisi, ZTE, CATT, DOCOMO, Spreadtrum,
* If LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH, down-select from the two options:
  + Option 1: 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.
    - Huawei/Hisi, ZTE, CATT, DOCOMO
  + Option 2: UE follows the same behaviour as that in case of PUSCH with HP HARQ-ACK.
    - Spreadtrum
  + Option 3: Reuse Rel-15 HARQ-ACK rate matching and RE mapping for LP HARQ-ACK if no HP CSI is present, otherwise, HARQ-ACK rate matching equation should be revised by taking HP CSI into account and Rel-15 CSI rate matching without consideration of LP HARQ-ACK is used for HP CSI.
    - Intel

**Issue 3.2-2: 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)
  + - HW, Nokia

**Issue 3.2-3: 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, CATT, Samsung (also RE reservation)

**Issue 3.2-4: 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
* 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

**Issue 3.2-5: CG-UCI multiplexing**

**Lenovo proposal:**

* 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.

**Intel proposal:**

* 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.

**LG proposal:**

**Proposal #12: 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.**

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| HW | ***Proposal 17: If HP HARQ-ACK without LP HARQ-ACK would be transmitted on LP PUSCH with/without UL-SCH, HP HARQ-ACK should be multiplexed on the LP PUSCH by reusing the rate matching/puncturing and RE mapping rules for the legacy HARQ-ACK.***  ***Proposal 18: If LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH with/without UL-SCH, LP HARQ-ACK should be multiplexed on the HP PUSCH by reusing the rate matching/puncturing and RE mapping rules for the legacy HARQ-ACK.***  ***Proposal 19: LP CSI only should be dropped when colliding with HP PUSCH.***  ***Proposal 20: 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 Type 1 HARQ-ACK on HP PUSCH in case of UL DAI = 0 regardless of the fallback cases of receiving only a SPS release or only a fallback DCI on PCell with C-DAI=1.***   ***Proposal 21: 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 22: 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.*** |
| Nokia | * **Proposal 3.8: For the scenarios where a high-priority PUSCH overlaps with a PUCCH carrying low-priority CSI, the low-priority CSI is always dropped.** * **Proposal 3.9: 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.** |
| ZTE | ***Proposal 14:*** *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.*  ***Proposal 15:*** *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.*  ***Proposal 16:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and LP CSI consisting of two parts would be transmitted on LP PUSCH conveying UL-SCH,*   * *If the leftover resources for LP HARQ-ACK and LP CSI part 1 is not sufficient, LP HARQ-ACK has higher priority than LP CSI part 1, and LP CSI part 1 may be partially dropped or compressed.*   ***Proposal 17:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and 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 18:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK, LP HARQ-ACK, and 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 19:*** *For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, if HP HARQ-ACK 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 for PUSCH grant.* |
| CATT | ***Proposal 7: To avoid the impact on HP PUCCH/PUSCH due to missing DCIs corresponding to LP HARQ-ACK codebook, it is proposed to indicate the number of LP HARQ-ACK bits by a new T-DAI field in DCI corresponding to HP PUCCH/PUSCH.***  ***Proposal 9: For multiplexing HP HARQ-ACK and LP CSI (if any) on LP PUSCH, or for multiplexing LP HARQ-ACK and HP CSI (if any) on HP PUSCH,***   * ***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.*** |
| DCM | **Proposal 6:**   * *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.*   **Proposal 8:**   * 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. |
| Spreadtrum | 1. ***If HP HARQ-ACK without LP HARQ-ACK and w/o CSI 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.*** 2. ***If LP HARQ-ACK without HP HARQ-ACK and w/o CSI would be transmitted on HP PUSCH, UE follows the same behaviour as that in case of PUSCH with HP HARQ-ACK.***     * ***When only LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH,***       + ***Reuse R15 CSI part 1 rate matching and RE mapping for LP HARQ-ACK.***    * ***When LP HARQ-ACK without HP HARQ-ACK and a single HP CSI would be transmitted on HP PUSCH***      + ***Reuse R15 CSI part 1 rate matching and RE mapping for the single HP CSI.***      + ***Reuse R15 CSI part 2 rate matching and RE mapping for LP HARQ-ACK.***    * ***When LP HARQ-ACK without HP HARQ-ACK and two HP CSI parts would be transmitted on HP PUSCH***      + ***LP HARQ-ACK is dropped.***      + ***Reuse R15 CSI part 1 rate matching and RE mapping for the HP CSI part 1.***      + ***Reuse R15 CSI part 2 rate matching and RE mapping for the HP CSI part 2.*** |
| Intel | **Proposal 9: 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 10: For multiplexing HP HARQ-ACK alone into a LP PUSCH, reuse Rel-15 HARQ-ACK rate matching and RE mapping for HP HARQ-ACK, and Rel-15 CSI rate matching and RE mapping for LP CSI, if any.**  **Proposal 11: For multiplexing LP HARQ-ACK alone into a HP PUSCH, reuse Rel-15 HARQ-ACK rate matching and RE mapping for LP HARQ-ACK if no HP CSI is present, otherwise, HARQ-ACK rate matching equation should be revised by taking HP CSI into account and Rel-15 CSI rate matching without consideration of LP HARQ-ACK is used for HP CSI.** |
| Lenovo | **Proposal 5**: 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. |
| QC | **Proposal 14: For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUSCH in R17, reuse the same power control formula as in Rel-15.** |
| LG | **Proposal #12: 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.** |
|  |  |

## 1st round discussion

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 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, down-select from the options:
  + Option 1: 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.”
    - Huawei/Hisi, ZTE, Sony, DOCOMO, ITRI, CATT, Panasonic, CTC, QC
  + Option 2: UE follows the same behaviour as that in case of PUSCH with HP HARQ-ACK.
    - Nokia/NSB, OPPO, LG, Apple, Sharp, Spreadtrum, New H3C, Lenovo
  + Option 3: Reuse Rel-15 HARQ-ACK rate matching and RE mapping for LP HARQ-ACK if no HP CSI is present, otherwise, HARQ-ACK rate matching equation should be revised by taking HP CSI into account and Rel-15 CSI rate matching without consideration of LP HARQ-ACK is used for HP CSI.
    - Intel, vivo

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support. We prefer Option 2. |
| Huawei/Hisi | Agree with the first main bullet.  For the second main bullet, Option 1 is preferred for simplicity.  For Option 2, the LP HARQ-ACK would be unnecessarily dropped in case there is HP CSI but no HP HARQ-ACK to be multiplexed on HP PUSCH.  For Option 3, determining the UCI encoding chain for LP HARQ-ACK depends on the presence of HP CSI, which seems too complex. |
| ZTE | Support. Option 1. For Options 3, the LP HARQ-ACK will be dropped if HP CSI has two parts. |
| OPPO | Support the first main bullet.  Support option 2 for the second bullet. |
| LG | Support FL’s proposal, and we also prefer Option 2. |
| Sony | Support 1st bullet.  Option 1 for 2nd bullet. |
| Apple | Support the first main bullet, support Option 2 for the second main bullet. |
| Sharp | Support the 1st bullet for HP HARQ-ACK on LP PUSCH.  Option 2 is preferred for the 2nd bullet to maintain the same behavior. |
| Samsung | Support. |
| Intel | We prefer option 3.  For option 1, we’d like to clarify, whether companies assume   * + - 1. It is possible that there is NOT sufficient number of REs for HP CSI, if no LP HARQ-ACK is present.   As in Rel-15/16, such case is allowed, i.e., part B can be smaller than part A in the equation as below. Then, HP CSI is partially dropped, e.g., for HP CSI part 2.   * + - 1. gNB should ensure there is always sufficient number of REs for HP CSI, if LP HARQ-ACK is present.   In other words, gNB ensures part B is always larger than Part A, when LP HARQ-ACK is present.  It is a bit strange that we add such restriction at gNB side for (2) while no restriction for (1). But if we don’t add such restriction, HP CSI would be partially dropped due to LP HARQ-ACK, which conflicts with principles of protecting HP UCI for all other cases agreed, e.g., in case of HP HARQ-ACK and HP CSI part 1&2, LP HARQ-ACK is dropped.  For option 2, it leads to LP HARQ-ACK dropping, for the case of 2-part HP CSI, no matter HP HARQ-ACK is present or not. And also, it is unclear how to apply the agreement of CG-UCI with prioirty i joint coding with HARQ-ACK for single priority j in case of single priroity HARQ-ACK in a PUSCH.  For option 3, to avoid drop of LP HARQ-ACK and also ensure HP CSI is prioritized, it is proposed to not take LP HARQ-ACK into accont, i.e., in the equation above does not include symbols for LP HARQ-ACK. And for LP HARQ-ACK, the rate matching equation should include . It is complicated than option 1 or option 2, but it protects HP UCI and reduces drop of LP HARQ-ACK. |
| DOCOMO | Support 1st bullet.  Prefer Option 1 for 2nd bullte. Share the similar view with HW/HiSi. |
| Spreadtrum | Support the proposal. Prefer Option 2 in the second main bullet. |
| ITRI | Support 1st bullet.  Prefer option 1 for 2nd bullet. |
| CATT | Support 1st bullet.  Prefer option 1 for 2nd bullet. |
| New H3C | Support 1st bullet.  Prefer option 1 for 2nd bullet. |
| Panasonic | We support the proposal. For the 2nd bullet, we prefer Option 1 for simplicity. |
| vivo | We prefer option 3. We share the same view with Intel. HP CSI should be prioritized over LP HARQ-ACK. |
| CTC | Support the first main bullet and option 1 for 2nd bullet. |
| Lenovo | Support the proposal with preference to option 2. |
| QC | Support the first bullet.  For the second bullet, we support option 1. Option 3 seems unnecessarily complicated. |
|  |  |
|  |  |
|  |  |

