**3GPP TSG RAN WG1 #107bis-e R1-2200xxx**

**e-Meeting, January 17th – 25th, 2022**

**Source: Moderator (CATT)**

**Title:** **Summary #3 of email thread [107bis-e-R17-IIoT-URLLC-03]**

**Agenda Item:** **8.3.3**

**Document for:** **Discussion and Decision**

# Introduction

This document summarizes the discussions in contributions and during RAN1#107bis-e under the following email thread:

[107bis-e-R17-IIoT-URLLC-03] Email discussion on intra-UE multiplexing/prioritization – Yanping (CATT)

* Focus on simultaneous TX of PUCCH/PUSCH and multiplexing/overlapping resolution procedure for intra-UE multiplexing of UCI of different priorities on PUCCH and PUSCH (Capability 1 only)
* 1st check point: January 20
* Final check point: January 25

# Agreements in previous meetings

## Rel-17 Intra-UE multiplexing & prioritization framework

**RAN1#106-e (Aug. 2021)**

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| **Working Assumption**  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   Note: Avoid recursive pseudo-code to implement this procedure  Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable |

**RAN1#106bis-e (Oct. 2021)**

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| **Agreement**  The following working assumption is confirmed.  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   Note: Avoid recursive pseudo-code to implement this procedure  Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable  **Agreement**  For both the subslot-based PUCCH and slot-based PUCCH, if simultaneous PUCCH/PUSCH transmission is not enabled, reuse Rel-16 procedure for Step 1 |

**RAN1#107-e (Nov. 2021)**

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| **Agreement**  For handling overlapping PUCCHs/PUSCHs with different priorities, Step 2 consists of the following sub-steps:   * Step 2.1: Resolve collision of LP PUCCHs and HP PUCCHs. * Step 2.2: Resolve collision of PUCCHs and PUSCHs of different priorities.   **Agreement**  If multiplexing of PUCCHs and/or PUSCHs with different priorities is enabled by RRC, support both of the following UE capabilities to resolve collision of PUCCHs and/or PUSCHs with different priorities in step 2:   * Capability #1: It is not expected that Rel-15 multiplexing timeline is not met for all overlapping channels [FFS the overlapping channels are resultant channels after step 1]. UE performs multiplexing or dropping of PUCCHs and/or PUSCHs with different priorities according to Rel-17 rules.   + Dynamic enabling/disabling multiplexing for different priorities is not supported for Capability #1 * (Working assumption) Capability #3: Rel-17 multiplexing for different priorities is dynamically enabled/disabled in step 2.   + Dynamic indication of enabling/disabling multiplexing for different priorities can be enabled only if multiplexing of PUCCHs/PUSCHs with different priorities is enabled by RRC configuration.     - If dynamic multiplexing for different priorities is indicated as enabled for a PUCCH / PUSCH, the UE performs Rel-17 multiplexing operation using the Rel-15 timeline       * The gNB is responsible to ensure that all the DCIs associated with all overlapping channels involved in multiplexing in step 2 meet the Rel-15 timeline for multiplexing.     - If dynamic multiplexing for different priorities is indicated as disabled for a PUCCH / PUSCH, the UE does not apply the Rel-17 intra-UE multiplexing       * If the UL channel associated with the DCI disabling multiplexing collides with another UL channel of a different priority, UE performs R16 PHY prioritization, using Rel-16 timeline. The gNB is responsible to ensure that the UE meets R16 PHY prioritization timeline.       * If the UL channel associated with the DCI disabling multiplexing does not collide with another UL channel of a different priority, UE transmits the UL channel as is.       * FFS: whether the UL channel associated with the DCI disabling multiplexing can collide with another UL channel of a same priority.   + UE does not expect to receive a dynamic indication resulting in demultiplexing of previously multiplexed PUCCHs/PUSCHs channels after the Rel-15 multiplexing deadline has passed   + FFS: UE does not expect to receive a dynamic indication resulting in demultiplexing of previously multiplexed PUCCHs/PUSCHs channels without any associated DCIs     - Note: demultiplexing of two previously multiplexed channels means decoupling two channels already multiplexed, dropping one channel, and multiplexing the other channel with another channel(s).   The above behaviors of Capability#3 at least apply to resolving collision of two UL channels resulting from Step 1 with different priorities. FFS: more than two UL channels.   * + FFS whether dynamic indication in multiple DCIs associated with a group of overlapping channels have to be consistent   + FFS: Configuration of prioritization / multiplexing of channels without dynamic indication   + Note: Capability 3 procedure is a super-set of Capability 1 procedure * FFS: Time unit to apply Rel-15 timeline (e.g. slot based, sub-slot based) * FFS: The set of PUSCH and PUCCH that eligible for Rel-15 multiplexing consideration   Note: “collision” refers to overlapping PUCCHs, overlapping PUCCH and PUSCH (excluding PUSCH supporting simultaneous transmission with PUCCH), overlapping PUSCHs on a same cell.  Note: “Rel-15 multiplexing timeline” means Rel15 timeline calculation in Rel-16 spec, including all the formula and all the values for the variables  Note: “Rel-16 prioritization timeline” means Rel-16 cancellation timeline calculation in Rel-16 spec, including all the formula and all the values for the variables |

**RAN#94-e (Dec. 2021)**

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| RAN to guide RAN1 to focus on the discussions on Capabilility#1 only in Q1 2022 for Rel-17 intra-UE multiplexing framework. |

## Intra-UE multiplexing enhancements of different priorities (on PUCCH & PUSCH)

**RAN1#102-e (Aug. 2020)**

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| 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:  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 |

**RAN1#103-e (Oct./Nov. 2020)**

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| Agreements:  For multiplexing UCIs of different priorities in a PUCCH in R17,   * Support of multiplexing between different resources not confined within a sub-slot if conditions are met   + FFS: Details * Support multiplexing in case a PUCCH overlaps with more than one PUCCH if conditions are met   + FFS details   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 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. |

**RAN1#104-e (Jan/Feb. 2021)**

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| 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:  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)   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? |

**RAN1#104bis-e (April 2021)**

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| 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 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. |

**RAN1#105-e (May 2021)**

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| 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: QC 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. QC accept the scheme for the sake of progress in RAN 1 with the concern on the performance reserved. |

**RAN1#106-e (Aug. 2021)**

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| **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**  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 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 |

**RAN1#106bis-e (Oct. 2021)**

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| **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 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 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. |

**RAN1#107-e (Nov. 2021)**

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| **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 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. |

## Simultaneous PUCCH/PUSCH transmission

**RAN1#102-e (Aug. 2020)**

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| Agreements:  Support simultaneous PUCCH/PUSCH transmissions on different cells at least for inter-band CA.   * FFS how to trigger this function. * FFS for intra-band CA. |

**RAN1#104-e (Jan/Feb. 2021)**

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| Agreements:  Per UE with the capability of inter-band CA, simultaneous PUCCH/PUSCH transmission of different PHY priorities over different cells can be RRC configured within the same PUCCH group   * FFS: dynamic indication |

**RAN1#106-e (Aug. 2021)**

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| **Conclusion**  Simultaneous PUCCH/PUSCH transmission on the same cell is not supported in Rel-17. |

**RAN1#107-e (Nov. 2021)**

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| **Conclusion**  There is no consensus in RAN1 to support simultaneous PUCCH/PUSCH transmission of same priority over different cells in Rel-17.  **Conclusion**  There is no consensus in RAN1 to support simultaneous PUCCH/PUSCH transmissions on different cells for intra-band CA in Rel-17. |

# Discussion

## Remaining issues of Rel-17 intra-UE multiplexing

### Timeline requirement for step 2

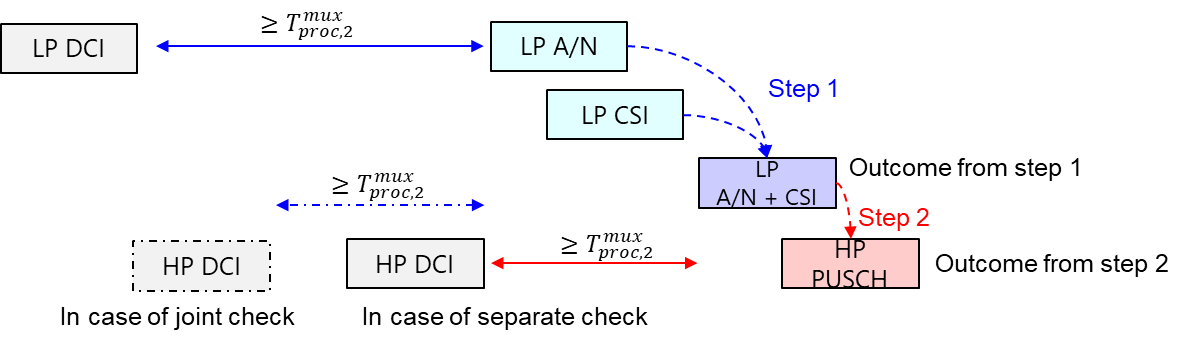
#### **1st round discussion**

In the agreement in RAN1#107-e, the following was agreed for multiplexing timeline in step 2 for Capability #1 with FFS highlighted in yellow. Note the following agreement is not complete and the irrelevant parts are omitted.

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| **Agreement**  If multiplexing of PUCCHs and/or PUSCHs with different priorities is enabled by RRC, support both of the following UE capabilities to resolve collision of PUCCHs and/or PUSCHs with different priorities in step 2:   * Capability #1: It is not expected that Rel-15 multiplexing timeline is not met for all overlapping channels [FFS the overlapping channels are resultant channels after step 1]. UE performs multiplexing or dropping of PUCCHs and/or PUSCHs with different priorities according to Rel-17 rules.   + Dynamic enabling/disabling multiplexing for different priorities is not supported for Capability #1 * (Working assumption) Capability #3:… * FFS: Time unit to apply Rel-15 timeline (e.g. slot based, sub-slot based) * FFS: The set of PUSCH and PUCCH that eligible for Rel-15 multiplexing consideration   Note: “collision” refers to overlapping PUCCHs, overlapping PUCCH and PUSCH (excluding PUSCH supporting simultaneous transmission with PUCCH), overlapping PUSCHs on a same cell.  Note: “Rel-15 multiplexing timeline” means Rel-15 timeline calculation in Rel-16 spec, including all the formula and all the values for the variables  Note: “Rel-16 prioritization timeline” means Rel-16 cancellation timeline calculation in Rel-16 spec, including all the formula and all the values for the variables |

On whether Rel-15 multiplexing timeline applies to resultant channels after step 1 or all overlapping channels before step 1, the views and the reasons based on the input contributions are summarized as follows.

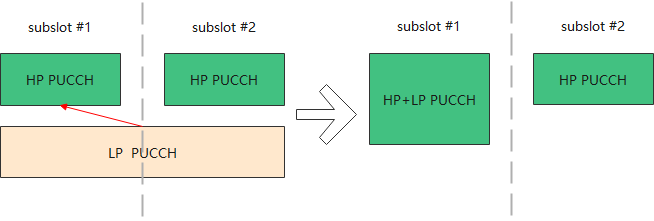
* Option 1: Rel-15 multiplexing timeline applies to the resultant overlapping channels after step 1.
  + Supported by: Huawei [4], CATT [7], DOCOMO [10], OPPO [14]
  + Reasons:
    - Better scheduling flexibility at gNB side for HP channels in case the resultant channel after step 1 is later in time or the resultant channel after step 1 does not overlap with HP channel [4][7][10]. An example in [10] is shown below.



* + - Different from Rel-15 where all overlapped original PUCCH/PUSCHs are multiplexed by a single procedure in Clause 9.2.5 of 38.213, Rel-17 introduces two sequential steps (i.e., Step 1 and Step 2) in which the multiplexing procedures of PUCCH/PUSCHs are individually carried out. In this sense, the Rel-15 timeline should be separately applied to the multiplexing procedures of Step 1 (also separately applied to LP PUCCH/PUSCH multiplexing and HP PUCCH/PUSCH multiplexing in Step 1) and Step 2, respectively, where the input channels before each particular step are separately used as the reference of timeline [4].
* Option 2: Rel-15 multiplexing timeline applies to all overlapping channels before step 1.
  + Supported by: Intel [17]
  + Reason:
    - If UE starts bit preparation for LP UCI carrying in LP PUSCH, e.g., perform rate matching according to the number of REs for LP UCI, determine RE locations for LP UCI mapping and also perform rate matching for PUSCH, at t0, and if HP DCI comes after t0, UE needs to redo the multiplexing for LP UCI as shown below.

The benefit of Option 1 is acknowledged by all the companies above including Intel. For the potential issue raised by Intel, it is only valid if UE prepares LP UCI before t1. But from UE processing time perspective, UE does not need to prepare LP UCI so early and Option 1 still provides sufficient processing time for UE.

In addition, it is proposed by Huawei [4] that time unit to adopt Rel-15 timeline should be based on the time unit of HP channel. For the case shown in the figure below, the DCI and PDSCH associated with HP PUCCH in subslot #2 do not need to meet Rel-15 multiplexing timeline with reference to the start of LP PUCCH or HP PUCCH in subslot #1, which provides better scheduling flexibility. However, note that the proposal may impact other discussions, e.g. multiplexing of LP HARQ-ACK overlapping with HP SR and HP HARQ-ACK where some companies proposed to multiplex LP HARQ-ACK in HP PUCCH with HARQ-ACK, and LP PUSCH overlapping with multiple HP PUCCHs with HARQ-ACK where some company proposed to drop LP PUSCH.



LG [26] proposed to allow the case that Rel-15 multiplexing timeline is not met for the overlapping resultant channels after Step 1. Furthermore, if the inter-priority multiplexing timeline requirements are not met, then the UE would proceed with the multiplexing/transmission only for the HP by dropping the LP. However, moderator’s understanding is that the proposal is not inline with the previous agreement for Capability #1.

Based on the above inputs, companies are invited to provide your views on the following proposal. The intention of the proposal is to define the multiplexing timeline based on resultant channels after step 1 instead of channels before step 1. In addition, the proposal that time unit to adopt Rel-15 timeline is the time unit of HP channel in [4] and the proposal to allow the case that Rel-15 multiplexing timeline is not met for the overlapping resultant channels after Step 1 in [26] are also precluded by the proposal.