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, reuse the same power control formula as in Rel-15.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support.  In addition, for the scenarios with low-priority PUSCH, we would like to propose to configure two sets of power control parameters (e.g. p0 and/or alpha). One set is used for the scenario where there is no high-priority HARQ-ACK to be multiplexed into the low-priorty PUSCH; and the other set used for the scenario where there is high-priority HARQ-ACK to be multiplexed into the low-priorty PUSCH. |
| Huawei/Hisi | Support. If we understand this proposal correctly, there is no addional spec impact. |
| OPPO | Support |
| LG | Support FL’s proposal. |
| Sony | Support. |
| Sharp | Support |
| Samsung | Support.  Agree with Huawei, there is no spec impact. It should be a proposed conclusion. |
| Intel | Support, and we share same undersntading with HW that no additional spec impact is epxeted. |
| DOCOMO | Support |
| Spreadtrum | Support the proposal. |
| ITRI | Support |
| CATT | Support |
| WILUS | Support |
| vivo | support |
| CTC | Support |
| Lenovo | Support |
| QC | Support |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 2nd round discussion

Proposal for email approval:

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.

|  |  |
| --- | --- |
| Supporting companies: | Sony, Lenovo, Nokia/NSB, Ericsson, Panasonic, Samsung, QC, LG, InterDigital Huawei/Hisi, NEC, Sharp, CATT, DOCOMO, New H3C, ITRI,OPPO, ZTE,vivo, Spreadtrum, Intel |
| Objecting companies: |  |
| Company | Reason for objection |
|  |  |
|  |  |

Proposed conclusion for email approval:

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.

* + No specification impacts.

|  |  |
| --- | --- |
| Supporting companies: | Sony, Lenovo, Nokia/NSB, Ericsson, Panasonic, Samsung, QC, LG, InterDigital Huawei/Hisi, NEC, Sharp, CATT, DOCOMO, New H3C, ITRI,OPPO, ZTE,vivo, Spreadtrum, Intel |
| Objecting companies: |  |
| Company | Reason for objection |
|  |  |
|  |  |

## 3rd round discussion

More clarifications on the two options are encouraged in this round, e.g., the case of CG-UCI on PUSCH for Option 2:

Proposal for 3rd round discussion:

If LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH, down-select from the options:

* Option 1: 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.
  + ZTE, Sony, Ericsson, DOCOMO, NEC, QC, Huawei/Hisi, CATT
* Option 2: UE follows the same behaviour as that in case of PUSCH with HP HARQ-ACK.
  + FFS for CG-UCI PUSCH.
  + New H3C, LG, vivo, Nokia/NSB, OPPO, Sony (can accept), Apple, Sharp, DOCOMO (can accept), Intel (If without CG-UCI), ITRI, Spreadtrum, Lenovo

|  |  |
| --- | --- |
| Company | Comments |
| New H3C | We support Option 2. |
| LG | We support Option 2.  Regarding the number of HP HARQ-ACK bits to be assumed by the UE with Option 2, it is straightforward that 2-bit is assumed and the corresponding REs are reserved on HP PUSCH as in Rel-15/16. |
| vivo | Between these two options, we support Option 2. It does not make sense to drop (even partially) CSI due to LP HARQ-ACK. In addtion, Option 1 has problem when the HP PUSCH has CG-UCI. |
| Nokia/NSB | We support Option 2.  Option 2 is preferred due to better protection of HP PUSCH and HP CSI if present. |
| OPPO | We support Option 2. |
| ZTE | Support Option 1. Option 1 will not cause the entire HP CSI dropping as we have three coding chains. For CG-UCI, it follows the same procedure to multiplex LP HARQ and CG-UCI, or the joint coding which mentioned in the GTW. |
| Sony | Option 1 (1st choice)  Also ok with Option 2.  Either way, we have separate betas for the gNB to manage the resources for LP HARQ-ACK. If there is HP CSI, then the gNB gives a lower beta to LP HARQ-ACK to ensure HP CSI is transmitted. This can be managed by gNB.  Anyway, the proposal is for LP HARQ-ACK without HP HARQ-ACK. Perhaps we need to consider sub-cases:   * LP HARQ-ACK without HP HARQ-ACK but with HP CSI * LP HARQ-ACK without HP HARQ-ACK but with HP CG-UCI * LP HARQ-ACK without HP HARQ-ACK but with HP CSI + HP CG-UCI |
| Apple | We support Option 2. |
| Sharp | We prefer Option 2.  Following the same logic as in Rel-15 multiplexing, the CSI is not using the HARQ-ACK coding chain even if there is no CSI. |
| Ericsson | Support Option 1.  We have several concerns on Option 2:   * For the case {[HP HARQ-ACK], LP HARQ-ACK, HP CSI}+HP PUSCH, the LP HARQ-ACK is dropped unnecessarily, even though HP HARQ-ACK is absent. * It’s not clear what is done for the HP A/N part when there is no HP A/N? Is this part not performed? Zero info bit and zero RE for HP A/N part? Or some dummy HP A/N bits are inserted? |
| DOCOMO | Slightly prefer Option 1 but we are also OK with Option 2.  Regarding the partial dropping of HP CSI, we have similar view with Sony that it can be avoided by beta-offset. However, if majority companies prefer Option 2, we can live with it. |
| Intel | First of all, I’d like to clarify CG-UCI issue, for the case of CG-UCI with LP HARQ-ACK on HP PUSCH, and CG-UCI with HP HARQ-ACK on LP PUSCH.  According to TS 38.212 for Rel-17, CG-UCI and HAQ-ACK with different priroity is jointly coded as Rel-16 NRU.  But my understanding for the agreement made in AI 8.3.2 was **WRONG**. We’ve checked with Sorour (FL for AI 8.3.2), the agreement only says CG-UCI and HARQ-ACK with different prioirty can be multiplexed together, while joint coding as Rel-16 NRU or separate coding as HP and LP UCI is up to AI 8.3.3. Thanks Sorour, Sukchel and Weidong for cross checking.     |  | | --- | | 38.212 (h00) 6.3.2      Uplink control information on PUSCH The following clauses 6.3.2.2, 6.3.2.3, and 6.3.2.5 apply regardless of whether the higher layer parameter *UCI-MuxWithDifferentPriority* is configured or not. The following clauses 6.3.2.1, 6.3.2.4, and 6.3.2.6 apply by assuming *UCI-MuxWithDifferentPriority* is not configured, or *UCI-MuxWithDifferentPriority* is configured and the UCIs for transmission on a PUSCH are of the same priority index, unless stated otherwise. **In addition, clauses 6.3.2.1.4, 6.3.2.4.1.5, 6.3.2.4.2.5 and 6.3.2.6 also apply if *UCI-MuxWithDifferentPriority* is configured and CG-UCI is of a different priority index with HARQ-ACK.** |  |  | | --- | | **Agreement**   * When performing Intra-UE multiplexing procedure, if a PUCCH withHARQ-ACK overlaps with a CG-PUSCH and the cg-RetransmissionTimer is configured:   + If the HARQ-ACK and the CG-PUSCH have the same priority and the CG-PUSCH is selected for HARQ-ACK multiplexing:     - ~~For multiplexing of HARQ-ACK on the CG-PUSCH~~       * If cg-UCI-Multiplexing is enabled for that CG-PUSCH, HARQ-ACK would be multiplexed in CG-PUSCH.       * Otherwise, CG-PUSCH would be dropped.   + If the HARQ-ACK and the CG-PUSCH have different priority and the CG-PUSCH is selected for HARQ-ACK multiplexing:     - If multiplexing HARQ-ACK on the CG-PUSCH with different priroity is not ~~supported~~indicated,       * The LP channel between PUCCH or CG-PUSCH would be dropped as in Rel-16.     - If multiplexing HARQ-ACK on the CG-PUSCH with different priroity is ~~supported~~indicated,       * + If cg-UCI-Multiplexing is enabled for that CG-PUSCH, HARQ-ACK would be multiplexed in CG-PUSCH.         + Otherwise, the LP channel would be dropped. |   Consideirng CG-UCI is still open, different solutions for CG-UCI has different impact on option 1 and option 2, we suggest to focus on the case with CG-UCI first for options above and continue to discuss the case for CG-UCI. Therefore, we suggest to revise the proposal as below.  If LP HARQ-ACK without HP HARQ-ACK and CG-UCI would be transmitted on HP PUSCH, down-select from the options:   * Option 1: 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. * Option 2: UE follows the same behaviour as that in case of PUSCH with HP HARQ-ACK. * FFS for CG-UCI PUSCH.   If without CG-UCI, we prefer option 2, to ensure HP UCI is always proctected.  Regarding Ericsson’s question for HP HARQ-ACK part, in our understanding, it is processed same as the case for a PUSCH with CSI but without HARQ-ACK in Rel-15. |
| NEC | Option 1 is slightly preferred. With option 2, if HP PUSCH carries HP CSI consisting of two parts, even HP HARQ-ACK is absent, the LP HARQ-ACK will be dropped unnecessarily. |
| ITRI | Perfer option 2. The HP UCI should be protected. |
| QC | Support option 1.  Several concerns on option 2.   * For the case {[HP HARQ-ACK], LP HARQ-ACK, HP CSI}+HP PUSCH, the LP HARQ-ACK is dropped unnecessarily, even though HP HARQ-ACK is absent. * How many bits we assume for the non-existing HP? Based on Rel-15 spec for legacy HARQ-ACK. It seems 2 bits dummy HP HARQ-ACK should always be assumed? Is that really necessary? What is the benefit of always assuming 2 bits NACK in this case? * About the LP HARQ-ACK performance, when LP HARQ-ACK is 2-bits, option 1 use simplex encoding, while option 2 pad it to 3 bits and use Reed Muller encoding. Option 1 is 0.7 dB better than option 2. |
| Huawei/Hisi | Support Option 1. For concerns of Option 2, share the same view with QC. Note that the insufficient resources for HP CSI exists also in R16, where the HP CSI part 2 may be dropped due to its uncertain payload (RANK number). For R17, gNB can schedule more RBs on PUSCH to accommondate LP HARQ-ACK.  In addition, we should not keep an open FFS on the candidate options at this phase, as there could be different understandings on how to multiplex CG-UCI, when there is LP HARQ-ACK on HP PUSCH without HP HARQ-ACK, as raided by Intel.  **Opt 2-1:** The reservation padding HP HARQ-ACK bits are jointed encoded with CG-UCI to reuse the legacy HARQ-ACK encoding chain.  **Opt 2-2**: CG-UCI jointly encode with LP HARQ-ACK to reuse the legacy HARQ-ACK encoding chain without considering the reservation padding HP HARQ-ACK bits.  **Opt 2-3**: CG-UCI only reuses the legacy HARQ-ACK encoding chain without considering the reservation padding HP HARQ-ACK bits, and separately encode with LP HARQ-ACK.  Either way would make the spec more complex.  For Option1, the multiplexing of LP HARQ-ACK with CG-UCI is more straightforward, regardless it jointly encode or separately encode with LP HARQ-ACK. |
| LG2 | We have some comments to some companies’ views.  @ Sony: It seems your last case “LP HARQ-ACK without HP HARQ-ACK but with HP CSI + HP CG-UCI” in above would not happen on HP CG PUSCH, isn’t it?  @ Ericsson & QC: In Rel-16, even if the UE missed HP DL DCI, there is no impact to HP UL-SCH rate-matching since the REs for 2-bit HP HARQ-ACK are reserved. But in this Rel-17 case, if the UE missed HP DL DCI, the UE would multiplex LP HARQ-ACK based on Rel-15 HARQ-ACK rate-matching/mapping in case with Option 1 but the gNB would expect that the LP HARQ-ACK is multiplexed based on Rel-15 CSI part 1 rate-matching/ mapping. Due to such wrong rate-matching, HP UL-SCH (as well as LP HARQ-ACK) reliability would be degraded compared to Rel-16 HP performance.  @ HW: It seems your Opt 2-1 is strange and quite different from Rel-16 where the reserved REs is defined only for 2-bit HP HARQ-ACK (not for the case of HP AN + CG-UCI). So, the Opt 2-1 can be removed first. |
| Spreadtrum | Option 2.  According to HP HARQ-ACK assumption when without HP HARQ-ACK, reuse the current Rel-15/16 procedure, the reserved resource is calculated by assume it is 2 bits.   |  | | --- | | 38212 clause 6.2.7 Data and control multiplexing  if the number of HARQ-ACK information bits to be transmitted on PUSCH is 0, 1 or 2 bits  the number of reserved resource elements for potential HARQ-ACK transmission is calculated according to Clause 6.3.2.4.2.1, by setting ; |   For Option 1, we think it has the following disadvantages:   1. When LP HARQ-ACK is less than 2bit, it would puncture HP CSI part 2 if it exits. That is unreasonable considering HP CSI part 2 should have higher priority than LP HARQ-ACK. 2. When LP HARQ-ACK is less than 2bit, it would puncture HP UL-SCH if it exits. 3. When LP HARQ-ACK is with large payload, it may cause the drop of HP CSI part 2, due to the CSI priority dropping rule. 4. Considering CG-UCI, alghough it is still open, however, we think Option 2 have advantage over Option 1. Since the main idea for LP and HP UCI, separate coding is applied. When without HP HARQ-ACK but with CG-UCI, LP HARQ-ACK should do joint coding with HP CG-UCI? We prefer not, because this is HP CG-PUSCH, CG-UCI should be HP. But Option 2 can provide unified solution for this case, that is separate coding for CG-UCI and LP-HARQ-ACK.   For CG-UCI, we think it is an issue for both Option 1 and Option 2. So we agree with Intel’s update. |
| CATT | We support Option 1 which avoids LP HARQ-ACK dropping even if there is no HP HARQ-ACK in the PUSCH. For the potential HP CSI part 2 dropping, we share the same view as Sony that it can be avoided by proper gNB scheduling. |
| Lenovo | HP CSI in HP PUSCH should be prioritized over LP HARQ-ACK. |
|  |  |
|  |  |
|  |  |

## Enhancements for multiplexing parameters

## Beta-offset value and configuration

#### Inputs from Tdocs

**Issue 3.3.1-1: Support Beta-offset =0?**

* Yes
  + Nokia, H3C, CATT, DCM
* No
  + ZTE, QC

**Issue 3.3.1-2: Details for Beta-offset values**

* Confirm the Beta-offset values in bracket in last meeting:
  + ZTE, OPPO
* Nokia proposal:

|  |
| --- |
|  |
| 0.8 |
| 0.64 |
| 0.5 |
| 0.4 |
| 0.32 |
| 0.2 |
| 0.1 |
| 0 |

* H3C proposal:

|  |
| --- |
|  |
| 0.8 |
| 0.64 |
| 0.5 |
| 0.4 |
| 0.32 |
| 0.25 |
| 0.2 |
| 0.1 |
| 0 |

**Issue 3.3.1-3: UCI coding rate greater than 1**

**QC proposal:**

The UE is not expected to receive an uplink DCI which indicates a UCI multiplexing on the PUSCH that results in the UCI coding rate greater than 1.

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Nokia | * **Proposal 3.6: For the scenarios of multiplexing HARQ-ACK bits in PUSCH of different priorities, RAN1 shall support the new table for beta-offset value <1 as below:**  |  | | --- | |  | | 0.8 | | 0.64 | | 0.5 | | 0.4 | | 0.32 | | 0.2 | | 0.1 | | 0 | |
| H3C | **Proposal 1: Define a new table for beta-offset values <1 as below.**   |  | | --- | |  | | 0.8 | | 0.64 | | 0.5 | | 0.4 | | 0.32 | | 0.25 | | 0.2 | | 0.1 | | 0 | |
| ZTE | ***Proposal 20****: The beta\_offset should not be used to disable the intra-UE multiplexing UCI with data*.  ***Proposal 21****: Confirm the beta\_offset value in the brackets in last meeting agreement*. |
| OPPO | ***Proposal 8:*** ***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 or or | 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 | |
| CATT | ***Proposal 8: A value of zero for beta-offset can be introduced to indicate that LP UCI is not multiplexed on the HP PUSCH scheduled by the DCI.*** |
| DCM | **Proposal 7:**   * *Support beta-offset =0 or a value disabling the UCI multiplexing on PUSCH of different priorities* |
| QC | **Proposal 12: Do not support beta-offset =0 in the new table for beta-offset values <1.**  **Proposal 13: The UE is not expected to receive an uplink DCI which indicates a UCI multiplexing on the PUSCH that results in the UCI coding rate greater than 1.** |
| LG | **Proposal #10: Consider whether/how to handle the case where actual coding rate of LP HARQ-ACK or LP CSI (which applies Rel-15 CSI part 2 rate-matching/RE mapping) on HP/LP PUSCH exceeds the coding rate provided based on the corresponding beta offset.** |
|  |  |
|  |  |