**Proposed Conclusion 1.1.1:**

For the timeline requirement of resolving collision of PUCCHs and/or PUSCHs with different priorities in step 2, it is not expected that Rel-15 multiplexing timeline is not met for all overlapping channels where the overlapping channels are the resultant overlapping channels after step 1.

|  |  |
| --- | --- |
|  | **Company** |
| Support | Nokia/NSB, ZTE, CATT, DOCOMO Huawei/Hisi, Sharp, New H3C,Samsung, Ericsson, vivo,OPPO, LG (can live) |
| Not support | Intel, Sony, QC, Spreadtrum |

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| --- | --- | --- |
| **Company** | **Comments** | |
| Intel | We support using all overlapping channels before step 1 as reference for Rel0-15 timeline, to minimize the impact on Rel-15/16 UE implementation.  In Rel-17, yes, same and different priorities are handled in two sequential steps, but we’d like to point out, in Rel-15, PUCCH/PUCCH multiplexing and PUCCH/PUSCH multiplexing are also two sequential steps, while Rel-15 timeline uses the earliest start channel of all overlapped PUCCH and PUSCHs as reference, rather than earliest start channel of resultant PUCCH and PUSCHs as reference. In Rel-17, similar logic as Rel-15 can be reused for two sequential steps (step 1 and step 2).  According to the figure shown by FL, if we reuse resultant LP PUCCH as reference for timeline (*t*1),   * At *t*0 (the deadline with reference to LP PUCCH resource with A/N), UE still has to start to determine LP PUCCH resource carrying both LP A/N and CSI (purple block, outcome from step 1). * At *t*2, assuming UE has determined PUCCH resource for LP. Since *t*2 is earlier than *t*1, UE stops processing and waits until *t*1. * At *t*1, UE starts step 2 if UE has detected HP DCI before *t*1. If no HP DCI has been detected, UE resumes LP PUCCH preparation which was stopped at *t*2.   The stop and wait procedure may have large impact on existing UE implementation, because Rel-15 UE implementation can process PUSCH from *t*0 without such stop and wait step.  We’d like to hear more views on the expected impact on existing UE implementation, if we go with timeline using resultant channel after step 1 as reference. | |
| ZTE | Fine with the proposal, just additional timeline consideration, for URLLC latency requirement, after the inter-priority multiplexing, the end of multiplexing resource is not expected to be later than the end of high priority channel. | |
| Sony | The main argument against Capability #2 (RRC configured but UE can also perform Rel-16 prioritisation) was that the UE is not aware of all these processing time for multiplexing/prioritisation. It was further argued that the UE will just do what it was told and very likely the UE will perform multiplexing as soon as it realises there are collisions rather than wait for further collisions. If UE is aware of all these multiplexing/processing timelines, then we do not see a reason why it could not perform Rel-16 prioritisation and Rel-17 multiplexing together (i.e. perform Capability #2).  Alternatively, we can define explicit timeline/deadline for the UE which are configurable and so the UE will be **explicitly aware** of the when it needs to do multiplexing. If we are going this route, we might as well allow the UE to perform Rel-16 prioritisation in addition to Rel-17 multiplexing. | |
| Huawei/Hisi | From the NW vendor perspective, we think the proposal is beneficial to relax the scheduling restriction to gNB and eventually contributes to better performance, but we would like to hear the voice from UE vendors. | |
| QC | We understand from NW vendor point of view, this proposal relax scheduler restriction so it is beneficial.  However, from UE perspective, this problem creates problem. We fully agree with the analysis provided by Intel on the created problem. In the following example provided by Intel. On high level, this proposal basically prohibits UE to start performance UCI multiplexing right after receiving LP DCIs for the two LP channels. UE has to on hold UCI multiplexing procedure until it receives the later HP DCI, to avoid the situation that UE has to discard the UCI mux result between LP UCI+LP PUSCH and redo the UCI mux with LP UCI+HP UCI+LP PUSCH.  Now, the question is: UE does not know there will be a later HP DCI, how long UE suppose to wait? Like Sony mentioned, to solve this issue, RAN1 effectively need to introduce a new functionality to ask UE do timeline check. However, this was already discussed extensively in last meeting and it was excluded already.  So, at this late stage of Rel-17, the reasonable route is applying Rel-15 timeline on all overlapping channels including HP and LP and close this issue. | |
| Spreadtrum | We totally agree with Intel, Sony and QC. This proposal requires UE have two timelines in parallel, which is for same priority and the other for different priority, which can certainly cause the stop, wait and restart operation. Clearly, it leads to totally different and more complex intra-UE multiplexing among the overlapped PUCCH/PUSCH. | |
| Sharp | | Since the UCI multiplexing with different priorities is only applied in Step 2. The channel considered should be the resultant channel after Step1.  Furthermore, the UE should not undo the multiplexing from Step 1 in Step 2. |
| Apple | We agree with Intel, Sony, QC and Spreadtrum. The timeline requirement should apply to all overlapping channels | |
| Samsung | UE does not need to redo the multiplexing for LP UCI. There is no need for the UE to prepare the LP REs at a deadline with reference to LP PUCCH and UE cannot always use the deadline with reference to the PUCCH because PUSCH can start before the PUCCH. Instead, the deadline for preparing the UCI REs can be and should be with reference to the PUSCH because the UCI is always transmitted on the PUSCH. At the deadline with reference to the PUSCH, the HP DCI should be decoded as well. | |
| Ericsson | Since Rel-15 multiplexing procedure (with modification) is applied again in Step 2, only input to Step 2 are considered in Rel-15 timeline calculation, i.e., resultant channels after Step 1. | |
| LG | We originally proposed to allow the case that Rel-15 multiplexing timeline is not met for the overlapping resultant channels after Step 1, so that UE could proceed the multiplexing/ transmission at least for the HP by dropping the LP, even in case when Rel-15 multiplexing timeline is not met for the overlapping resultant channels after Step 1.  But, if it is hard to be accepted by the group, then we can live with the proposed conclusion 1.1.1 provided by FL in the context of relaxing gNB’s scheduling burden. | |

### Resultant PUCCH with UCI of different priorities

#### **1st round discussion**

There is a note in previous agreement to avoid recursive pseudo-code to implement two steps for Rel-17 intra-UE multiplexing.

|  |
| --- |
| **Agreement**  The following working assumption is confirmed.  For handling overlapping PUCCHs/PUSCHs with different priorities in R17   * Step 1: Resolve overlapping PUCCHs and/or PUSCHs with the same priority * Step 2: Resolve overlapping PUCCHs and/or PUSCHs with different priorities   Note: Avoid recursive pseudo-code to implement this procedure  Note: It is expected that Rel-15 intra-UE UCI multiplexing timeline will be applicable |

Since companies have different understandings on the note, whether a resultant PUCCH with HP and LP UCI in step 2 is allowed to be overlapped with a HP PUCCH and/or a HP PUSCH, as shown in the figure below, was discussed in RAN1#107-e meeting. But it was not concluded.



The following alternatives were provided in RAN1#107-e and companies’ views based on the input contributions are as follows.

* Alt. 1: the resultant PUCCH with HP and LP UCI in step 2 is not expected to be overlapped with a HP PUSCH.
* Alt. 2: the resultant PUCCH with HP and LP UCI in step 2 is not expected to be overlapped with a HP PUCCH.
* Supported by: Nokia [3], Huawei [4], vivo [5], Ericsson [19]
* Alt. 3: the resultant PUCCH with HP and LP UCI in step 2 is not expected to be overlapped with a HP PUCCH or a HP PUSCH.
* Supported by: OPPO [14], ETRI [15], Intel [17]
* Alt. 4: the resultant PUCCH with HP and LP UCI in step 2 overlapping with a HP PUCCH or a HP PUSCH is allowed.
* Supported by: CATT [7]

It seems to the moderator that the intentions from companies are different. Proponents of Alt. 2 basically would like to avoid recursive processing in step 2. Given that only PUCCH time domain location may change after multiplexing while PUSCH does not, proponents of Alt. 2 would like to preclude the resultant PUCCH overlapping with another PUCCH only but are fine if the resultant PUCCH with HP and LP UCI overlaps with a HP PUSCH. Note that recursive processing of PUCCH collision handling is allowed in Rel-15/16 and step 1 in Rel-17 intra-UE multiplexing, which is handled by the pseudo code defined in clause 9.2.5 of TS38.213. Huawei [4] pointed out that pseudo code in clause 9.2.5 has to be performed twice in Step 1 for LP PUCCH and HP PUCCH separately, the complexity on processing would be further increased if a third round of such operation is additionally performed in Step 2.1; as a result, there would be a risk that the UE can hardly complete the pseudo code operations for up to three times even within the Rel-15 timeline. More views on the feasibility at UE side would be helpful to make a decision.

Proponents of Alt. 3 think that Alt. 3 is required to achieve the agreed Note “Avoid recursive pseudo-code to implement this procedure”. In addition, if the resultant HP PUCCH can overlap with a HP PUSCH which are not overlapped after step 1, additional rule is needed to select a PUSCH to multiplex UCI, e.g., whether to prioritize HP PUSCH or LP PUSCH, and the relation between PUSCH priority and A-CSI.

Proponent of Alt. 4 thinks that it provides best scheduling flexibility and pseudo code in clause 9.2.5 of TS38.213 can be a unified solution to handle different combinations of overlapping of multiple PUCCHs. In addition, it does not mean going back to step 1 so it does not violate the previous Note in the agreement.

Please take the above arguments into account and provide your views on the following alternatives in the tables.

**Proposal 1.2.1:**

For resolving collision of PUCCHs and/or PUSCHs with different priorities in step 2, down-select from:

* Alt. 1: a resultant PUCCH with HP and LP UCI is not expected to be overlapped with a HP PUSCH.
* Alt. 2: a resultant PUCCH with HP and LP UCI is not expected to be overlapped with a HP PUCCH.
* Alt. 3: a resultant PUCCH with HP and LP UCI is not expected to be overlapped with a HP PUCCH or a HP PUSCH.
* Alt. 4: a resultant PUCCH with HP and LP UCI overlapping with a HP PUCCH or a HP PUSCH is allowed.

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| --- | --- |
|  | **Supporting Company** |
| Alt. 1 |  |
| Alt. 2 | Nokia/NSB, ZTE, DOCOMO Huawei/Hisi, New H3C, LG (can accept) |
| Alt. 3 | Intel, QC |
| Alt. 4 | Sony, CATT, LG |

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| --- | --- |
| **Company** | **Comments** |
| Intel | It seems different companies have different understanding of “Avoid recursive pseudo-code to implement this procedure”. For example,  Interpretation 1: Not go back to step 1 in the middle or after step 2.  Interpretation 2: Not reuse Rel-15 pseudo-code in step 2, e.g., only single check of a pair of LP and HP PUCCH is allowed.  Interpretation 3: 1+2  Interpretation 4: …  Our understanding is interpretation 1. We’re open for the discussion for interpretation 2, if running Rel-15 pseudo-code in step 2 would lead to very tight processing time, but on top of interpretation 2, we still prefer to avoid unnecessary complexity in step 2.2 caused by moving HP PUCCH to overlap with both LP and HP PUSCH. Therefore, we support Alt 3. |
| Sony | Unclear why this is complicated for UE. If the processing timeline is met, why can’t the UE perform the additional multiplexing. Capability#1 is already restrictive enough, we do not see why we need to further impose restriction to the scenarios that can or cannot be multiplex, which would render the feature useless. |
| CATT | We do not think Alt 4 means going back to step 1 and it provides the best scheduling flexibility. |
| Huawei/Hisi | We prefer Alt.2.  The operation of the pseudo code in 9.2.5 has to be performed in Step 1 twice, separately for HP only and LP only. We should avoid introducing the recursive procedure in Step 2 for a third time, as a result of which, the complexity would be triple to R15, and in that sense even the R15 timeline can hardly be met.  The gNB can easily configure the HP PUCCH resources for hybrid HP and LP, so that after the one-step multiplexing of HP PUCCH and LP PUCCH, the resultant HP channel will not overlap with another HP PUCCH, and the recursion of the pseudo code is not introduced.  For PUSCH, on the other hand, since the PUCCH to PUSCH multiplexing will anyway be needed in Step 2.2, and there is no recursion issue as the pseudo code for PUCCH, we believe there is no need to limit that the hybrid HP+LP PUCCH should not overlap with HP PUSCH. |
| LG | We prefer Alt 4, and can also accept Alt 2 as compromise.  We don’t see the reason not to allow the overlapping between PUCCH with HP + LP UCIs and HP PUSCH, even though it was already agreed to support {HP AN + LP AN on HP PUSCH}. |
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In addition, Ericsson [19] proposed to cancel LP PUCCH if a resultant PUCCH with multiplexed HP and LP UCI in step 2.1 overlaps with a LP PUCCH. It is discussed in section 3.1.3.

#### **2nd round discussion**

Based on the GTW discussion on Monday, the proposal 1.2.1 is down-selected to Alt. 2 and Alt. 3 for further discussion. Between the two alternatives, the main discussion point is whether Alt. 3 introduces additional complexity at UE side by performing additional UCI multiplexing in PUSCH. From moderator’s point of view, it does not since step 2.2 needs to be performed between HP PUCCH with LP PUSCH as well. As discussed in section 3.1.6, one PUSCH among a set of candidate PUSCHs would be selected for UCI multiplexing and no additional complexity is expected.

**Proposal 1.2.1a:**

For resolving collision of PUCCHs and/or PUSCHs with different priorities in step 2, down-select from:

* Alt. 2: a resultant PUCCH with HP and LP UCI is not expected to be overlapped with a HP PUCCH.
* Alt. 3: a resultant PUCCH with HP and LP UCI is not expected to be overlapped with a HP PUCCH or a HP PUSCH.