#### 1st round discussion

Proposal for 1st round discussion:

The values for beta-offset values <1 are:

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

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Not support.  We would like to introduce the value of “0” for beta-offset for the purpose of gNB flexibility to enable/disable multiplexing of low-priority HARQ-ACK on high-priority PUSCH. In this way, the flexibility is achieved without any additional signalling overhead and the impact on specification is almost negligible, i.e. justing including the value “0” in the table.   |  | | --- | |  | | 0.8 | | 0.64 | | 0.5 | | 0.4 | | 0.32 | | 0.2 | | 0.1 | | 0 | |
| Huawei/Hisi | Support. As Capability#1 does not support dynamic enabling/disabling flag, there is no need to introduce beta-offset=0 which actually requires the UE to perform such adaptation. |
| ZTE | Support.  Share the view of Huawei for value=0. |
| OPPO | Support. Adding proposed new values in the existing beta-offset tables, mapping to index 16-23 |
| LG | Support FL’s proposal. |
| Apple | Zero value should be not be included. Support the FL’s proposal. |
| Sharp | Support. No need for beta=0. |
| Samsung | Not support.  The smallest of the new beta\_offset values is still too large and the largest value is too large. It should be as low as at least to 0.01. For example, for a 10-5 BLER for the HP TB and a 10-2 BLER for the LP HARQ-ACK. Although it is not clear what ratios of LP UCI BLER over HP TB BLER are assumed but, regardless, 0.1 is too large as a smallest value. Basically, the new values require discussion. |
| Intel | Support.  We don’t support beta=0. Though it is a pity to exclude dynamic indication in RAN 94, we respect the conclusion for UE capability #1. |
| DOCOMO | Support |
| CATT | Although we prefer to introduce beta offset=0 for better gNB scheduling flexibility, we do see that there would be additional discussion on step 2.2. So we can live with the proposal for the sake of progress. |
| New H3C | We are fine with this proposal. |
| Panasonic | We are OK with the proposal. We also support the inclusion of the value “0”. |
| vivo | We are fine with the proposal. We also support to include “0”. |
| CTC | We are fine with this proposal. |
| QC | To respect RAN1 94e conclusion, we don’t support beta-offset =0 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal for 1st round discussion:

The UE is not expected to receive an uplink DCI which indicates a UCI multiplexing on the PUSCH that results in the UCI coding rate greater than 1.

* + Support: Nokia/NSB, Apple, Sharp, Intel, DOCOMO, ITRI, CATT, WILUS, vivo, CTC, Lenovo
  + Not support: Huawei/Hisi, OPPO (not necessary for specification), Sony, Samsung

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support. |
| Huawei/Hisi | Not support. By the description it seems to make a clarification for R15 behaviour; as per our understanding, there is no restriction in R15 for the code rate of UCI on PUSCH. |
| OPPO | Reosanable but not necessary to capture in specification. |
| LG | Support FL’s proposal. |
| Sony | Not support. This should be up to gNB’s scheduler to decide. |
| Apple | Support |
| Sharp | Support |
| Samsung | Not support.  It brings additional restriction for gNB and it is not necessary. |
| Intel | Fine with the proposal. |
| DOCOMO | Support |
| ITRI | Support |
| CATT | Support |
| WILUS | Support |
| vivo | ok |
| CTC | Support |
| Lenovo | Support |
| Ericsson | Support, but the proposal is not necessary, since Rel-15 spec text already ensures it. See spec text from 38.212 section 5.3.1:  “UE is not expected to be configured with , where  is the number of parity check bits defined in Clause 5.3.1.2.” |
| QC | The intention of this proposal is to use this principle to determine what is the smallest beta-offset value in the new table.  Given the smallest coding rate for PUSCH = 60/q/1024 (TS38.214 Table 6.1.4.1-2), when q=2 (QPSK), the smallest coding rate for PUSCH = 0.03.  Given the fact that UCI coding rate = PUSCH coding rate / beta-offset, or equivalently, beta-offset = PUSCH coding rate/UCI coding rate, if we require UCI code rate >1, we know beta-offset < PUSCH coding rate. From TS38.214 Table 6.1.4.1-2, we know the smallest coding rate for PUSCH is 0.03, then the smallest beta value should be 0.03. Any beta-value smaller than 0.03 will just resulting UCI coding rate >1, which is useless.  It is OK to not agree on the proposal on UCI coding rate not exceeding 1, which is a common knowledge with or without this agreement. But we just want to establish this principle such that we can determine what is the smallest value for beta-offset. |
|  |  |
|  |  |
|  |  |
|  |  |

#### 2nd round discussion

Proposal for 2nd round discussion:

The values for beta-offset values <1 are:

|  |
| --- |
|  |
| 0.8 |
| 0.64 |
| 0.5 |
| 0.4 |
| 0.32 |
| 0.2 |
| 0.1 |
| 0.01 |

* + They are mapped to index 16-23 in the table.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | We still would prefer 0 instead of 0.01, but would not object to this proposal either. |
| Ericsson | Do not support.  We prefer to include a beta-offset value of 0 to indicate “do not multiplex”.  We don’t support beta-offset = 0.01 above. The intention may be to use it to mimic beta-offset=0. However it may be rarely usable, and requires the scheduler to perform additional checking to ensure the UCI code rate is >=1.  38.212 section 5.3.1:  “UE is not expected to be configured with , where  is the number of parity check bits defined in Clause 5.3.1.2.”  Suggest to delete 0.01. |
| Panasonic | We have same view with Nokia. |
| Samsung | We don’t support the value 0. It cancels the functionality of beta\_offset for HP UCI in order to indicate no multiplexing for LP HARQ-ACK - that is unacceptable. The cost of explicit indication for multiplexing is 1 bit or less (e.g. when beta\_offset is 1 bit itself). The two functionalities should not be mixed.  As we commented earlier the value of 0.8 is too large, we suggest the following values. Open to any other set of values that has some uniformity in the step size and has a small enough value corresponding to about 2-3 orders of magnitude difference between HP TB BLER and LP UCI BLER.   |  | | --- | |  | | 0.64 | | 0.32 | | 0.16 | | 0.08 | | 0.04 | | 0.02 | | 0.01 | | 0.005 | |
| QC | First of all, to respect RAN-P 94e conclusion, we don’t support beta-offset =0  We don’t support beta-value = 0.01, based on the following analysis  Given the smallest coding rate for PUSCH = 60/q/1024 (TS38.214 Table 6.1.4.1-2), when q=2 (QPSK), the smallest coding rate for PUSCH = 0.03.  Given the fact that UCI coding rate = PUSCH coding rate / beta-offset, or equivalently, beta-offset = PUSCH coding rate/UCI coding rate, if we require UCI code rate >1, we know beta-offset < PUSCH coding rate. From TS38.214 Table 6.1.4.1-2, we know the smallest coding rate for PUSCH is 0.03, then the smallest beta value should be 0.03. **Any beta-value smaller than 0.03 will just resulting UCI coding rate >1, which is useless.**  It is OK to not agree on the proposal on UCI coding rate not exceeding 1, which is a common knowledge with or without this agreement. But we just want to establish this principle such that we can determine what is the smallest value for beta-offset.  With the above, we think 0.01 should be replaced by 0.03. For the other values, the step size can be also optimized a little, current step size seems a little ad hoc. But except the smallest value 0.03, we don’t have strong view on other values.  So we suggest the following table.   |  | | --- | |  | | 0.6 | | 0.5 | | 0.4 | | 0.3 | | 0.2 | | 0.1 | | 0.05 | | 0.03 | |
| LG | We are OK with either the updated (2nd round) proposal in above or the original (1st round) proposal.  We do not support the inclusion of beta offset = 0. |
| Huawei/Hisi | Support the 1st round version (0.1 as the minimum value), also fine with QC proposal.  The LP UCI on HP PUSCH code rate could emulate the LP UCI on HP PUCCH. Considering that the PUCCH code rate range is  PUCCH-MaxCodeRate ::= ENUMERATED {zeroDot08, zeroDot15, zeroDot25, zeroDot35, zeroDot45, zeroDot60, zeroDot80}  For LP UCI on HP PUCCH, the minimum code rate ratio of HP UCI: LP UCI can be 0.08:0.8=0.1, when LP UCI selects maximum code rate of 0.8 while HP UCI selects minimum code rate 0.08. Moving to the LP UCI on HP PUSCH case, the minimum beta-offset, i.e. the minimum code rate ratio of HP data: LP UCI can be 0.1, to align the performance with the LP UCI on HP PUCCH case. So we think a minimum value of 0.1 is enough.  Considering the difference on tx power, coding approach between PUCCH and PUSCH, a lower than 0.1 value can be acceptable, but we do think the value as low as 0.01 is not necessary. 0.03 would be fine for us. |
| Sharp | We are fine with either table, and prefer not to include beta offset =0. |
| DOCOMO | We are fine with either the updated (2nd round) proposal in above or the original (1st round) proposal. |
| New H3C | We are fine with 0.1 or 0.03 for minimum value and we don’t support beta offset = 0 |
| OPPO | We object beta-offset=0 due to dynamic indication to enable/disable intra UE multiplexing has been precluded. So we should not repeat this issue again.  We do not prefer beta-offset=0.01, due to we do not think there is linear relation between target BLER ratio of LP UCI and HP data efficient coding rate. |
| ZTE | Fine with the lowest value =0.1 or 0.03. Don’t support beta offset = 0 |
| vivo | Same view with Nokia. |
| Intel | For the minimum value for beta -offset, we prefer 0.03 considering minimum code rate for PUSCH as 0.03 and UCI code rate is no larger than 1, as analyzed by QC. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Separate configurations of alpha values?