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|  | **Supporting Company** |
| Alt. 2 | Nokia/NSB, Sony, Sharp (with clarification), ZTE, CATT, Ericsson, DOCOMO,vivo Huawei/Hisi, LG |
| Alt. 3 | QC, Spreadtrum, Apple, Intel, Lenovo, Samsung, ITRI ,OPPO |

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| --- | --- |
| **Company** | **Comments** |
|  |  |
| QC | We support Alt 3.  In GTW today, companies support Alt 2 does not require recursive pseudo codes. We’d like to understand how Alt 2 can avoid going back to step 1. In our understanding, here is the flow to run the mux pseudo codes.   * Step 1.1: Mux HP PUCCH with HP PUCCH. Mux LP PUCCH with LP PUCCH. * Step 1.2: MUX HP PUCCH with HP PUSCH. Mux LP PUCCH with LP PUSCH. * Step 2.1: MUX HP PUCH with LP PUCCH -> resulting PUCCH is HP because HP PUCCH resource is used. * Go back to run Step 1.2: if resulting HP PUCCH overlap with HP PUSCH * Step 2.2: Mux PUCCH on PUSCH with different priorities.   This additional step creates a recursive behavior, because it goes back to step 1. One can argue this is only 1 time “go back”. But strictly speaking, it is still recursive.  One more question is that, with simultaneous PUCCH/PUSCH transmission, should we do the “go back” before or after checking simultaneous Tx?  Anyway, the additional “go back” step definitely complicates the overall UCI mux procedure. Given we are in maintenance, we prefer to take the simplest solution which is not allowing the “go back”. |
| Sharp | We prefer to clarify the second HP PUCCH: it should be limited to HP PUCCH for HARQ-ACK reporting.  For a PUCCH with a positive HP SR, the gNB does not know the SR status in advance. A simple solution could be drop the HP SR or hold the SR to a later instance if the overlapping occurs. Thus, no impact on the specifications. |
| Apple | We support Alt. 3: the UE implementation needs to be have a bounded processing time.  In our view: it is difficult to put the design as a gNB implementation choice to guarantee there is no overlapping of resultant HP PUCCH and a processed HP PUCCH and/or HP PUSCH.  A simple way to achieve that is through a best effort strategy at UCI multiplexing:   1. If the resultant HP PUCCH can keep the same foot print as the original HP PUCCH (i.e. the additional payload due to LP UCI does not induce selecting a different PUCCH resource set), then it is guaranteed there won’t be any overlap between the resultant HP PUCCH and any other surviving HP PUCCH/PUSCH after step 1. 2. If the resultant HP PUCCH would overlap with a HP PUCCH/PUSCH, then the LP UCI over it is dropped (consequently there won’t be any need to change PUCCH resource set selection due to payload size change).   Note due to the agreement two meetings ago on PUCCH resource set selection (simple addition of HP UCI/LP UCI bits without considering their code rates), in general in Rel-17 PUCCH resource sets can be quite coarse, we really don’t see the point to highly optimize the design for changing UCI payload when the PUCCH resource set selection itself is flawed or compromised. |
| ZTE | We think the recursive behavior is going back to pseudo codes for PUCCH only. No need to restrict the PUSCH scheduling. For the joint operation with simultaneously transmission, as simultaneously transmission is only for different priorities channels, it will not affect the multiplexing of resulting HP PUCCH and HP PUSCH. |
| Lenovo | Agree with QC’s assessment for recursive operation, so Alt 3 is preferred. Network can schedule a resultant PUCCH properly to avoid overlapping with another HP PUCCH or HP PUSCH. |
| Samsung | We support Alt 3, it is the simplest solution. |
| Ericsson | We support Alt 2.  We do not agree with QC interpretation of “Go back to run Step 1.2: if resulting HP PUCCH overlap with HP PUSCH”. Why does the resulting PUCCH has to be called HP PUCCH? Why is this PUCCH – PUSCH multiplexing interpreted as “going back to run Step 1.2”?  This step is simply one case of PUCCH-PUSCH multiplexing of Step 2.2. For example, the following two cases should be treated as parallel sub-cases in Step 2.2:   * Resultant PUCCH {HP HARQ-ACK, LP HARQ-ACK} multiplex with HP PUSCH; * Resultant PUCCH {HP HARQ-ACK, LP HARQ-ACK} multiplex with LP PUSCH; |
| ITRI | Suppport Alt. 3 to avoid additional complexity on UCI multiplexing. |
| vivo | We share similar view with ZTE and Erission. We think Step 2.2 can be understood as Mux PUCCH on PUSCH with same/different priorities if the PUCCH with LP and HP UCI is called PUCCH with HP. |
| OPPO | If Alt-2 is followed, people can have two paths ahead:   1. The “resultant PUCCH with HP and LP UCI” is considered a HP PUCCH: the consequence is that the step-2 can land on the overlapping between this HP PUCCH and a HP PUSCH, which should have been solved by step-1. Then Alt-2 could leave the whole step-1/step-2 framework incomplete unless the step-1 is triggered again after step-2. But rerun a step-1 after step-2 is not an agreed framework step and it conflicts the agreed note saying “Avoid recursive pseudo-code to implement this procedure”. 2. The “resultant PUCCH with HP and LP UCI” is considered neither a HP PUCCH nor a LP PUCCH; instead, it is treated as a “3rd priority PUCCH”: the consequence of having a “3rd priority PUCCH” would complicate the whole framework logic and it does not even solve the original concern, for example, what about the below-mentioned overlapping after step-2:  * a resultant PUCCH with HP and LP UCI and another resultant PUCCH with HP and LP UCI   So we see both paths are quite challenging.  With Alt-3, the “resultant PUCCH with HP and LP UCI” is considered a HP PUCCH, and the Alt-3 itself excludes the condition to trigger step-1 again. |
| Huawei/Hisi | The pseudo codes specifically means the multiple PUCCH multiplexing procedure, since the resultant PUCCH may overlap with a new PUCCH, causing the recursion. For PUCCH and PUSCH multiplexing, there is only one step anyhow, so the additional complexity is very limited. |
| LG | We have similar view with ZTE.  As commented in above, we don’t see the reason not to allow the overlapping between PUCCH with HP + LP UCIs and HP PUSCH, even though it was already agreed to support {HP AN + LP AN on HP PUSCH}. |

Based on the above feedback from companies, it is proposed to agree the common part and leave HP PUSCH for further discussion.

**Proposal 1.2.1b:**

For resolving collision of PUCCHs and/or PUSCHs with different priorities in step 2, a resultant PUCCH with HP and LP UCI is not expected to be overlapped with a HP PUCCH.

* FFS whether a resultant PUCCH with HP and LP UCI can be overlapped with a HP PUSCH.

### PUCCH overlapping with multiple PUCCHs of a different priority in step 2

#### **1st round discussion**

Based on previous agreements, overlapping PUCCHs with same priority is resolved in step 1 and overlapping PUCCHs with different priorities are resolved in step 2.1. LP SR and LP CSI are not eligible for inter-priority multiplexing. Whether multiplexing of LP HARQ-ACK with HP SR is supported or not has not been concluded. If not supported, LP HARQ-ACK overlapping with HP SR is not eligible for multiplexing as well.

For a HP PUCCH overlapping with multiple LP PUCCHs, there are three cases as categorized below and illustrated in the figure below. LP UCIs that are not eligible for UCI multiplexing are in grey.

* Case 1: each of the LP PUCCHs includes UCI eligible for UCI multiplexing
* Case 2: none of the LP PUCCHs includes UCI eligible for UCI multiplexing
* Case 3: some of the LP PUCCH(s) include UCI eligible for UCI multiplexing and other LP PUCCH(s) includes UCI not eligible for UCI multiplexing only



OPPO [14], ETRI [15] and LG [26] proposed to preclude the case that a HP PUCCH overlaps with multiple LP PUCCHs. ZTE [6] proposed to preclude multiplexing in case a PUCCH overlapping with multiple PUCCHs in general.

It needs to be discussed that whether/how the above cases are supported.

For Case 1, the same rule/principle as discussed in section 3.1.4 can be adopted, i.e. a UE does not expect to multiplex HARQ-ACK information that the UE would transmit in different LP PUCCHs in a HP PUCCH.

**Proposal 1.3.1:**

A UE does not expect to multiplex HARQ-ACK information that the UE would transmit in different LP PUCCHs in a HP PUCCH.

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|  | **Company** |
| Support | Nokia/NSB, Sharp, Intel, Samsung , CATT, Ericsson (with modification to proposal), DOCOMO, ITRI,OPPO Huawei/Hisi, LG |
| Not support | Sony (need clarification), QC |

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| **Company** | **Comments** |
| Sony | Case 1 seems to happen only if HP PUCCH is slot and LP PUCCH is sub-slot. Is this the expected configuration? Also why would a gNB configures something like this? |
| QC | The intention of the proposal sounds reasonable: exclude those complicated 3 way collisions. However, the wording of the proposal is not clear. It says “A UE does not expect to multiplex …”. But does it mean that it is an error case or it is a legitimate case where UE does not mux but UE fallback to Rel-16 to do prioritization? |
| Spreadtrum | We would like to check the proposal just want to exclude case 1 and 3. It allows the case 2 because it is just cancelation without multiplexing. Is it right understanding?  For case 1, we agree that it is untypical case, but there is no fault to exclude it clearly. |
| Sharp | Case 1 should not happen because the subslot for HP PUCCH should be smaller or equal to subslot for LP PUCCH. Thus, the HP HARQ-ACK can only overlap with one LP HARQ-ACK.  Case 2 and Case 3 are already covered by existing agreements or not in the scope of the WI, thus, HP HARQ-ACK should drop the LP SR and LP CSI. |
| ZTE | Case 1 is rare, can be an error case. Case 2 and 3 is clear as LP SR and LP CSI is not eligible for multiplexing with different priority channel. So maybe we could split this proposal to two proposals, one is for error case, the other is for non-eligible? |
| Lenovo | Agree with the intention. The case 1 can be considered as an error case. |
| Samsung | Regarding QC’s question, we think the proposal means error case. The wording is aligned with 38.213, in general, “UE does not expect” means error case. |
| Ericsson | The main reason these cases may happen is, HP HARQ-ACK is has larger (sub-)slot duration than LP HARQ-ACK.  We suggest to address the problem by the proposal below:  **Proposal:**  (sub-)slot duration configured for HP HARQ-ACK is shorter than or equal to the (sub-)slot duration configured for LP HARQ-ACK. |
| vivo | We think QC’ question is valid, we are open to discuss it. If it means error case, it seems to be worse than that in NR 16 where the case is allowed and prioritization is used. |
| Huawei/Hisi | We understand it is error case, and gNB should avoid scheduling such case. For Ericsson’s modification, we think limiting HP PUCCH shorter than LP PUCCH does not resolve the overlapping case of one HP PUCCH vs multiple LP PUCCHs. |
| LG | We are fine the proposal 1.3.1 with slight update below for clarification, and also have same understanding with Samsung on QC’s question.  **Proposal 1.3.1 (updated):**  A UE does not expect to multiplex HARQ-ACK information that the UE would transmit in multiple different LP PUCCHs in a HP PUCCH. |

For Case 1, it does not only happen when the (sub-)slot duration of HP HARQ-ACK is longer, it also happens for the case when HP HARQ-ACK is configured with 2-OS sub-slot while LP HARQ-ACK is configured with 7-OS sub-slot. In addition, some companies think proposal 1.3.1 is not clear whether Case 1 is allowed and LP PUCCHs are dropped or Case 1 is an error case so the proposal is revised as follows.

**Proposal 1.3.1a:**

For resolving collision of LP PUCCHs and HP PUCCHs in step 2.1, a HP PUCCH with HARQ-ACK is not expected to be overlapped with multiple LP PUCCHs with HARQ-ACK.

For Case 2, it is straightforward to drop all the LP PUCCHs.

For Case 3, more discussion is needed. Different options can be considered. For example, PUCCH multiplexing procedure as defined in Rel-16 TS38.213 clause 9.2.5 can be reused and PUCCH resource for UCI multiplexing is determined according to Rel-17 rules. Then the collision of LP CSI and HP HARQ-ACK is first to be resolved and LP CSI is dropped. Then multiplexing of LP HARQ-ACK and HP HARQ-ACK is performed according to Rel-17 rules. Alternatively, multiplexing of LP HARQ-ACK and HP HARQ-ACK can be performed first and if the resultant channel does not overlap with PUCCH carrying LP CSI, LP CSI can be transmitted; otherwise the LP CSI is dropped. It is proposed to discuss the case together with a LP PUCCH overlapping with multiple HP PUCCHs.

A LP PUCCH with HARQ-ACK may overlap with multiple HP PUCCHs and the HP PUCCHs can be within a same HP PUCCH time unit or in different HP PUCCH time units and the HP PUCCH may include HARQ-ACK and/or SR. The solutions for these cases need to be discussed.

Given that the time unit for HP PUCCH is typically shorter than that for LP PUCCH and UCIs of different priorities are expected to be multiplexed in HP PUCCH resource, Huawei [4], vivo [5], CATT [7], Samsung [9], DOCOMO [10], Spreadtrum [11] and LG [26] proposed to use time unit of HP PUCCH as the time unit for multiplexing in step 2.1, while ZTE [6] would like to preclude multiplexing between resources with different time units. Furthermore, the following options were proposed by companies.

If a LP PUCCH overlapping with multiple HP PUCCHs in different HP PUCCH time units,

* Option 1: LP PUCCH is multiplexed in the first overlapping HP PUCCH time unit according to Rel-17 rules.
  + Supported by: Huawei, vivo, Spreadtrum, OPPO
* Option 2: LP PUCCH is multiplexed in the first overlapping HP PUCCH time unit with HP HARQ-ACK according to Rel-17 rules. If LP PUCCH doesn’t overlap with any HP PUCCH with HARQ-ACK, LP PUCCH is multiplexed in the first overlapping HP PUCCH time unit according to Rel-17 rules.
  + Supported by: Samsung, DOCOMO, Sharp, LG
* Option 3: LP PUCCH joins the multiplexing procedure in each of the overlapping HP PUCCH time units for multiplexing from the first overlapping time unit, unless the LP PUCCH is determined to be dropped or multiplexed with other channels.
  + Supported by: CATT

For the case illustrated in the figure below, LP HARQ-ACK would be multiplexed with HP SR for option 1 or with HP HARQ-ACK for option 2 according to Rel-17 rules. If the multiplexing is not supported, LP HARQ-ACK is dropped. The intention of option 2 is to minimize LP HARQ-ACK dropping given that the multiplexing of LP HARQ-ACK and HP SR is still under discussion and may not be supported. However, note that multiplexing of HARQ-ACKs with different priorities in PF2 is also under discussion which may not be supported. The intention of option 3 is to address the case that LP HARQ-ACK multiplexing with HP SR is supported and LP HARQ-ACK is not multiplexed with HP SR in case the SR is negative. Then LP HARQ-ACK would be multiplexed with HP HARQ-ACK according to Rel-17 rules.