#### Inputs from Tdocs

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

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Nokia | * **Proposal 3.7: For the scenarios of multiplexing HARQ-ACK bits in a PUSCH of different priorities, do not support separate configurations of the scaling factor “alpha”.** |
| LG | **Proposal #13: 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.** |
|  |  |

## 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 HARQ-ACK is dropped
  + Intel, Apple
* Option 2: The LP UCI is compressed/bundled.
  + ZTE
* Option 3: UE does not expect this case
  + Nokia

For the scenarios where multiplexing high-priority HARQ-ACK, low-priority HARQ-ACK and low-priority CSI part 1 onto low-priority PUSCH, UE does not expect insufficient resource for multiplexing all three UCIs.

* + Nokia

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| Nokia | * **Proposal 3.10: For the scenarios where multiplexing low-priority HARQ-ACK onto high-priority PUSCH, UE does not expect insufficient resource for multiplexing low-priority HARQ-ACK.** * **Proposal 3.11: For the scenarios where multiplexing high-priority HARQ-ACK, low-priority HARQ-ACK and low-priority CSI part 1 onto low-priority PUSCH, UE does not expect insufficient resource for multiplexing all three UCIs.** |
| ZTE | ***Proposal 22:*** *LP UCI compression is slightly preferred in case there is no enough resource left for LP UCI.* |
| Intel | **Proposal 12: In case of insufficient number of REs for LP HARQ-ACK, LP HARQ-ACK is dropped as legacy CSI part 2.** |
| Apple | **Proposal 5-1: When UCI part 1 or UCI part 2’s capacity is exceeded, part of the HARQ-ACK feedback (initial HARQ bits / Type 1 or Type 2 codebook/deferred SPS HARQ-ACK) can be dropped.**  **Proposal 5-2: When UCI part 1 or UCI part 2’s capacity is exceeded, part of the HARQ-ACK feedback (initial HARQ codebook/retransmitted HARQ codebook) can be dropped.** |
|  |  |

## 1st round discussion

Proposal for 1st round discussion:

For the scenarios where multiplexing low-priority HARQ-ACK onto high-priority PUSCH, down-select from the options:

* + Option 1: In case of insufficient resource for LP HARQ-ACK, LP HARQ-ACK is dropped
    - Nokia/NSB (can accept), OPPO, Sony, Sharp, Intel, DOCOMO, ITRI, Panasonic, WILUS, NEC
  + Option 2: LP HARQ-ACKs are mapped to the rest REs of the PUSCH based on the rate matching equation, if HP HARQ-ACK and/or HP CSI have been mapped in prior on the PUSCH.
    - Huawei/Hisi, QC
  + Option 3: UE does not expect insufficient resource for multiplexing low-priority HARQ-ACK.
    - Nokia/NSB, vivo,QC
  + The agreement is not needed: Samsung, CATT, New H3C

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support FL proposal.  Between these two options, Option 3 is preferred. If Option 3 is not agreeable, Option 1 should be chosen. |
| Huawei/Hisi | Not support. The gNB is in full flexibility to schedule the resource of the HP PUSCH: if the LP HARQ-ACK is important, gNB will ensure there is sufficient resource; otherwise the gNB expect to receive partial systematic bits. The same principle with multiplexing HP HARQ-ACK and LP HARQ-ACK on PUCCH as shown in the agreement below should be adopted as a unified design, i.e.,  Option 2: LP HARQ-ACKs are mapped to the rest REs of the PUSCH based on the rate matching equation, if HP HARQ-ACK and/or HP CSI have been mapped in prior on the PUSCH.   |  | | --- | | **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. | |
| OPPO | Support and prefer to option 1 |
| LG | Support FL’s proposal. |
| Sony | Option 1.  In Rel-15, UCI mux into PUSCH, when there is insufficient resource, UE is capable of dropping CSI bits. Hence dropping a separately encoded LP HARQ-ACK should not be an issue in Rel-17. |
| Sharp | Support Option 1. The HP PUSCH should be given higher priority than LP HARQ-ACK if there is not enough resources for multiplexing. |
| Samsung | Not support.  The proposal is not necessary, current spec can work.  It is not clear about the wording “insufficient resource” . |
| Intel | We prefer option 1. |
| DOCOMO | Support and prefer Option 1. |
| ITRI | Support and prefer option 1 |
| CATT | We are also not clear how to define “insufficient resource” and would like to hear some clarification. |
| New H3C | The definition of “insufficient resource” isn’t clear to us. We hope proponent to clarify this.  This issue can be hanlded by gNB implementation. |
| Panasonic | We are fine with the proposal. Our preference is Option 1. |
|  | Support FL’s proposal and prefer Option 1 |
| vivo | Fine with the proposal. Our preference is Option 3. |
| Lenovo | Prefer option 2. |
| QC | We support option 2 or 3. No need to define dropping behavior following option 1 for this corner case. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Proposal for 1st round discussion:

For the scenarios where multiplexing high-priority HARQ-ACK, low-priority HARQ-ACK and low-priority CSI part 1 onto low-priority PUSCH, UE does not expect insufficient resource for multiplexing all three UCIs.

* + Support: Nokia/NSB, Intel, vivo
  + Not support: Sony, Sharp, Samsung, DOCOMO, WILUS
  + Not support (another option): Huawei/Hisi (all three UCIs are mapped to the REs of the PUSCH based on the rate matching equation)

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Support. |
| Huawei/Hisi | Not support. Same reason as the last proposal, that there should not be restriction to gNB scheduling. The changes could be:  For the scenarios where multiplexing high-priority HARQ-ACK, low-priority HARQ-ACK and low-priority CSI part 1 onto low-priority PUSCH, ~~UE does not expect insufficient resource for multiplexing all three UCIs~~ all three UCIs are mapped to the REs of the PUSCH based on the rate matching equation. |
| LG | Better to have same handling with the above case. (i.e., multiplexing LP HARQ-ACK on HP PUSCH) |
| Sony | Not support.  Unclear why we need such restriction in Rel-17, since even in Rel-15, UE is able to drop part of the UCI such as CSI if there is insufficient resource in the PUSCH. |
| Sharp | Not support. No need for restriction.  If there is not enough resource, the UCI can be dropped based on the priority order from the lowest priority until there is enough resources. |
|  |  |
| Samsung | Not support.  Same reason as above. |
| Intel | Fine with the proposal. |
| DOCOMO | Not support. Share the similar view with Sony. |
| CATT | Same question as above. |
| WILUS | Not support. It should not be restriction to gNB’s scheduling. We share the same view with Sharp that if not enough resource, UCI should be dropped based on priority order. |
| vivo | ok |
| QC | We can support this proposal. We are also fine with Huawei’s proposal. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 2nd round discussion

Void.