For a LP PUCCH with HARQ-ACK overlapping with multiple HP PUCCHs in a same HP PUCCH time unit, the following options were proposed by companies.

* Option 1: Reuse PUCCH multiplexing procedure as defined in Rel-16 TS38.213 clause 9.2.5 and determine a single resource for UCI multiplexing according to Rel-17 rules.
  + Supported by: vivo, CATT
* Option 2: If there is overlapping HP PUCCH with HARQ-ACK, LP HARQ-ACK is multiplexed with HP HARQ-ACK first.
  + Supported by: Samsung, Sharp, LG
* Option 3: LP PUCCH is multiplexed with the first HP PUCCH
  + Supported by: OPPO

Whether/how to support multiplexing of LP HARQ-ACK and HP SR and whether/how to support multiplexing of LP HARQ-ACK and HP HARQ-ACK in PF2 are not concluded yet, which may impact the discussion of a LP PUCCH with HARQ-ACK overlapping with multiple HP PUCCHs. For the case shown in the left figure below, if multiplexing of HP and LP HARQ-ACKs in PF2 is not supported and if the resultant PUCCH format of LP HARQ-ACK and HP HARQ-ACK in sub-slot #2 is PF2, it needs to be discussed whether LP HARQ-ACK is dropped or can be multiplexed with HP HARQ-ACK in sub-slot #2. Similarly, for the case shown in the right figure below, if multiplexing of HP SR and LP HARQ-ACK is not supported or if LP HARQ-ACK is transmitted in LP PUCCH if HP SR is negative, it needs to be discussed whether LP HARQ-ACK is dropped or can be multiplexed with HP HARQ-ACK.



Therefore, it is proposed to discuss the cases when a LP PUCCH with HARQ-ACK overlaps with multiple HP PUCCHs later based on the progress on whether/how to support multiplexing of LP HARQ-ACK and HP SR and whether/how to support multiplexing of LP HARQ-ACK and HP HARQ-ACK in PF2.

#### **2nd round discussion**

**A HP PUCCH overlapping with multiple LP PUCCHs**

Based on the discussions in section 3.1.2, companies would like to avoid recursive processing in step 2.1. So one-step collision handling is considered without using the pseudo code in 38.213 Clause 9.2.5 in the following discussion.

For the three cases for a HP PUCCH overlapping with multiple LP PUCCHs as in section 3.1.3.1, Case 1 was concluded as an error case according to the following agreement.

|  |
| --- |
| **Agreement**  For resolving collision of LP PUCCHs and HP PUCCHs in step 2.1, a HP PUCCH with HARQ-ACK is not expected to be overlapped with multiple LP PUCCHs with HARQ-ACK.   * It’s up to the editor whether/how to capture this |

In this round, we continue the discussions for the other two cases.

For Case 2 where none of the LP PUCCHs overlapping with the HP HARQ-ACK includes UCI eligible for UCI multiplexing, i.e. each LP PUCCH includes SR and/or CSI only, it is straightforward to drop all the LP PUCCHs.

**Proposal 1.3.2:**

For resolving collision of LP PUCCHs and HP PUCCHs in step 2.1, if a HP PUCCH overlaps with multiple LP PUCCHs and none of the LP PUCCHs includes LP HARQ-ACK, all the LP PUCCHs are dropped.

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| Not support |  |

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For Case 3 where one of the LP PUCCHs includes HARQ-ACK, different options can be considered.

* Option 1: Perform pair-wise collision resolution sequentially in time.
* Option 2: Collision between LP PUCCH with HARQ-ACK (if any) and HP PUCCH is resolved first. All the LP PUCCH(s) overlapping with the resultant PUCCH are dropped.
* Option 3: LP PUCCH(s) without HARQ-ACK are dropped and the collision between the remaining LP PUCCH with HARQ-ACK (if any) and HP PUCCH is resolved.

The options are illustrated using the examples shown below.

The outcomes of the three options are the same for the following scenario assuming the resultant PUCCH with HP HARQ-ACK and LP HARQ-ACK overlaps with LP CSI. Only PUCCH with HP HARQ-ACK and LP HARQ-ACK is transmitted.



If HP HARQ-ACK is replaced by HP SR, assuming multiplexing of LP HARQ-ACK and HP SR is not supported, the outcomes of the three options are also the same, i.e. all the overlapping LP PUCCHs are dropped.

For scenario 1 and 2 shown in the left figure and right figure below:

* For Option 1, only PUCCH with HP HARQ-ACK and LP HARQ-ACK is transmitted and LP CSI is dropped before multiplexing of HP HARQ-ACK and LP HARQ-ACK for Scenario 1. For Scenario 2, both PUCCH with HP HARQ-ACK and LP HARQ-ACK and PUCCH with LP CSI are transmitted since the resultant PUCCH for HP HARQ-ACK and LP HARQ-ACK does not overlap with LP CSI.
* For Option 2, for both scenarios, both PUCCH with HP HARQ-ACK and LP HARQ-ACK and PUCCH with LP CSI are transmitted.
* For Option 3, LP CSI is dropped for both scenarios and only PUCCH with HP HARQ-ACK and LP HARQ-ACK is transmitted.



Among the three options, Option 3 is the worst in terms of LP HARQ-ACK dropping and does not apply to the case that a LP PUCCH overlapping with multiple HP PUCCHs, it is proposed to down-select from the first two options

**Proposal 1.3.3:**

For resolving collision of LP PUCCHs and HP PUCCHs in step 2.1, if a HP PUCCH overlaps with multiple LP PUCCHs and one of the LP PUCCHs includes LP HARQ-ACK, down-select from:

* Option 1: Perform pair-wise collision resolution sequentially in time.
* Option 2: Collision between LP PUCCH with HARQ-ACK (if any) and HP PUCCH is resolved first. All the LP PUCCH(s) overlapping with the resultant PUCCH are dropped.

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|  | **Company** |
| Option 1 |  |
| Option 2 |  |

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**A LP PUCCH overlapping with multiple HP PUCCHs**

If a LP PUCCHs overlaps with multiple HP PUCCHs and the LP PUCCH does not include HARQ-ACK, then the LP UCI is not eligible for UCI multiplexing and should be dropped.

**Proposal 1.3.4:**

For resolving collision of LP PUCCHs and HP PUCCHs in step 2.1, if a LP PUCCH overlaps with multiple HP PUCCHs and the LP PUCCH does not include LP HARQ-ACK, the LP PUCCH is dropped.

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For the case that a LP PUCCH with HARQ-ACK overlaps with multiple HP PUCCHs, different options can be considered.

* Option 1: Perform pair-wise collision resolution sequentially in time.
* Option 2: Collision between LP PUCCH and first HP PUCCH with HARQ-ACK (if any) is resolved first. If LP HARQ-ACK cannot be multiplexed with the first HP PUCCH with HARQ-ACK, LP HARQ-ACK is dropped.

For the following case that a LP HARQ-ACK overlaps with multiple HP HARQ-ACKs, the outcomes of the two options are the same. If LP HARQ-ACK can be multiplexed with HP HARQ-ACK in sub-slot #1, it is multiplexed; otherwise it is dropped.



For the following case, assuming LP HARQ-ACK cannot be multiplexed with HP SR, LP HARQ-ACK is dropped according to Option 1 and it is multiplexed with HP HARQ-ACK if supported for Option 2.



**Proposal 1.3.5:**

For resolving collision of LP PUCCHs and HP PUCCHs in step 2.1, if a LP PUCCH overlaps with multiple HP PUCCHs and the LP PUCCHs includes LP HARQ-ACK, down-select from:

* Option 1: Perform pair-wise collision resolution sequentially in time.
* Option 2: Collision between LP PUCCH and first HP PUCCH with HARQ-ACK (if any) is resolved first. If LP HARQ-ACK cannot be multiplexed with the first HP PUCCH with HARQ-ACK, LP HARQ-ACK is dropped.

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| Option 2 |  |

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### PUSCH overlapping with multiple PUCCHs

#### **1st round discussion**

**Multiplexing of multiple HARQ-ACKs in different PUCCHs of a same priority in a PUSCH**

Multiplexing multiple HARQ-ACKs in different PUCCHs in a PUSCH of the same priority is not supported in Rel-15/16.

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| **Agreement (RAN1#101)**  It is an error case for Rel-16 that more than one PUCCH carrying HARQ-ACK overlapping with a PUSCH or another PUCCH with the same priority |
| **TS 38.213 Clause 9**  A UE does not expect to multiplex in a PUSCH transmission in one slot with SCS configuration UCI of same type that the UE would transmit in PUCCHs in different slots with SCS configuration if .  A UE does not expect to multiplex in a PUSCH transmission or in a PUCCH transmission HARQ-ACK information that the UE would transmit in different PUCCHs. |

Sharp [22] proposed to clarify whether a HP PUSCH overlaps with more than one HP PUCCH with HARQ-ACK is supported.

Ericsson [19] proposed that for a given priority index, it is an error case in Rel-17 that more than one PUCCH carrying HARQ-ACK overlap with a PUSCH or another PUCCH as in Rel-16.

For a HP PUSCH overlapping with multiple LP PUCCHs with HARQ-ACK (Case 1) and a LP PUSCH overlapping with multiple HP PUCCHs with HARQ-ACK (Case 2) as shown below, companies’ views are summarized as follows.



Nokia [3] proposed that for both cases, multiplexing of more than one PUCCH carrying HARQ-ACK on a PUSCH of different priorities should not be supported. Huawei [4] proposed that Case 1 should be avoided by gNB and Case 2 is avoided by gNB or LP PUSCH is dropped. ETRI [15] proposed no special handling for Case 1. Intel [17] proposed to drop LP PUSCH for Case 2. Ericsson [19] proposed to cancel LP channel(s) for both cases. Sharp [22] proposed that HP HARQ-ACK may be jointly reported on the LP PUSCH or the LP PUSCH should be dropped for Case 2. LG [26] proposed that a LP PUCCH firstly overlapping (and satisfying the multiplexing timeline) with HP PUSCH is selected for the multiplexing on the HP PUSCH while other LP PUCCHs are dropped for Case 1 and dropping LP PUSCH can be considered for Case 2.

It is proposed to follow the same rule/principle as in Rel-16. Note that the following case is valid although LP PUSCHs overlaps with two HP PUCCHs with HARQ-ACK.



**Proposed conclusion 1.4.1:**

A UE does not expect to multiplex HARQ-ACK information that the UE would transmit in different PUCCHs of a same priority in a PUSCH.

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|  | **Company** |
| Support | Sony, Nokia/NSB, Spreadtrum, Intel, ZTE, Samsung, CATT, Ericsson, DOCOMO, OPPO(clarification) Huawei/Hisi, LG |
| Not support | QC(clarification of the proposal is needed), Sharp, Lenovo, ITRI |

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| **Company** | **Comments** |
| QC | Same comment as for previous proposal. Does the proposal mean this an error case or UE should fallback to Rel-16? |
| Sharp | Instead of saying “UE is not expected to…”, it is better to define the behaviour on how to handle it, e.g., for Case 2   * Simplest way is to drop the LP PUSCH, and transmits the HP PUCCHs, or * If timeline is satisfied, the HP HARQ-ACK can be jointly reported on the LP PUSCH.   Note that the same logic was already agreed for deferred HARQ-ACK transmission under HARQ-ACK enhancements. The deferred HARQ-ACK can be jointly reported with another HARQ-ACK of the same priority. |
| Intel | With Rel-15 timeline, more typical case for Rel-17 intra-UE multiplexing is slot-based PUCCH for both LP and HP. Rel-15/16 rule can reused.  If sub-slot PUCCH is to be supported for intra-UE multiplexing (we suggest deprioritizing such case), it would be possible that one LP PUSCH overlaps with more than one HP PUCCH with HARQ-ACKs. But, with Rel-15 timeline, there is typically sufficient time for gNB to avoid scheduling a LP PUSCH overlapping with HP HARQ-ACKs in different sub-slot, e.g., a shorter LP PUSCH or move LP PUSCH to next slot. |
| Lenovo | We think UE should be allowed to multiplex HARQ-ACK of multiple HP PUCCHs of sub-slot into a PUSCH of slot, as long as Rel-15 multiplexing timeline condition is met. |
| Ericsson | We are supportive of the proposal, which is an extension of Rel-16 agreement below:  **Agreement (RAN1#101)**  It is an error case for Rel-16 that more than one PUCCH carrying HARQ-ACK overlapping with a PUSCH or another PUCCH with the same priority  We are fine to treat this as error case, the same as in Rel-16. |
| ITRI | Prefer to define a UE behaviour to handle the case 2 (i.e., drop LP PUSCH). As for the Case 1, Rel-15 rule can be reused, if the LP HARQ-ACKs are scheduled in the same slot. |
| vivo | Share the same view from QC. |
| OPPO | Clarification on proposal. Is it an error case or fall back to R16?  We are fine to treat this as error case. |
| LG | To be clear, we think the proposed conclusion 1.4.1 provided by FL is only focusing on the case of overlapping between multiple PUCCHs and a PUSCH with same priority (not between different priorities).  In this sense, we are fine with the proposed conclusion 1.4.1 since avoiding any further complications should be pursued at this late stage. |
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**Multiplexing of multiple HARQ-ACKs in different PUCCHs of different priorities in a PUSCH**

Ericsson [19] also discussed the case when two PUCCHs of different priorities carrying HARQ-ACK overlap with a PUSCH as shown below and proposed that the two PUCCHs are multiplexed onto the PUSCH.



Based on the previous agreement, LP/HP HARQ-ACK should be multiplexed in the LP/HP PUSCH in step 1. So after step 1, there is only LP/HP HARQ-ACK overlapping with HP/LP PUSCH (with HP/LP HARQ-ACK). It is expected that LP/HP HARQ-ACK is multiplexed in HP/LP PUSCH according to Rel-17 rules.

Companies are invited to comment whether additional agreement/conclusion is needed for this case.

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| **Company** | **Comments** |
| Sony | Shouldn’t this be resolved in Step 1? That is in the case on the left, the HP HARQ-ACK would mux with HP-PUSCH resulting in only HP-PUSCH after Step 1. Similarly in the case on the right, after Step 1, there will only be one LP-PUSCH and 1 HP-HARQ-ACK. Why is this problem different? |
| QC | We are also puzzled why there is a problem for this case. |
| Spreadtrum | We agree with the assessment of the FL, there is no issue for these two case. |
| ZTE | We don’t need agree one thing twice. |
| Samsung | Agree with FL. No need further discussion. |
| Ericsson | We are fine to align the understanding without any explicit agreement. The understanding is, for the above cases, the HP HARQ-ACK and LP HARQ-ACK are multiplexed onto the overlapping PUSCH.  (In contrast, if the two HARQ-ACK have the same priority (both HP, or both LP), then such multiplexing cannot be performed) |
| DOCOMO | We agree with the assessment of the FL. |
| vivo | Agree with FL, LP/HP HARQ-ACK can be multiplexed in HP/LP PUSCH with HP/LP HARQ-ACK. |
| LG | We also have same understanding with FL. |

#### **2nd round discussion**

Based on the 1st round discussion, the proposed conclusion 1.4.1 is supported by majority companies. The only controversial part is whether Case 2 where a LP PUSCH overlapping with multiple HP PUCCHs with HARQ-ACK is allowed. Therefore, the proposal is revised to cover other cases and discuss Case 2 separately.

**Proposed conclusion 1.4.1a:**

A UE does not expect to multiplex HARQ-ACK information that the UE would transmit in different LP PUCCHs in a PUSCH.

A UE does not expect to multiplex HARQ-ACK information that the UE would transmit in different HP PUCCHs in a HP PUSCH.

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| Not support |  |

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| **Company** | **Comments** |
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For a LP PUSCH overlapping with multiple HP PUCCHs with HARQ-ACK, in general we can discuss the following two options.

* Option 1: If a UE would multiplex HARQ-ACK information that the UE would transmit in different HP PUCCHs in a LP PUSCH, LP PUSCH is dropped.
* Option 2: A UE does not expect to multiplex HARQ-ACK information that the UE would transmit in different HP PUCCHs in a LP PUSCH

For single cell case shown below, it is a valid case for Option 1 and LP PUSCH is dropped while it is an error case for Option 2.



Note that for the following CA case, it is valid for both options and the first HP HARQ-ACK is multiplexed in LP PUSCH1 and the second HP HARQ-ACK is multiplexed in LP PUSCH2.



**Proposed conclusion 1.4.1b:**

For a LP PUSCH overlapping with multiple HP PUCCHs with HARQ-ACK, down-select from:

* Option 1: If a UE would multiplex HARQ-ACK information that the UE would transmit in different HP PUCCHs in a LP PUSCH, LP PUSCH is dropped.
* Option 2: A UE does not expect to multiplex HARQ-ACK information that the UE would transmit in different HP PUCCHs in a LP PUSCH

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|  | **Supporting Company** |
| Option 1 |  |
| Option 2 |  |

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| **Company** | **Comments** |
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### LP PUSCH overlapping with HP PUCCH including positive SR

#### **1st round discussion**

In Rel-15/16, SR multiplexing in PUSCH is not supported. In Rel-17, there is no agreement to support SR multiplexing in a PUSCH with different priority until now. Therefore, for overlapping LP PUSCH and HP PUCCH with SR, HP SR cannot be multiplexed in LP PUSCH and the LP PUSCH is expected to be dropped.



In addition, Samsung [9] and Sharp [22] discussed the case of LP PUSCH overlapping with HP HARQ-ACK and HP SR.



Sharp [22] proposed to multiplex both HP SR and HP HARQ-ACK in the LP PUSCH for Case A above. For Case B, Samsung proposed that a UE does not expect to multiplex a HP HARQ-ACK in a LP PUSCH that would be canceled by HP SR. Sharp proposed that the HP SR should be dropped if there is HP HARQ-ACK multiplexing on the LP PUSCH in the above case.

Considering all the cases above, a unified solution to drop LP PUSCH is proposed as follows.

**Proposal 1.5.1:**

For resolving collision of PUCCHs and PUSCHs of different priorities in step 2.2, LP PUSCH(s) overlapping with HP PUCCH including positive SR are dropped.

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|  | **Company** |
| Support | Intel, Nokia/NSB, ZTE, CATT, DOCOMO Huawei/Hisi (with modification), QC, Spreadtrum, New H3C, Samsung, CATT, Ericsson (with modified proposal), ITRI, vivo,OPPO, LG |
| Not support | Sharp, Lenovo |

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| **Company** | **Comments** |
| Intel | HP UCI should always be prioritized over LP channel. |
| Nokia/NSB | Agree with Intel |
| Huawei/Hisi | We should focus on the discussion of pairwise PUCCH and PUSCH of different priorities since we have not achieved a conclusion whether/how to support Case B (to our understanding, Case B is not expected), so we recommend the proposal is modified as  **Proposal 1.5.1:**  For resolving collision of pairwise PUCCH~~s~~ and PUSCH~~s~~ of different priorities in step 2.2, LP PUSCH~~(s)~~ overlapping with HP PUCCH including positive SR ~~are~~is dropped. |
| QC | We support FL proposal. |
| Sharp | We can agree to drop the SR for Case B if HP HARQ-ACK is already multiplexed on the LP PUSCH. Otherwise, if HP HARQ-AKC is multiplexed on the LP PUSCH, the LP PUSCH should be dropped.  For Case A, the HP HARQ-ACK and HP SR are already multiplexed in Step 1. Drop the positive HP SR will undo Step 1. There is no spec impact by treating the multiplexed HP bits them together as HP HARQ-ACK. |
| Intel2 | We’d like to point out, it would be more difficult to avoid LP PUSCH overlapping with HP HARQ-ACK and HP SR, compared with LP PUSCH overlapping with 2 HP HARQ-ACKs, because HP SR resource would be quite frequent and gNB does not know whether positive or negative SR at UE side. Therefore, it is reasonable to allow case B, and it is simple to drop LP PUSCH for case B. |
| New H3C | We have the similar with Intel. |
| ZTE | For confirmation, in the Case B, the HP HARQ and HP SR will be survived when the LP PUSCH is cancelled if the proposal is triggered. |
| Lenovo | We think HP SR can be multiplexed in LP PUSCH to avoid dropping of a transport block delivered to PHY for the LP PUSCH. |
| Samsung | Agree with Intel |
| Ericsson | Since there is no plan to design SR multiplexing onto PUSCH, we are fine with intention of above proposal, which is inline with existing MAC processing with LCH prioritization enabled, i.e., HP SR is prioritized over LP PUSCH, and no PDU is generated for the LP PUSCH (see 38.321 section 5.4.4). If a PUSCH has no MAC PDU, then it does not participate in PHY intra-UE multiplexing procedure.  Considering that existing Rel-16 MAC spec already ensures that no HP SR overlaps with LP PUSCH with MAC PDU, we suggest to add the following. Then the HP SR overlapping with LP PUSCH may only occur due to {HP SR + HP HARQ-ACK}.  **Proposal:**  Rel-17 physical layer expects the same MAC handling of SR prioritization over PUSCH as in Rel-16. |
| LG | We are fine with the proposal 1.5.1 |

#### **2nd round discussion**

According to the agreement below, LP PUSCH is dropped in the example shown below.

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| **Agreement**  For resolving collision of PUCCHs and PUSCHs of different priorities in step 2.2, LP PUSCH(s) overlapping with HP PUCCH including positive SR are dropped. |

The remaining issue is that whether LP PUSCH dropping is performed before or after multiplexing of HP HARQ-ACK in LP PUSCH. If it is performed before multiplexing, both HP HARQ-ACK and HP SR are transmitted. Otherwise if it is performed after multiplexing, it is possible that HP-HARQ-ACK is multiplexed in LP PUSCH and then LP PUSCH with HP HARQ-ACK is dropped. It seems that it is more reasonable to perform dropping before multiplexing.



**Proposal 1.5.2:**

For resolving collision of PUCCHs and PUSCHs of different priorities in step 2.2, LP PUSCH(s) dropped due to overlapping with HP PUCCH including positive SR are excluded from candidate PUSCHs for UCI multiplexing.

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| **Company** | **Comments** |
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### PUSCH selection for UCI multiplexing in step 2.2

#### **1st round discussion**

According to previous agreement, collision of PUCCHs and PUSCHs of different priorities are resolved in step 2.2. One remaining issue is the PUSCH selection rule in case a PUCCH overlaps with multiple PUSCHs. Note that the case when there are overlapping PUSCHs on the same cell is separated discussed in section 3.1.7.

Huawei [4], CATT [7], Intel [17] and Ericsson [19] proposed to reuse Rel-15/16 rule for PUSCH selection, while Samsung [9], DOCOMO [10], OPPO [14] and Lenovo [24] proposed to take some other factors into account, including:

* PUSCH without UCI > PUSCH with UCI
* HP PUSCH > LP PUSCH
* PUSCH(s) with earliest ending among the PUSCH(s) determined from step 1

Given the divergent views on whether/which additional factor(s) are considered for PUSCH selection for UCI multiplexing, it is proposed to follow Rel-15/16 rules.

**Proposal 1.6.1:**

For resolving collision of PUCCHs and/or PUSCHs with different priorities in step 2, if there are multiple candidate PUSCHs for UCI multiplexing, Rel-15/16 rule is reused for PUSCH selection.

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|  | **Company** |
| Support | Nokia/NSB, Sony, QC, Spreadtrum, Sharp, Intel (with clarifcation for candidate PUSCHs), New H3C, ZTE, CATT, Ericsson (with clarification), DOCOMO (can accept), ITRI,OPPO Huawei/Hisi, LG |
| Not support | Samsung |

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| **Company** | **Comments** |
| Nokia/NSB | Reusing Rel-15/16 rules would be the simplest here (least specs & implementation effort). |
| Apple | Some modifications are necessary: excluding PUSCHs for the same priority as PUCCH (we don’t want to repeat the work), conditional on the configuration of simultaneous PUCCH/PUSCH configuration. |
| Intel | We support reusing Rel-15/16 rule for PUSCH selection, but we’d like to clarify, the proposal does not exclude the case that some PUSCH can be excluded from candidate PUSCHs first, i.e., PUSCH in a different band, a LP PUSCH overlapping with HP PUSCH in the same serving cell, a LP PUSCH overlapping with HP PUCCH with repetitions or HP SR. These issues are still under discussion in other sections. |
| ZTE | Fine with the proposal. Regarding the issue of checking multiplexing timeline of PUSCHs, whether the multiplexing timeline checking on PUSCHs is before the PUSCH selection or after the PUSCH selection? |
| Lenovo | Reusing Rel-15/16 rules is fine for PUSCHs of a same priority. For multiple candidate PUSCHs of different priorities, we think a HP PUSCH should be selected so that a resultant PUSCH cannot be cancelled by another HP PUCCH. |
| Samsung | We think “PUSCH without UCI > PUSCH with UCI” should be supported. It can help avoid dropping LP UCI because of the limited encoding chain. This is a new case in Rel-17.  In addition, it is beneficial to ensure the reliability of LP UCI if a HP HARQ-ACK is multiplexed in a PUSCH without LP UCI.  For “HP PUSCH > LP PUSCH”, if a PUCCH with HP HARQ-ACK and LP HARQ-ACK overlaps with both HP PUSCH and LP PUSCH, Rel-16 rules cannot be reused.  For “PUSCH(s) with earliest ending among the PUSCH(s) determined from step 1”, similar issue was discussed in Rel-15 and can thus be deprioritized.  We also share similar view as Intel, candidate PUSCH should be clarified. |
| Ericsson | We are supportive of reusing Rel-15/Rel-16 rules as much as possible.  On the other hand, we share similar concern as Intel that the set of candidate PUSCH for UCI multiplexing need to be modified in Rel-17, for example,  (a) simultaneous PUCCH/PUSCH tx is applicable or not;  (b) if Rel-17 supports the combination of the UCI and PUSCH (e.g., Rel-17 does not support the combination of LP CSI and HP PUSCH) |
| DOCOMO | Although we think it is beneficial to take latency condition into account for the PUSCH selection, we can accept the proposal considering the limited time. |
| vivo | We think the proposal is not very clear, Rel-15/16 rule is reused for PUSCH selection means that UE selects a PUSCH among PUSCHs with the same priority or among all PUSCHs regardless of priority. |
| Huawei/Hisi | Regarding the comments from Ericsson, some changes as below:  At least for the case where simultaneous PUCCH/PUSCH tx is diabled, ~~F~~for resolving collision of PUCCHs including HARQ-ACK(s) and/or PUSCHs with different priorities in step 2, if there are multiple candidate PUSCHs for UCI multiplexing, Rel-15/16 rule is reused for PUSCH selection. |
| LG | We have similar view with Nokia.  BTW, some clarification may be needed in case when simultaneous PUCCH+PUSCH TX is enabled if companies want (in other words, the proposal 1.6.1 can be proposed at least for the case when simultaneous PUCCH+PUSCH TX is disabled). |

### Overlapping PUSCHs on the same cell

#### **1st round discussion**

For Rel-17 intra-UE multiplexing in case of overlapping PUSCHs on the same cell, Nokia [3] proposed to not support joint operation of Rel-17 intra-UE multiplexing and PHY prioritization of overlapping CG and DG PUSCHs with different priorities. OPPO [14] proposed that a UE does not expect overlapping PUSCHs in one cell during Rel-17 intra-UE multiplexing.

Based on the agreements from last meeting, the case is allowed as highlighted in cyan.

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| **Agreement**  If multiplexing of PUCCHs and/or PUSCHs with different priorities is enabled by RRC, support both of the following UE capabilities to resolve collision of PUCCHs and/or PUSCHs with different priorities in step 2:   * Capability #1: It is not expected that Rel-15 multiplexing timeline is not met for all overlapping channels [FFS the overlapping channels are resultant channels after step 1]. UE performs multiplexing or dropping of PUCCHs and/or PUSCHs with different priorities according to Rel-17 rules.   + Dynamic enabling/disabling multiplexing for different priorities is not supported for Capability #1 * (Working assumption) Capability #3:… * FFS: Time unit to apply Rel-15 timeline (e.g. slot based, sub-slot based) * FFS: The set of PUSCH and PUCCH that eligible for Rel-15 multiplexing consideration   Note: “collision” refers to overlapping PUCCHs, overlapping PUCCH and PUSCH (excluding PUSCH supporting simultaneous transmission with PUCCH), overlapping PUSCHs on a same cell.  Note: “Rel-15 multiplexing timeline” means Rel-15 timeline calculation in Rel-16 spec, including all the formula and all the values for the variables  Note: “Rel-16 prioritization timeline” means Rel-16 cancellation timeline calculation in Rel-16 spec, including all the formula and all the values for the variables |

In last RAN1 meeting, the following conclusion was made in Rel-16 URLLC maintenance.