## 3rd round discussion

Discussion for 3rd round discussion:

This round is used to clarify the questions to Option 1:

*For the scenarios where multiplexing low-priority HARQ-ACK onto high-priority PUSCH, down-select from the options:*

* + *Option 1: In case of insufficient resource for LP HARQ-ACK, LP HARQ-ACK is dropped*

Being questioned by some companies in the 1st round: “What is the case of “insufficient resource for LP HARQ-ACK”, please proponents of Option 1 provide more information.

|  |  |
| --- | --- |
| Company | Comments |
| New H3C | At least we don’t support this proposal before insufficient resource is clear defined. |
| LG | Regarding the “insufficient resource for LP HARQ-ACK”, our understanding is that the condition to determine whether the resource is sufficient or not, may follow same principle with that for Rel-15/16 CSI part 2 to determine whether the CSI part 2 is partially omitted (captured in 38.214 as below), by replacing CSI part 2 into LP HARQ-ACK in below.   |  | | --- | | When the UE is scheduled to transmit a transport block on PUSCH multiplexed with a CSI report(s), Part 2 CSI is omitted only when  is larger than , where parameters , , , , , , , ,  and are defined in Clause 6.3.2.4 of [5, TS 38.212].  Part 2 CSI is omitted level by level, beginning with the lowest priority level until the lowest priority level is reached which causes the  to be less than or equal to .  When part 2 CSI is transmitted on PUSCH with no transport block, lower priority bits are omitted until Part 2 CSI code rate, which is given by where , , are given in clause 6.3.2.4 of [5, 38.212] before HARQ-ACK puncturing part 2 CSI if any, is below a threshold code rate lower than one, where    - is the CSI offset value from Table 9.3-2 of [6, TS 38.213]  - *R* is signaled code rate in DCI | |
| vivo | Not support. we prefer to support option 3 to keep unifed solution as LP HARQ-ACK multiplexed on PUCCH. |
| Nokia/NSB | Option 3 is preferred.  Related to “insufficient resource for LP HARQ-ACK”, we share similar understanding as LG following RAN1 agreement from last meeting “*Reuse Rel-15 CSI part 2 rate matching and RE mapping for LP HARQ-ACK.*”. Better to check whether all companies have the same understanding or not? |
| OPPO | Share view as LG |
| Samsung | NOT support.  The issue is not essential and should be up to gNB.  DON’T agree with LG, HARQ-ACK and CSI are quite different and should not follow CSI rules. |
| ZTE | For option 1, it should be clarified that ‘*LP HARQ-ACK is dropped*’ is partially dropped or totally dropped, because as the cited specification from LG, the dropping seems to be partially dropping similar with the CSI-part 2.  In generally, we are fine with the direction of dropping LP HARQ-ACK. |
| Sony | Support.  In Rel-15 we have definition of insufficient resources where the max REs allocated for a UCI as defined by alpha is not enough to carried the required symbols with UCI × beta bits, which is explained in more detail by LG above.  I find it strange that companies said they did not understand what it meant by “*insufficient resources*” in **PUSCH** but yet can draw the parallel and insist to unify with the case of “insufficient resources” for the LP HARQ-ACK and **PUCCH**.  **@vivo**: How is following LP HARQ-ACK mux into **PUCCH** a unified solution? In Rel-15, when there is insufficient resource in a **PUSCH** as described by LG above, we drop the CSI or CSI part 2. Hence should the “unified solution” be aligned with Rel-15 behaviour if **PUSCH** multiplexing rather than randomly/arbitrarily picking a totally different channel such as **PUCCH** and insist it is a unified solution? I do not follow your logic that somehow **PUCCH** is more unified than **PUSCH** in this case. |
| Ericsson | Support Option 1.  We share the same understanding as LG and Sony, i.e., “*insufficient resource*” refers to the existing spec text on checking RE. |
| DOCOMO | Share the same understanding LG/Sony/Ericsson. |
| Intel | For insufficient resource, we share the same understanding with LG. |
| NEC | Share the same understanding LG/Sony/Ericsson/DOCOMO/Intel. |
| ITRI | Share the same view as LG. |
| QC | We don’t think there is ambiguity on the definition of “*insufficient resource*”. But we think we should take a unfied solution on this issue between multiplexing on PUCCH and PUSCH. So option 2 is the unified solution. |
| Huawei/Hisi | Can accept Option 1 for progress. But better to clarify whether this behavior should be captured in 212 or 213. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 4th round discussion

With the clarifications from some companies on “insufficient resource”, let us check again companies’ positions on the options.

Proposal for 4th round discussion:

For the scenarios where multiplexing low-priority HARQ-ACK onto high-priority PUSCH, down-select from the options:

* + Option 1: In case of insufficient resource for LP HARQ-ACK, LP HARQ-ACK is entirely dropped
    - Sony, Ericsson, Apple, LG, Intel, CATT (can accept), Huawei/Hisi (can accept), DOCOMO, Nokia/NSB (can accept), NEC, Sharp,OPPO
  + Option 2: LP HARQ-ACKs are mapped to the rest REs of the PUSCH based on the rate matching equation, if HP HARQ-ACK and/or HP CSI have been mapped in prior on the PUSCH.
    - Samsung, ZTE, CATT, QC, Huawei/Hisi, vivo, DOCOMO (can accept), Lenovo
  + Option 3: UE does not expect insufficient resource for multiplexing low-priority HARQ-ACK.
    - Nokia/NSB
  + The agreement is not needed: Samsung

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Option 1.  We think Option 1 is the unified solution as in Rel-15, we drop specific UCI (e.g. CSI) when there are insufficient resource.  Option 2 deviates from Rel-15 behaviour and should be avoided. The argument that Option 2 is a unified solution is not correct as it refers to multiplexing into PUCCH rather than PUSCH. |
| Ericsson | Option 1.  Option 3 is not acceptable. There is always the checking if there are adequate resources. There are many parameters that go into the UCI resource calculation (alpha, beta, maxCodeRate, ….). The procedure ensures that not too much PUSCH resources are carved out for UCI. It is not possible to expect that there is always sufficient resource for UCI. HP PUSCH reliability may be significantly degraded as a result. |
| Apple | Somehow feel the same as Ericsson, without a specification based solution, asking gNB to exhaust all possibilties for this particular case before issuing a command seems unreasonable, and if the gNB does not do that, the percentage of error cases can be rather large. With SPS deferral or HARQ retransmission, actually whether there is sufficient resource for HP HARQ-ACK can be a problem also. We need a solution for that more than for this. |
| Samsung | Option 2.  We don’t think the proposal is necessary and Option 2 is the default behavior. If all the other companies think it is necessary to make an agreement, Option 2 is the only choice.  We share similar view as Huawei and QC, same principle should apply for PUCCH and PUSCH.  We object Option 1 and Option 3. |
| LG | Option 1 is preferred compared to other options.  BTW, similar (but more critical) situation could occur in the case of HP HARQ-ACK on LP PUSCH, if the amount of REs available for UCI mapping on the LP PUSCH is not sufficient to satisfy the coding rate of the HP HARQ-ACK based on the corresponding beta offset. This would be due to the scaling factor (i.e., alpha) configured for the LP PUSCH, and might be hard to be avoided by gNB since the LP PUSCH would be scheduled earlier than the HP HARQ-ACK. |
| ZTE | Support Option 2. I think the same logic for PUCCH can be used here. For Option 1, I think it should be further clarified that the LP HARQ-ACK is **entirely** dropped. |
| Intel | We share similar view with Sony, and we prefer option 1.  We’d like to understand the relation between this proposal and option 1/2 under 3.2.4. For option 1 under 3.2.4 (use legacy HARQ-ACK chain for LP HARQ-ACK on HP PUSCH), do we consider the case of insufficient resource for LP HARQ-ACK? If yes, it means, both LP HARQ-ACK and HP CSI is dropped, because REs for LP HARQ-ACK is firstly allocated. Therefore, if we go with option 1 under 3.2.4, it seems option 3 is a better choice ?  @LG, if we follow Rel-15 restriction as discussed under Yanping’s thread, DCI for LP or HP HARQ-ACK should come before the UL grant for LP PUSCH. |
| CATT | We prefer Option 2 to have a unified solution for both PUSCH and PUCCH.  We can also accept Option 1 for the sake of progress. |
| QC | We support option 2, which is a unified solution between PUCCH and PUSCH.  @Sony, Yes, in Rel-15, we have CSI dropping. But that is partial CSI dropping. The purpose is drop those less important CSI so at least the critical CSI info such as CQI/RI can be decoded. But here, the proposed HARQ-ACK is not partial HARQ-ACK codebook dropping, it is dropping the whole HARQ-ACK codebook. Comparing to 1) dropping the whole HARQ-ACK codebook vs 2) transmit the HARQ-ACK codebook with remaining REs and let gNB try its luck to decode it, why not choose 2)? Is it 2) better than 1)?  In Rel-15, we don’t have HARQ-ACK dropping. So Option 1 does not deviate from Rel-15. |
| New H3C | Before making the conclusion, it is better to clearly define “insufficient resource” although LGE offer some explanation on insufficient resource the similar as Rel-15/16 CSI part 2. |
| Huawei/Hisi | First preference is Option 2. Can accept Option 1 for progress. But better to clarify whether this behavior should be captured in 212 or 213. |
| vivo | We support option 2 for unified solution for both PUSCH and PUCCH, we agree with the comments from QC on the droping in Rel15/16 and this proposal. |
| DOCOMO | Option 1 is preferred to align with Rel-15, but we can accept Option 2 as it would have a better performance. |
| Nokia/NSB | We would have preferred Option 3, but Option 1 is also acceptable for us. |
| NEC | Option 1 is preferred to follow Rel-15 rule. |
| Lenovo | Option 2. We don’t think Option 1 is relevant to Rel-15 behavior, since HARQ-ACK is rate-matched based on available REs in Rel-15. |
| Sharp | Option 1 is preferred. |
| OPPO | Option 1 is preferred. |
|  |  |
|  |  |
|  |  |
|  |  |

## Agreements in this meeting

**Agreement**

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.