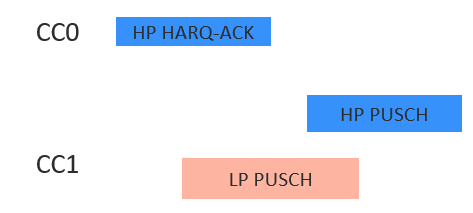
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| **Conclusion**  In the Rel-16 multiplexing/prioritization procedures described in TS 38.213 section 9, the UE is expected to apply the procedures to the PUSCH(s) for which a transport block is delivered by MAC, while the PUSCH(s) for which a transport block is not delivered is ignored. |

CATT [7] proposed that UE only considers PUSCH(s) for which a transport block is delivered by MAC, the PUSCH(s) for which a transport block is not delivered is ignored as in Rel-16. Samsung [9] proposed to resolve overlapping PUSCHs with different priorities on a same cell before step 2.2. Intel [17], Ericsson [19] and NEC [23] proposed to handle overlapping PUSCHs with different priorities before step 1.

Based on the contributions, different options are proposed in proposal 1.7.1 and the differences of the proposals are illustrated using the examples shown below assuming Rel-17 intra-UE multiplexing is enabled.



Example 1



Example 2

If only one MAC PDU is delivered between the LP and HP PUSCHs, the different options are equivalent. For the examples, if only PDU for LP PUSCH is delivered by MAC, then HARQ-ACK would be multiplex on LP PUSCH; if only PDU for HP PUSCH is delivered by MAC, then HARQ-ACK is transmitted on PUCCH.

However, if two PDUs are delivered by MAC, for option 1, HARQ-ACK would be multiplexed on LP PUSCH and then be dropped. For option 2, HARQ-ACK would not be multiplexed on PUSCH for both examples. For option 3, HARQ-ACK would be multiplexed on LP PUSCH and then be dropped in example 1 and HARQ-ACK would not be multiplexed on PUSCH for example 2. For option 2 and 3, in order to perform PUSCH prioritization before multiplexing, MAC should deliver the PDU for HP PUSCH sufficiently early so that UE can have sufficient time for PUCCH preparation.

Please provide your preference among the options.

**Proposal 1.7.1:**

For Rel-17 intra-UE multiplexing in case of overlapping PUSCHs on the same cell, down-select from:

* Option 1: When UE performs UCI multiplexing on a PUSCH in Rel-17, UE only consider PUSCH(s) for which a transport block is delivered by MAC, the PUSCH(s) for which a transport block is not delivered is ignored.
* Option 2: PUSCH prioritization is performed before Step 1 and when MAC delivers two PDUs to both of the overlapping grants, then the LP PUSCH is cancelled and ignored, while the HP PUSCH is preserved and participates in the multiplexing/prioritization procedure.
* Option 3: PUSCH prioritization is performed before Step 2.2.
* Option 4: others

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|  | **Supporting Company** |
| Option 1 | Sony (Need clarification), Intel, CATT Huawei/Hisi |
| Option 2 | Sony (Need clarification), Samsung, vivo |
| Option 3 | Samsung |
| Option 4 | Nokia/NSB, Lenovo (modified option 1),OPPO |

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| **Company** | **Comments** |
| Nokia/NSB | We prefer to not support the joint operation of ‘handling overlapping DG PUSCH and CG PUSCH of different priorities’ and ‘multiplexing and prioritization using Steps 1 and 2 considering UE capability #1’. This would simplify the discussions, something that is preferred especially that we have entered the maintenance phase.  So in this respect Option 1, but we think it should be clarified that there should be only a single MAC PDU delivered on a CC (i.e. there should be no case where PHY prioritization of overlapping PUSCHs on a CC is to be handled). |
| Sony | Are Option 1 and Option 2 really different options? Option 1 is for case where only 1 PDU is delivered to L1 whilst Option 2 is for the case where 2 PDU’s are delivered to L1. Shouldn’t we combine Option 1 and Option 2 for different cases? |
| QC | We also feel the proposal can be reformulated. Our view is that, there are 4 options here: Option 1: CG/DG PUSCH prioritization is done before step 1; option 2: CG/DG PUSCH prioritization is done after step 2; option 3: CG/DG PUSCH prioritization is performed before Step 2.2; Option 4: not supporting joint operation of CG/DG prioritization and step 1&2 multiplexing. |
| Intel | We also think, maybe some clarification for Opt 1 and Opt 2 is needed. For both Options, LP PUSCH is excluded before step 1. The difference is, opt 1 is for single MAC PDU, and opt 2 is for two MAC PDUs.   * If companies think, only single MAC PDU case is supported for intra-UE multiplexing, opt 1 is the preferred option.   In our understanding, with Rel-15 timeline, there is sufficient time to know the presence of HP PUSCH in advance, only single MAC PDU is delivered to PHY. So, we support opt 2.   * If companies think, only two MAC PDU case is supported for intra-UE multiplexing, opt 2 is the preferred option. * If companies think, both single and two MAC PDU cases are supported for intra-UE multiplexing, opt 1+ opt 2 is the preferred option.   We’re also fine with opt 4, i.e., CG/DG PUSCH prioritization is not supported if intra-UE multiplexing is configured. We can save time for debating whether single or/and two MAC PDUs are supported for this case. |
| ZTE | We slightly prefer solving the CG/DG PUSCH prioritization before step 1. |
| Lenovo | We suggest the following update in option 1:  “When UE performs UCI multiplexing on a PUSCH in Rel-17, UE only consider PUSCH(s) for which a transport block is delivered by MAC or PUSCH(s) with SP-CSI or A-CSI, the PUSCH(s) for which neither a transport block is ~~not~~ delivered nor CSI report(s) is included is ignored.” |
| Samsung | Our first preference is Option 3. We are also fine with Option 2 although it seems violate previous agreements.  We have two clarification questions on Option 1 and Option 2.  Q1: Does it include resolving semi-static DL symbols/SSB as discussed in 3.1.9 **Processing order or Rel-17 intra-UE multiplexing and cancellation?** In our understanding, if a CG PUSCH collides with semi-static DL symbols, MAC should not deliver a MAC PDU.  Q2: Does the MAC layer generate a MAC PDU if a CG PUSCH collides with a DG PDSCH on a same cell? The related issue is discussed in 3.1.9. |
| CATT | We would like to clarify that Option 1 includes two PDU case as explained by FL above the proposal. |
| Ericsson | We support performing CG-vs-DG PUSCH prioritization before step 1.  For the options, We support Option 2.  Option 1 is the same as the conclusion in Rel-16 maintenance, and can be put under Option 2. Option 1 is adequate if MAC delivers only one PDU, as in Rel-16. Option 2 text provides the additional processing if MAC delivers two PDU. |
| DOCOMO | We share similar view with other companies that the proposal can be reformulated. |
| vivo | Option 2 can avoid unnecessary dropping of LP HARQ-ACK as shown in the following figure. |
| OPPO | We prefer to not support the joint operation of ‘handling overlapping DG PUSCH and CG PUSCH of different priorities’ and ‘intra UE multiplexing’, considering the following points:   1. Different timeline requirement for ‘handling overlapping DG PUSCH and CG PUSCH of different priorities’ and ‘intra UE multiplexing’, how to handle different timeline requirement?   Complex gNB reception. There is blind decoding on whether CG PUSCH exists or not |
| Huawei/Hisi | Agree with Nokia and OPPO that the UE Capability#1 cannot support the prioritization between DG PUSCH vs CG PUSCH both delivered with MAC PDUs (which actually follows the R16-like prioritization timeline as N2+d1+d3), i.e., Option 2 and Option 3. The joint configuration should not be supported. Only Option 1 is the valid case for intra-UE multiplexing Capability#1. |
| LG | We also have similar view with QC.  It can be better to reformulate the options including legacy procedure/rule. |

#### **2nd round discussion**

It seems that the proposal in 1st round needs some clarifications. The intention of Option 1 was to consider both one MAC PDU and two MAC PDU cases. In this round, one MAC PDU and two MAC PDU cases are separately discussed.

For one MAC PDU case, I hope that companies have the same understanding. Please check the following proposal.

**Proposal 1.7.1a:**

For Rel-17 intra-UE multiplexing in case of overlapping PUSCHs on the same cell, if only one TB is delivered by MAC, only the PUSCH for which a TB is delivered by MAC is considered in step 1 and step 2.2, while the PUSCH for which a TB is not delivered by MAC is ignored in step 1 and step 2.2.

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| Support |  |
| Not support |  |

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| **Company** | **Comments** |
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For two MAC PDU case, different options can be considered.

* Option 1: Both PUSCHs are considered in step 1 and step 2.2.
* Option 2: Only HP PUSCH is considered in step 1 and step 2.2.
* Option 3: Both PUSCHs are considered in step 1 and only HP PUSCH is considered in step 1 and step 2.2.

The benefit of Option 1 is that it does not require MAC to deliver the PDU for the later PUSCH too early in order to not perform UCI multiplexing on the earlier PUSCH. The benefit of Option 2 is that HARQ-ACK dropping can be avoided in the two examples shown in section 3.1.7.1. The benefit of Option 3 is that HARQ-ACK dropping can be avoided in example 2 shown in section 3.1.7.1.

**Proposal 1.7.1b:**

For Rel-17 intra-UE multiplexing in case of overlapping PUSCHs on the same cell, if two TBs are delivered by MAC for both PUSCHs, down-select from:

* Option 1: both PUSCHs are considered in step 1 and step 2.2.
* Option 2: only HP PUSCH is considered in step 1 and step 2.2.
* Option 3: both PUSCHs are considered in step 1 and only HP PUSCH is considered in step 1 and step 2.2.

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|  | **Supporting Company** |
| Option 1 |  |
| Option 2 |  |
| Option 3 |  |

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| **Company** | **Comments** |
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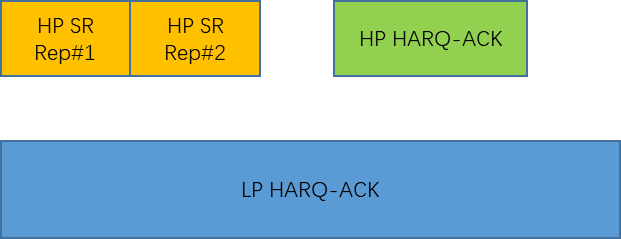
### Interaction with PUCCH repetitions

#### **1st round discussion**

Samsung [9] and Intel [17] discussed the joint operation of Rel-17 intra-UE multiplexing.

Samsung proposed that if a LP PUCCH overlaps in time with a HP PUCCH in Step 2.1 and at least one of the PUCCHs is with repetitions, the LP PUCCH is dropped. When there are more than two overlapping PUCCHs and at least one of the PUCCHs is with repetitions, Samsung proposed that Step 2.1 can consist of the following sub-steps to avoid LP HARQ-ACK dropping in the case illustrated in the following figure.

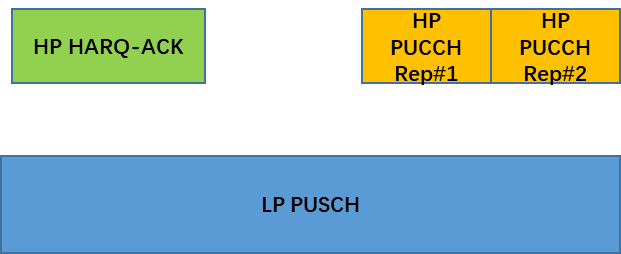
* Sub-step 2.1.1: Resolve collision of PUCCHs without repetitions
* Sub-step 2.1.2: Resolve collision of PUCCHs (with or without repetitions)



For Step 2.2, Samsung’s proposal is as follows to avoid HP HARQ-ACK dropping in the case shown in the following figure.

For handling overlapping PUCCHs/PUSCHs with different priorities in R17, Step 2.2 can consist of the following sub-steps.

* Sub-step 2.2.1: Resolve overlapping PUSCHs with different priorities on a same cell.
* Sub-step 2.2.2: Resolve overlapping PUCCHs with repetitions and PUSCHs.
* Sub-step 2.2.3: Resolve overlapping PUCCHs without repetitions and PUSCHs.



Intel proposed that if a LP PUCCH overlaps with a HP PUCCH with repetition, LP PUCCH should be cancelled. If a LP PUSCH overlaps with HP PUCCH with repetition, then LP PUSCH should be dropped.

The issue was not discussed in previous meetings. Companies are invited to share your views on the following proposals.

**Proposed Conclusion 1.8.1:**

For resolving collision of two overlapping channels with different priorities in Step 2,

* If a LP PUCCH overlaps with only one HP PUCCH and the LP or HP PUCCH is with repetitions, the LP PUCCH is dropped.
* If a LP PUSCH overlaps with a HP PUCCH with repetitions, the LP PUSCH is dropped.
* If a HP PUSCH overlaps with a LP PUCCH with repetitions, the LP PUCCH is dropped.

Note: the dropping of LP PUCCH/PUSCH is performed per repetition.

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|  | **Company** |
| Support | Nokia/NSB (in principle – see comment below), Sharp, Intel (only support 2nd sub-bullet and 3rd sub-bullet), ZTE,Samsung, CATT, Ericsson (further clarification needed), DOCOMO,OPPO, Huawei/Hisi |
| Not support | QC |

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| **Company** | **Comments** |
| Nokia/NSB | We support the proposal if its intention is to only drop the LP PUCCH repetitions that overlap with the HP PUCCH/PUSCH. This is probably what the Note is alluding to, but we would like to confirm our interpretation of the proposal. |
| Sony | **Sub-bullet 1**: Why is this restricted to “only one HP PUCCH”? Does this “one HP PUCCH” refers to one repetition of a HP PUCCH or two separate HP PUCCH, e.g. PUCCH#1 and PUCCH#2 where either PUCCH#1 or PUCCH#2 or both contains repetition?  **Sub-bullet 3**: The text seems to say the entire LP PUCCH is dropped, i.e. all repetitions but in the NOTE it said dropping is done per repetition. Perhaps we need to clarify that it meant only the LP PUCCH repetitions that overlaps with HP PUSCH are dropped. That is:   * + If a HP PUSCH overlaps with a LP PUCCH with repetitions, the LP PUCCH repetition that overlaps with HP PUSCH is dropped. |
| QC | 1, We are wondering whether this is Rel-16 maintenance issue or Rel-17 maintenance issue?  2, a minor question on this: “If a LP PUCCH overlaps with **only one HP PUCCH** and the LP or HP PUCCH is with repetitions, the LP PUCCH is dropped.” Why limiting to only one HP PUCCH? If the LP PUCCH overlap with more than 1 HP PUCCH, then what is UE behaviour? |
| Sharp | Agree in principle. Not sure if we need to describe the cases. The same principle as in current spec can be used to include UCI with different priorities, e.g.  “A UE does not multiplex different UCI types or UCIs from overlapping channels with different priorities in a PUCCH transmission with repetitions.” |
| Intel | We support to always drop LP PUCCH, as long as the LP PUCCH overlaps with a HP PUCCH and at least one of the LP and HP PUCCH is with repetition. 1st sub-bullet is to optimize the LP PUCCH dropping by adding additional rule, e.g., when a LP PUCCH overlaps with both HP HARQ-ACK and HP SR with repetition, UE first checks whether LP PUCCH can be multiplexed onto HP HARQ-ACK. It is similar to the issue under section 3.1.3 (only difference is HP SR is without repetition). We don’t prefer such optimization at this late stage. Therefore, we don’t support 1st sub-bullet    We support 2nd and 3rd sub-bullet for PUSCH handling. To answer QC’s question for Rel-16 vs Rel-17 issue, in Rel-16, LP is dropped no matter LP or HP is with repetition, but in Rel-17, LP is dropped only if one of them is with repetition. |
| ZTE | Agree Sony, QC, Sharp’s comments, the revision from Sharp sounds better. |
| Samsung | For two overlapping channesl, the proposal is already captured in current spec as following. We are fine to clarify it if companies think it is necessary.  if // this is for cases the UE supports multiplexing information of different priorities in a PUCCH/PUSCH  - a PUCCH transmission with HARQ-ACK information, without repetitions, with smaller priority index overlaps with a PUCCH transmission with HARQ-ACK information, without repetitions, with larger priority index, or  - a PUCCH transmission with HARQ-ACK information, without repetitions, with smaller or larger priority index overlaps, respectively, with a PUSCH transmission with larger or smaller priority index  the UE multiplexes HARQ-ACK information of different priority indexes in a same PUCCH or PUSCH transmission and applies the procedures in clause 9.2.5.3 or 9.3, respectively  - else  - if the UE would transmit the following channels that would overlap in time where, if a channel transmission is with repetitions, the following are applicable per repetition  - a first PUCCH of larger priority index and a second PUCCH of smaller priority index  - a first PUCCH of larger priority index and a second PUSCH of smaller priority index when the UE cannot simultaneously transmit the first PUCCH and second PUSCH  - a first PUCCH of smaller priority index and a second PUSCH of larger priority index when the UE cannot simultaneously transmit the first PUCCH and second PUSCH  - a first PUSCH of larger priority index and a second PUSCH of smaller priority index on a same serving cell, where at least one of the two PUSCHs is a configured grant PUSCH  the UE  - transmits the PUCCH or the PUSCH of the larger priority index, and  - does not transmit a PUCCH or a PUSCH of smaller priority index  Sharp’s proposal is not acceptable to us, “not expect” means error case. This is too restrictive for HP PUCCH. |
| Ericsson | We agree in principle that reusing existing procedures for repetition cases is the easiest.  In this sense, it seems sufficient to **conclude that Rel-17 reuse Rel-16 procedure for handle the overlapping cases with repetition.** Then for the question of dropping one or dropping all repetitions, our understanding is, Rel-16 performs dropping per repetition, and this should be reused in Rel-17; |
| vivo | For PUCCH/PUSCH repetition, we prefer to reuse the current rule. That is, if PUCCH is with repetition, only prioritization is supported. |
| LG | We also have similar view with QC and Sharp.  We are not sure if something beyond current spec needs to additionally be described. |

**Proposal 1.8.2:**

For resolving collision of PUCCHs and/or PUSCHs with different priorities in Step 2.1, first resolve collision of PUCCHs without repetitions and then resolve collision of PUCCHs (with or without repetitions).

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|  | **Company** |
| Support | Nokia/NSB (with small change),Samsung |
| Not support | QC,vivo |

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| **Company** | **Comments** |
| Nokia/NSB | We talk about step 2.1 and mention resolving PUCCH & PUSCH overlap. ‘and/or PUSCH’ should be removed here, as this is step 2.2 discussed in the proposal below!? |
| QC | We can understand the intention of Proposal 1.8.3 is to avoid drop HP HARQ-ACK. But for this proposal which is targeting the following scenario. If we follow the proposal, HP A/N and LP A/N may be mux on a new resource which overlap with the HP SR repetition. Then SR with repetition wins and HARQ-ACK will be dropped, no? If we do the opposite way to handle SR repetitions and LP HARQ-ACK first, LP HARQ-ACK will be dropped. But at least the HP HARQ-ACK is transmitted. |
| Samsung | The intention of the proposal is to clarify UE behaviour.  In the case above mentioned by QC, UE behaviour is not clear. There can be two options.  Option 1: LP HARQ-ACK is dropped.  Option 2: LP HARQ-ACK is multiplexed with HP HARQ-ACK.  The above options depend on the order of how to handle the collision.  If UE resolves the collision of PUCCH with repetitions first, LP HARQ-ACK should be dropped.  If UE resolves the collision of PUCCH without repetitions first, LP HARQ-ACK is multiplexed in the HP HARQ-ACK PUCCH.  UE behaviour should be clarified.  Regarding QC’s comment, we don’t agree with “intention of Proposal 1.8.3 is to avoid drop HP HARQ-ACK”, the intention is to avoid dropping LP HARQ-ACK.  Regarding “HP A/N and LP A/N may be mux on a new resource which overlap with the HP SR repetition.” may not happen, the common understanding for **Proposal 1.2.1a:** is the resulting PUCCH won’t overlap with HP SR. The difference is on the HP PUSCH.  Regarding “ Then SR with repetition wins and HARQ-ACK will be dropped”, we don’t agree, if the case happens, the SR should be dropped according to 9.2.6.   |  | | --- | | A UE does not multiplex different UCI types in a PUCCH transmission with repetitions over slots. If a UE would transmit a first PUCCH over more than one slot and at least a second PUCCH over one or more slots, and the transmissions of the first PUCCH and the second PUCCH would overlap in a number of slots then, for each slot of the number of slots and with UCI type priority of HARQ-ACK > SR > CSI with higher priority > CSI with lower priority  - the UE does not expect the first PUCCH and any of the second PUCCHs to start at a same slot and include a UCI type with same priority  - if the first PUCCH and any of the second PUCCHs include a UCI type with same priority, the UE transmits the PUCCH starting at an earlier slot and does not transmit the PUCCH starting at a later slot  - if the first PUCCH and any of the second PUCCHs do not include a UCI type with same priority, the UE transmits the PUCCH that includes the UCI type with higher priority and does not transmit the PUCCH that include the UCI type with lower priority | |
| vivo | We think in step 2.1, it should follow the same procedure for PUCCHs overlapping handling in R15. The issue also exists in R15, as shown in the following figure, where all PUCCHs are with the same priority, CSI is dropped because SR is configured with repetition. The proposal is for optimization and should be deprioritized. |
| Samsung2 | Regarding vivo’s comment “The issue also exists in R15”. We think UE behaviour in Rel-15 is not clear either. Consider the example below,  When considering the collision of SR and HARQ-ACK, SR should be dropped.  When considering the collision of SR and CSI, CSI should be dropped.  When considering the collision of CSI and HARQ-ACK, CSI should be multiplexed with HARQ-ACK.  The order how UE handles the collision is not defined.  In this case, whether CSI is dropped is not clear. |
| LG | We’d like to understand the motivation.  Is the motivation of “first resolve collision of PUCCHs without repetitions” to avoid drop LP HARQ-ACK? |
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**Proposal 1.8.3:**

For resolving collision of PUCCHs and/or PUSCHs with different priorities in Step 2.2, first resolve collision of PUCCHs with repetitions and PUSCHs, and then resolve collision of PUCCHs without repetitions and PUSCHs.

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|  | **Company** |
| Support | Nokia/NSB (with small change), Samsung |
| Not support | LG |

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| **Company** | **Comments** |
| Nokia/NSB | We talk about step 2.2 and mention resolving PUCCH and/or PUSCH overlap. As this is step 2 it should be ‘and~~/or~~ PUSCH’ (as without PUSCH, there is no step 2.2?). |
| Samsung | Similar as Proposal 1.8.2, UE behaviour should be clarified.  Fine with Nokia’s update. |
| LG | We think the case of overlapping between LP PUSCH and two HP PUCCHs, anyhow, needs to be handled without differentiation according to whether repetition is applied for the HP PUCCH. |
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### Others

#### **1st round discussion**

**Number of polar coding chains**

Nokia discussed the case when more than 3 polar encoding chains are required for the UE to enable the simultaneous transmission of two PUSCHs including UCIs on different UL CCs, e.g. a low-priority PUSCH containing UCI (e.g., LP HARQ-ACK) on UL CC1 and a high-priority PUSCH with UCI (e.g., HP HARQ-ACK and A-CSI consisting of CSI part 1 & part 2) on UL CC2 and proposed the following clarification in [3].

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| **Proposal 2.4: RAN1 to clarify, that simultaneous PUSCH transmissions of different PHY priorities with multiplexed-UCI (based on Step 1 of the Rel-17 Intra-UE multiplexing framework) on different UL CCs requiring in total more than 3 Polar encoding chains is supported.** |

**Proposed Conclusion 1.9.1:**

RAN1 to clarify, that simultaneous PUSCH transmissions of different PHY priorities with multiplexed-UCI (based on Step 1 of the Rel-17 Intra-UE multiplexing framework) on different UL CCs requiring in total more than 3 Polar encoding chains is supported.

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|  | **Company** |
| Support | Nokia/NSB, Samsung, CATT Huawei/Hisi |
| Not support | OPPO |

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| **Company** | **Comments** |
| Nokia/NSB | It’s good to conclude on this aspect, so that we are sure that companies have the same understanding for the cases where the number of required UCI encoding chains exceeds 3. |
| Samsung | We think similar issue exists in Rel-16, for example, two PUSCHs with different priorities on different cells and both PUSCHs are multiplexed with UCIs. By default, the proposal is supported but fine to clarify it. |
| OPPO | To avoid additional complexity, the same total polar encoding chain number should be kept as R15/16. Even total polar encoding chain number is 3, simultaneous PUSCH transmission of different PHY priorities still works in some cases. In other words, increased total polar encoding chain number is not necessary condition to support simultaneous PUSCH transmission of different PHY priorities in some cases. |
| LG | We also have same understanding with Samsung.  It seems there could be the cases requiring more than 3 Polar encoding chains even in Rel-16, so we are not sure if any further clarification is needed. |
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**Enabling Rel-16 Prioritization when Rel-17 Mux is Enabled**

In [8], the following mechanism is proposed for UE to operate Rel-16 prioritization when Rel-17 intra-UE multiplexing with different priorities is RRC enabled. Please refer to the contribution for more details.

***Proposal 2: Introduce a time window TWinDrop that overlaps the slot or sub-slot of LP PUCCH/PUSCH and if the first DL transmission scheduling a HP PUCCH/PUSCH that overlaps with the LP PUCCH/PUSCH:***

* ***ends within TWinDrop, the UE uses Rel-16 prioritisation to resolve the collision***
* ***ends outside of TWinDrop, the UE uses Rel-17 Mux to resolve the collision***

It is moderator’s understanding that the proposal is not inline with the agreement for Cap#1. Companies please comment if you think otherwise.

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| **Company** | **Comments** |
| Sony | Only Cap#3 (dynamic indication of enabling/disabling of multiplexing) is not discussed. Since this is not dynamic indication, this is inline with Cap#1 discussion. |
| QC | Object. We prefer not to reopen the discussion on dynamic switch between Rel-16 and Rel 17 behaviour, which was already concluded in last meeting. The proposal is just another way to implement it. |
| Samsung | Agree with FL. |
| Nokia/NSB | We have a similar view as the moderator. |
| OPPO | Object. And Agree with FL’s analysis. |
| Huawei/Hisi | Agree |
| LG | We also agree with FL. |

**Processing order or Rel-17 intra-UE multiplexing and cancellation**

For Rel-16 intra-UE multiplexing we have the following agreements in RAN1#104e.

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| **Agreement**  To address collision with semi-static DL symbols and SSB, the following easy way is suggested:   * Step1: Perform intra UE prioritization (including multiplexing, overriding) according to related working assumption in 102 e-meeting and produce final PUCCHs/PUSCHs. * Step 2: Final PUCCHs/PUSCHs is cancelled by semi-static DL symbols and SSB symbols. |

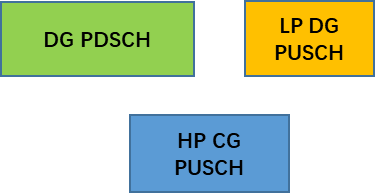
Samsung [9] proposed that for handling overlapping PUCCHs/PUSCHs with different priorities in R17, cancel PUSCHs with semi-static DL conflict before intra-UE multiplexing/prioritization to avoid dropping HARQ-ACK multiplexed in a PUSCH which is cancelled by semi-static DL symbols and SSB symbols.

DOCOMO [10] proposed to discuss processing order of intra-UE multiplexing with different priorities and cancellation due to dynamic SFI/UL CI/semi-static TDD and SSB.

In Rel-16, intra-UE multiplexing is performed before cancellation. So the question is whether we need to change the principle for Rel-17 intra-UE multiplexing. Companies are invited to share your views.