**Conclusion**

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.

* + No specification impacts.

**Agreement**

The values for beta-offset values <1 are:

|  |
| --- |
|  |
| 0.6 |
| 0.4 |
| 0.2 |
| 0.1 |
| 0.05 |

* + They are mapped to indices 16-20 in the table.
  + These values are used in addition to the legacy values in indices 0-15.

# PHY prioritization between DG and CG PUSCHs with different priorities

## Agreements in previous meetings

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.*

**Agreement**

The following working assumption is confirmed

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.

## Remaining issues

## Inputs from Tdocs

|  |  |
| --- | --- |
| Company | Proposals/observations from Tdocs |
| E/// | [Proposal 6 Similar to Rel-16, MAC is allowed to deliver two MAC PDUs to CG-vs-CG with different priorities in Rel-17.](#_Toc95752010)  [Proposal 7 UE implementation makes sure that the low priority CG-PUSCH is cancelled and does not participate in intra-UE multiplexing/prioritization procedure, including UCI-PUSCH multiplexing.](#_Toc95752011)  [Proposal 8 MAC may send two PDUs to two overlapping grants only if the later grant has higher PHY priority than the earlier grant.](#_Toc95752012)  [Proposal 9 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.](#_Toc95752013)  [Proposal 10 For the scenario of HP DG vs LP CG, reuse Rel-15 timeline for the scheduling PDCCH.](#_Toc95752014)  [Proposal 11 For the scenario of LP DG vs HP CG, no new timeline requirement is introduced for the scheduling PDCCH.](#_Toc95752015) |
| DCM | **Proposal 13:**   * *Agree the proposed conclusion for overlapping of CG PUSCHs of different priorities. Two MAC PDUs are not expected to be delivered to PHY when different priorities CG PUSCHs are overlapping if Rel-17 intra-UE multiplexing is enabled.* |
| Intel | **Proposal 5: If UCI-MuxWithDifferentPriority or UCI-MuxWithDifferentPriority-secondaryPUCCH group is enabled for a cell group, it is not expected that MAC PDUs are delivered for two overlapping CG PUSCHs of different PHY priorities on a serving cell within the same cell group.** |
|  |  |

# 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. |

## 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, CTC
  + Not support: Samsung, Intel, DOCOMO, vivo

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | Fine to have this clarification. |
| Huawei/Hisi | Support. It is better to explicitly capture the UE behavior for UCI dropping in the spec (similar as the dropping of CSI part 2 in the legacy spec), and to distinguish the resultant channel including HP UCI only, or including HP UCI + LP UCI, as different behaviours/restrictions may be applied for these two cases. |
| OPPO | Clarification is required. The above TP only solves an extremely special case, i.e. the rest RE on the resultant PUCCH for LP HARQ-ACK is 0. How to handle insufficient resource for LP HARQ-ACK in resultant PUCCH, which is more general. |
| LG | Support in principle, but seems to need clarification on which one is correct between following two equations:  1)  2) |
| Samsung | Not support.  Current spec is clear. The TP is not needed. |
| Intel | Share same view with Samsung. |
| DOCOMO | Current spec should be clear but we are fine to have the clarification. |
| vivo | Not support. Share same view with Samsung. |
| CTC | We are fine with it. |
| Lenovo | If clarification is really needed, we think it should be as follows:  If , the HARQ-ACK information bits of priority 0 are dropped |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# Proposals for GTW sessions

## GTW session on 23rd Feb. (Wednesday).

Proposal 1:

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,
  + 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.
* Note: If the new T-DAI field is not RRC configured, 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.
* Note: The agreement is applied for multiplexing LP HARQ-ACK sub-codebook for TB-based PDSCH on HP PUCCH or HP PUSCH
* ~~FFS whether/how to multiplex LP HARQ-ACK sub-codebook for CBG-based PDSCH on HP PUCCH or HP PUSCH with single new T-DAI field.~~
* Support: Nokia/NSB, Huawei/Hisi, ZTE, Samsung, Intel, DOCOMO, ITRI, Panasonic, WILUS
* Not support: Ericsson
* Concerned about the existence of the solution for the FFS point: OPPO, Apple, Spreadtrum
* Suggested solutions for the FFS point: Nokia/NSB, Samsung, QC, LG, Huawei/Hisi, NEC, Sharp, ZTE, vivo, Intel
* Do not think the FFS point is a critical case: Nokia/NSB, QC, LG, InterDigital, NEC, Sharp, CATT, DOCOMO, ZTE, vivo

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 the HP SR is positive,
  + 1 bit LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=6} representing {NACK, ACK} respectively;
  + 2 bits LP HARQ-ACK should be transmitted on the HP SR PUCCH resource by using m0 +{mCS=0, mCS=3, mCS=6, mCS=9} representing {NACK/NACK, NACK/ACK, ACK/ACK, ACK/NACK} respectively.
  + Where m0 is configured by initialCyclicShift in the configuration of the HP SR PF0 resource in Rel-16.
* 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 on the same SR resource with QPSK.
* Support: Nokia/NSB, Huawei/Hisi, LG, Sony, Sharp, DOCOMO, Spreadtrum, ITRI, CATT, Panasonic, New H3C, WILUS, vivo, CTC, QC
* Not support: Samsung, Intel

Proposal 3:

If LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH, down-select from the options:

* Option 1: 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.”
  + Huawei/Hisi, ZTE, Sony, DOCOMO, ITRI, CATT, Panasonic, CTC, QC
* Option 2: UE follows the same behaviour as that in case of PUSCH with HP HARQ-ACK.
  + Nokia/NSB, OPPO, LG, Apple, Sharp, Spreadtrum, New H3C, Lenovo
* Option 3: Reuse Rel-15 HARQ-ACK rate matching and RE mapping for LP HARQ-ACK if no HP CSI is present, otherwise, HARQ-ACK rate matching equation should be revised by taking HP CSI into account and Rel-15 CSI rate matching without consideration of LP HARQ-ACK is used for HP CSI.
  + Intel, vivo

Proposal 4:

The values for beta-offset values <1 are:

|  |
| --- |
|  |
| 0.6 |
| 0.5 |
| 0.4 |
| 0.3 |
| 0.2 |
| 0.1 |
| 0.05 |
| 0.03 |

* + They are mapped to index 16-23 in the table.

Proposal 5:

For the scenarios where multiplexing low-priority HARQ-ACK onto high-priority PUSCH, down-select from the options:

* + Option 1: In case of insufficient resource for LP HARQ-ACK, LP HARQ-ACK is dropped
    - Nokia/NSB (can accept), OPPO, Sony, Sharp, Intel, DOCOMO, ITRI, Panasonic, WILUS, NEC
  + Option 2: LP HARQ-ACKs are mapped to the rest REs of the PUSCH based on the rate matching equation, if HP HARQ-ACK and/or HP CSI have been mapped in prior on the PUSCH.
    - Huawei/Hisi, QC
  + Option 3: UE does not expect insufficient resource for multiplexing low-priority HARQ-ACK.
    - Nokia/NSB, vivo, QC
  + The agreement is not needed: Samsung, CATT, New H3C

## GTW session on 1st March (Tuesday).

Proposal 1:

If LP HARQ-ACK without HP HARQ-ACK would be transmitted on HP PUSCH, down-select from the options:

* Option 1: 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.
  + ZTE, Sony, Ericsson, DOCOMO, NEC, QC, Huawei/Hisi, CATT
* Option 2: UE follows the same behaviour as that in case of PUSCH with HP HARQ-ACK.
  + FFS for CG-UCI PUSCH.
  + New H3C, LG, vivo, Nokia/NSB, OPPO, Sony (can accept), Apple, Sharp, DOCOMO (can accept), Intel (If without CG-UCI), ITRI, Spreadtrum, Lenovo

Proposal 2:

|  |  |
| --- | --- |
| Option 0 | Samsung |
| Option 1 |  |
| Option 2 | Sony, Nokia/NSB (can accept), Sharp, New H3C, DOCOMO, ZTE (can accept), OPPO, Huawei/Hisi, Ericsson, CATT, Intel (can accept) |
| Option 3 | Nokia/NSB, DOCOMO (can accept), ZTE, Ericsson (can accept), Intel, vivo, |
| Option 4 | LG |
| Option 5 | QC |
| Option 2+5 | Lenovo |
| Option 6 | Sony |
| Option 7 | LG |

When a PUCCH carrying ~~explicit/implicit~~ HP SR and HP HARQ-ACK with PUCCH format 0/1 overlaps with a PUCCH carrying LP HARQ-ACK, where the original PUCCH carrying the HP HARQ-ACK before Step 1 overlaps with K HP SRs which are all negative or include at least one positive,

* In Step 1, 1-bit HP SR is multiplexed to HP HARQ-ACK bits (based on Rel-15 rules) for determining the resultant PUCCH resource.
  + Note: The description of Step 1 here is only for information purpose, which has no spec impact.
* In Step 2, down-select from the following options,
  + Option 0: LP HARQ-ACK is dropped.
  + Option 1: bits of HP SRs are appended, 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 .
  + Option 2: 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is
    - The resultant PUCCH resource for multiplexing HP SR + HP HARQ-ACK + LP HARQ-ACK is either of PF2, PF3, or PF4.
  + Option 3:
    - If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
    - If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is
      * For HP SR with PF0/PF1 and HP HARQ-ACK with PF0, the 1-bit HP HARQ-ACK + 1-bit HP SR + 1-bit LP HARQ-ACK are multiplexed on the PUCCH resource (with PF0) of HP HARQ-ACK by treating the LP HARQ-ACK as HP bit and following Rel-15/Rel-16 mux rules.
      * For HP SR with PF0 and HP HARQ-ACK with PF1, according to Rel-15/Rel-16 rules, the SR is dropped. Then, the 1-bit LP HARQ-ACK is treated as HP bit and multiplexed with the HP HARQ-ACK bit on the PUCCH resource (with PF1) of HP HARQ-ACK.
      * For HP SR with PF1 and HP HARQ-ACK with PF1, the 1-bit HP HARQ-ACK + 1-bit HP SR are multiplexed based on Rel-15/Rel-16 by ‘transmitting’ HP HARQ-ACK on the SR resource when the SR is positive; and ‘transmitting’ HP HARQ-ACK on the HP HARQ-ACK resource when the SR is negative. Then, the 1-bit LP HARQ-ACK is treated as HP bit and multiplexed with the HP HARQ-ACK bit (and thus implicitly with the HP SR) on the resulting PUCCH resource (with PF1) containing the HP HARQ-ACK bit.
  + Option 4 (LG):
    - If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK,
      * If HP SR and HP HARQ-ACK are on PUCCH format 1, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
      * If HP SR and HP HARQ-ACK are on PUCCH format 0, LP HARQ-ACK is dropped.
    - If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2,
      * If HP HARQ-ACK is dynamic HARQ-ACK or SPS HARQ-ACK with sps-PUCCH-AN-List, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is (i.e. ).
      * If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped.
  + Option 5 (QC): Based on total number of HP HARQ-ACK bits, LP HARQ-ACK bit, and SR bit, determine a resulting PUCCH resource in the configured HP PUCCH resources, either following PRI or sps-PUCCH-AN-List.
    - If the resulting PUCCH is in PF0, treat the 1-bit LP A/N as if it is HP and reuse Rel-15 procedure to multiplex the three bits in the PF0 PUCCH.
    - If the resulting PUCCH is in PF2/3/4, append the HP SR to HP HARQ-ACK bits, then multiplex with LP HARQ-ACK by reusing the procedures for multiplexing of LP HARQ-ACK and HP HARQ-ACK on PUCCH resource in PF 2/3/4.
  + Option 6 (Option 3 + 4):
    - If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK,
      * If HP SR and HP HARQ-ACK are on PUCCH format 1, LP HARQ-ACK bit can be simply treated as HP HARQ-ACK bit, and the two HP HARQ-ACK bits are multiplexed with the HP SR using Rel-16/Rel-15 rules.
      * If HP SR and HP HARQ-ACK are on PUCCH format 0, LP HARQ-ACK is dropped.
    - If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is
  + Option 7
    - If there is 1-bit HP HARQ-ACK and 1 bit LP HARQ-ACK, LP HARQ-ACK is dropped.
    - If at least one of the HP HARQ-ACK payload size or LP HARQ-ACK payload size is greater than or equal to 2,
      * If HP HARQ-ACK is dynamic HARQ-ACK or SPS HARQ-ACK with sps-PUCCH-AN-List, 1-bit HP SR is appended to HP HARQ-ACK bits. The number of HP UCI bits is .
      * If HP HARQ-ACK is SPS HARQ-ACK with n1PUCCH-AN, LP HARQ-ACK is dropped.

Proposal 3:

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,
  + A T-DAI field in a DL DCI format associated with HP HARQ-ACK to indicate the T-DAI of LP HARQ-ACK.
  + Working assumption: 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.
  + Working assumption: 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.
* Note: If the new T-DAI field is not RRC configured, 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.
* FFS whether/how to multiplex LP HARQ-ACK sub-codebook for CBG-based PDSCH on HP PUCCH or HP PUSCH with single new T-DAI field.
* Support: New H3C, LG, vivo (can accept), Nokia/NSB, Samsung, ZTE, Sony, DOCOMO, Intel, NEC, QC, Spreadtrum, Huawei/Hisi, ITRI, Panasonic, WILUS, InterDigital, CATT
* Not support: Apple, Ericsson, OPPO (can compromise if is the only objecting company)

Proposal 4:

For the scenarios where multiplexing low-priority HARQ-ACK onto high-priority PUSCH, down-select from the options:

* + Option 1: In case of insufficient resource for LP HARQ-ACK, LP HARQ-ACK is entirely dropped
    - Sony, Ericsson, Apple, LG, Intel, CATT (can accept), Huawei/Hisi (can accept), DOCOMO, Nokia/NSB (can accept), NEC, Sharp, OPPO
  + Option 2: LP HARQ-ACKs are mapped to the rest REs of the PUSCH based on the rate matching equation, if HP HARQ-ACK and/or HP CSI have been mapped in prior on the PUSCH.
    - Samsung, ZTE, CATT, QC, Huawei/Hisi, vivo, DOCOMO (can accept), Lenovo
  + Option 3: UE does not expect insufficient resource for multiplexing low-priority HARQ-ACK.
    - Nokia/NSB
  + The agreement is not needed: Samsung

# References

1. [R1-2200960](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2200960.zip) Intra-UE multiplexing enhancements Huawei, HiSilicon
2. [R1-2201003](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201003.zip) Intra-UE Multiplexing/Prioritization Enhancements for IIoT/URLLC Ericsson
3. [R1-2201018](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201018.zip) On UL intra-UE prioritization and multiplexing enhancements Nokia, Nokia Shanghai Bell
4. [R1-2201023](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201023.zip) Intra-UE multiplexing and prioritization New H3C Technologies Co., Ltd.
5. [R1-2201091](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201091.zip) Remaining issues on intra-UE Multiplexing/Prioritization for Rel-17 URLLC vivo
6. [R1-2201162](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201162.zip) Discussion on enhanced intra-UE multiplexing ZTE
7. [R1-2201296](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201296.zip) Enhancements on intra-UE multiplexing/prioritization OPPO
8. [R1-2201357](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201357.zip) Intra-UE multiplexing and prioritization CATT
9. [R1-2201379](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201379.zip) Discussion on intra-UE multiplexing with different priorities Panasonic Corporation
10. [R1-2201439](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201439.zip) Discussion on remaining issue for intra-UE multiplexing China Telecom
11. [R1-2201476](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201476.zip) Discussion on intra-UE multiplexing/prioritization for Rel.17 URLLC NTT DOCOMO, INC.
12. [R1-2201545](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201545.zip) Discussion on intra-UE multiplexing/prioritization Spreadtrum Communications
13. [R1-2201580](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201580.zip) Remaining issues on intra-UE multiplexing & prioritisation Sony
14. [R1-2201612](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201612.zip) Intra-UE Multiplexing/Prioritization ETRI
15. [R1-2201654](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201654.zip) Intra-UE multiplexing and prioritization InterDigital, Inc.
16. [R1-2201695](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201695.zip) Remaining Open Details of Intra-UE Uplink Channel Multiplexing and Prioritization Intel Corporation
17. [R1-2201770](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201770.zip) Views on Intra-UE Multiplexing/Prioritization Apple
18. [R1-2201904](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2201904.zip) Discussion on Intra-UE prioritization and multiplexing NEC
19. [R1-2202010](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2202010.zip) Maintenance on Intra-UE Multiplexing/Prioritization Samsung
20. [R1-2202093](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2202093.zip) Intra-UE multiplexing enhancement for IIoT/URLLC Lenovo
21. [R1-2202136](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2202136.zip) Intra-UE multiplexing and prioritization for IOT and URLLC Qualcomm Incorporated
22. [R1-2202191](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2202191.zip) Channel collision handling and intra-UE UCI multiplexing with different priorities Sharp
23. [R1-2202243](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2202243.zip) Discussion on intra-UE multiplexing and prioritization ITRI
24. [R1-2202342](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2202342.zip) Discussion on Intra-UE multiplexing/prioritization LG Electronics
25. [R1-2202485](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_108-e\Docs\R1-2202485.zip) Remaining issues on intra-UE multiplexing/prioritization for URLLC/IIoT WILUS Inc.