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| **Company** | **Comments** |
| Samsung | Yes.  The 2 steps order is Rel-16 degrades UCI performance and should be reconsidered in Rel-17. Even if a PUCCH can be transmitted before multiplexing with CG PUSCH, it may not be transmitted after multiplexing.  In addition, we think this issue is related to proposal 1.7.1 and should be discussed together. |
| DOCOMO | We are fine with either of the processing orders unless the processing order is clarified but slightly prefer to reuse the Rel-16 processing order for simplicity. |
| Nokia/NSB | In principle, we prefer to follow similar order as in Rel-16, i.e. intra-UE handling is done before cancellation due to e.g. DL symbols. But we are open for further discussions on this aspect. |
| OPPO | Prefer to follow R16 processing order. |
| Huawei/Hisi | Following the Rel-16 rule is preferred. |
| LG | We also prefer to follow Rel-16 rule/order. |
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In addition, Samsung [9] discussed the case that a CG PUSCH is canceled by a DG PDSCH. If a CG PUSCH overlaps with both DG PDSCH and DG PUSCH on a same cell, UE behavior is not clear. An example is shown below where a HP CG PUSCH overlaps with both DG PDSCH and LP DG PUSCH. If the UE first resolves collision between PDSCH and CG PUSCH, the UE can transmit the LP DG PUSCH, otherwise, UE cannot transmit LP DG PUSCH.



Samsung proposed that if a CG PUSCH overlaps with a DG PDSCH on a same cell, a UE cancels/drops the CG PUSCH before resolving collision of the CG PUSCH and other UL channels, if any. Companies are invited to share your views.

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| **Company** | **Comments** |
| OPPO | Same principle as above issue, i.e. follow R16 processing order. |
| Samsung2 | Could oppo clarify a bit more about Rel-16 order for this case? |
| LG | We also have same view with OPPO |
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**Power allocation**

Samsung [9] proposed that in the power limited scenario of multiple PUSCHs, the power allocation should be reconsidered if a HP HARQ-ACK is multiplexed in a LP PUSCH. The power allocation should be prioritized for the LP PUSCH with HP HARQ-ACK to ensure the reliability of HP HARQ-ACK. The Proposal is that for PUSCH power allocation in case of CA, a LP PUSCH with HP HARQ-ACK should be prioritized over a PUSCH without HP HARQ-ACK. Companies are invited to share your views.

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| **Company** | **Comments** |
| Nokia/NSB | We don’t see this as essential, especially that the multiplexing of HP HARQ-ACK on LP PUSCH could be avoided by gNB implementation in case of power limited CA scenarios. |
| OPPO | Follow current spec. No enhancement at this stage. |
| Huawei/Hisi | We agree that power allocation rules have to be updated to distinguish priorities of PUSCH with inter-priority UCI, including HP PUSCH with LP-HARQ-ACK, and LP PUSCH with HP HARQ-ACK. |
| LG | We also have similar view with Nokia. |
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## Simultaneous PUCCH/PUSCH transmission

### Separate enabling simultaneous PUCCH/PUSCH transmission for secondary PUCCH cell group

#### **1st round discussion**

A remaining issue for simultaneous PUCCH/PUSCH transmission is whether simultaneous PUCCH/PUSCH operation can be separately / independently configured for the primary and secondary PUCCH cell group, i.e. whether the RRC parameter *simultaneousPUCCH-PUSCH-secondaryPUCCHgroup* is supported or not. Companies please share your views on the following proposal.

**Proposal 2.1.1:**

*simultaneousPUCCH-PUSCH-secondaryPUCCHgroup* is supported to enable simultaneous PUCCH and PUSCH transmissions with different priorities within the secondary PUCCH cell group separately from primary PUCCH cell group.

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|  | **Company** |
| Support | Intel, Nokia/NSB, ZTE, CATT, DOCOMO, ~~QC,~~ Sharp, New H3C, Lenovo, Samsung, CATT, vivo, LG |
| Not support | Huawei/Hisi, QC, Ericsson |

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| **Company** | **Comments** |
| Huawei/Hisi | The motivation of introducing separate enable/disable flags for primary PUCCH group and secondary PUCCH group is not justified, and a unified RRC parameter is preferred for both, to save spec effort. |
| QC | Besides saving spec effort to simply RRC parameters, it would be a necessary burden for UE to run two different procedures, one disabling simultaneous transmissions, one enabling simultaneous transmissions, for two different PUCCH groups, which does not seems a well justified use case in real deployment. |
| Ericsson | We don’t see the use case of having separate flags for the two PUCCH groups. One flag is sufficient regardless of one or two PUCCH groups. |
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### PHR for PUCCH

#### **1st round discussion**

It was proposed to support PHR for PUCCH in NR in Rel-17 in RAN1#107-e without conclusion.

DOCOMO [10] proposed to define PHR type for PUCCH transmission with two possible solutions.

1. PHR type for PUCCH transmission based on the equation of PUCCH transmission power defined in section 7.2 of 38.213
2. Replace PHR for PUSCH of LTE Type 2 PHR by virtual PHR

Qualcomm [12] proposed to support type 2 actual PHR to report PHR for an actual PUCCH transmission on Pcell or a Scell in a PUCH group and type 2 virtual PHR to report PUCCH PHR on Pcell or a Scell without actual PUCCH transmission in a PUCCH group for PUCCH cell switch in NR Rel-17.

Intel [17] proposed to not consider PUCCH PHR in Rel-17 URLLC considering the benefit is not much as that in LTE with simultaneous PUCCH/PUSCH transmission in the same serving cell and to avoid impacting other WGs.

Companies are invited to provide your views on the following proposal.

**Proposal 2.2.1:**

Support PHR for PUCCH in NR in Rel-17.

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|  | **Company** |
| Support | QC |
| Not support | Intel, Nokia/NSB Huawei/Hisi, Sony, New H3C, CATT, Ericsson, DOCOMO (can accept),OPPO, LG |

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| **Company** | **Comments** |
| Intel | We understand PUCCH PHR would provide more accurate PHR than type-2 PUSCH PHR, but it is unclear how much gain can be achieved, compared with gNB approximately derive the power range for PUCCH transmission based on type-2 PUSCH PHR.  We also have concern on standard effort for PUCCH PHR (can we finish all in this meeting to ensure RAN2 has sufficient time to handle new PHR?). For example,   * Virtual or real PHR depending on the relation between DCI for PUCCH and DCI for PUSCH carrying PHR? * Different numerology for PUCCH and PUSCH carrier? * How to handle sub-slot PUCCH case? * Condition to report PUCCH PHR, e.g., configured by gNB, depending on whether gNB configures simultaneous PUCCH/PUSCH transmission or PUCCH carrier switching? And also, if a UE multiplexes UCI into a PUSCH, whether UE reports type-2 PHR for PUSCH and/or virtual or real PHR for PUCCH?   Elaboration from proponent companies on the above two aspects would be very helpful. |
| Nokia/NSB | Not an essential issue to be solved. And UE will allocate Tx power according to channel priorities and types. |
| Huawei/Hisi | Firstly, we do not observe strong motivation of introducing the new PUCCH PHR report. What are the specific applicable cases?  In addition, we have a similar feeling with Intel, that non-trivial RAN2 spec impact is observed, such as type 2 PHR reporting procedure, MAC CE design, etc., and we are not optimistic that the whole PHR report feature can be quickly finished within one or two meetings. |
| QC | We understand companies have concern to introduce new PHR type here. But this is not about introduce a new functionality which needs use cases to justify. This is to fix a hole in current spec for the following scenario. If we don’t do anything, my question is very simple: According to current RAN2 spec, UE need to report PHR for both Pcell and Scell in the following scenario. What should UE report for Scell? Please let us know your solution/answer to this open question. Even if your answer is UE report nothing for Scell, then despite the fact that we intentionally keep this feature broken, RAN1 still need to send a LS to RAN2 to ask RAN2 change spec to reflect this RAN1 decision. Regardless of what decision we take here (including even not report PHR for Scell), RAN1 need to discuss this issue and send LS to RAN2. And RAN2 have to change their spec accordingly. Therefore, we’d better wrap up this issue in this meeting. |
| Intel2 | @QC, in our understanding, UE reports virtual type-2 PHR for Scell according to 38.213, because UE does not transmit PUSCH on Scell. |
| New H3C | We have the similar view with Nokia. |
| DOCOMO | Although we think it is important to support PUCCH PHR, we understand the concern on the RAN2 impact at this late stage. We can compromise given the situation. |
| QC2 | Thank Intel for answering my question. I guess you meant UE report virtual type 1 PUSCH PHR for Scell. So, is it your assumption that gNB can figure out what is PUCCH power headroom based on PUSCH PHR for Scell? I assume the answer is yes. Honestly, I don’t think gNB can do it, because PUCCH and PUSCH are with totally separate power control loops and gNB cannot infer one from the other, given that gNB does not know UE received or missed power control commands for PUCCH and PUSCH respectively. However, maybe there are some magic gNB can play and I don’t know about it. So, I can give up my proposal and accept your proposal, conditioning on the assumption on capability of gNB is formally documented in Chairman’s notes, as the following. Can Intel and other companies accept this note?  **Conclusion: PHR for PUCCH is not supported in Rel-17 for simultaneous PUCCH/PUSCH transmissions.**  **Note: it is expected that gNB is capable to infer PUCCH power headroom based on PUSCH PHR for the same CC.** |
| LG | We also have similar view with Nokia. |

### Interaction with intra-UE multiplexing/prioritization

#### **1st round discussion**

Nokia [3], Huawei [4], ZTE [6], CATT [7], Samsung [9], DOCOMO [10], Qualcomm [12], Panasonic [13], ETRI [15], Intel [17], Apple [18], Ericsson [19], Quectel [21] and LG [26] discussed the details of joint operation of Rel-17 intra-UE multiplexing and Rel-17 simultaneous PUCCH/PUSCH transmission in their contributions while vivo [5] proposed to not support the joint operation. It is proposed to first discuss the details of joint operation of Rel-17 intra-UE multiplexing and Rel-17 simultaneous PUCCH/PUSCH transmission to see whether we can converge. If the views cannot be converged, the consequence is that the joint operation is not supported in Rel-17.

Based on the previous conclusions, only simultaneous PUCCH/PUSCH transmission of different priorities on different cells for inter-band CA is supported in Rel-17. Consequently, for joint operation of Rel-17 intra-UE multiplexing and Rel-17 simultaneous PUCCH/PUSCH transmission, simultaneous PUCCH/PUSCH transmission is only considered in Step 2.2 only, which seems to be the common understanding. There are generally two options to apply simultaneous PUCCH/PUSCH transmission in step 2.2 and option 2 is supported by more companies.

If the simultaneous PUCCH/PUSCH transmission is enabled, the handling of overlapping PUCCH(s) and PUSCH(s) of different PHY priorities at Step 2.2 is done as follows:

* Option 1: If a PUCCH (that could be multiplexed into PUSCH) does not overlap with a PUSCH on the same band, consider simultaneous transmission of this PUCCH and overlapping PUSCH(s) on a different band; otherwise, i.e. if a PUCCH overlaps with a PUSCH on the same band, consider the PUSCHs on all CCs and bands as candidates for multiplexing the UCI(s) carried in this PUCCH(s) and apply the corresponding Rel-17 (and Rel-15) multiplexing rules. [3]
* Option 2: A PUSCH that can be simultaneously transmitted with a PUCCH is excluded for multiplexing the UCI of the PUCCH.

The difference of the two options is illustrated in the following figure. For option 1, given that LP PUCCH overlaps with HP PUSCH2 on the same band, PUSCHs on all CCs and bands are candidates for UCI multiplexing and HP PUSCH1 is selected due to smaller CC index. But for option 2, given that LP PUCCH can be simultaneously transmitted with HP PUSCH1, HP PUSCH1 is excluded for multiplexing and UCI is multiplexed in HP PUSCH2. The intention of Option 1 is to preserve legacy behavior on handling overlapping PUCCH and PUSCHs for CA cases, where UCI carried on the PUCCH is multiplexed on the PUSCH of the serving cell with lowest index.



In addition, several companies discussed joint operation of Rel-16 intra-UE prioritization and Rel-17 simultaneous PUCCH/PUSCH transmission. Option 2 can be extended to be applied to intra-UE prioritization. The following proposal is proposed to collect companies’ views.

**Proposal 2.3.1:**

If the simultaneous PUCCH/PUSCH transmission is enabled, a PUSCH that can be simultaneously transmitted with a PUCCH is excluded from overlapping channels for multiplexing the UCI of the PUCCH and for intra-UE prioritization with the PUCCH.

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|  | **Company** |
| Support | QC, Intel, ZTE, Lenovo, Apple, Samsung, CATT, Ericsson, DOCOMO Huawei/Hisi (with changes) |
| Not support | Nokia/NSB (see comment below) |

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| **Company** | **Comments** |
| Nokia/NSB | As discussed in our Tdoc, and captured by the Moderator above, Option 1 preserves legacy behavior on handling overlapping PUCCH and PUSCHs for CA cases, where UCI carried on the PUCCH is multiplexed on the PUSCH of the serving cell with lowest index. On the other hand, Option 2/Proposal 2.3.1 diverges from the legacy operation. |
| Ericsson | In our view the above proposal can be realized by running Step 2.2 for each band separately, including identifying the PUSCH for UCI mux.  Suggest to modify the proposal so that it avoids the question of “what’s a “PUSCH that can be simultaneously transmitted”?” |
| vivo | We think the discussion for single feature of intra-UE multiplexing or simultaneous PUCCH/PUSCH transmission should be prioritized. There are still so many essential issues for single feature, we should make sure that a single feature can work well first. |
| Huawei/Hisi | We think the intention here is the simultaneous PUCCH/PUSCH Tx and intra-UE multiplexing are both enabled? Thus the operation of Step 2 is per band performed as mentioned by Ericsson.  Changes as below to make it clear:  If the simultaneous PUCCH/PUSCH transmission and intra-UE multiplexing are simultaneously ~~is~~ enabled, the intra-UE multiplexing in Step 2 is performed per band ~~a PUSCH that can be simultaneously transmitted with a PUCCH is excluded from overlapping channels for multiplexing the UCI of the PUCCH and for intra-UE prioritization with the PUCCH~~. |
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In addition, Samsung [9] discussed that for a PUSCH supporting simultaneous PUSCH and PUCCH transmissions, the UCI would not be multiplexed in the PUSCH for intra-UE multiplexing of different priorities and PUCCH would not be dropped because of the PUSCH, there is no need to satisfy the timeline requirement for the PUSCH. Without the timeline requirement, the scheduling flexibility can be increased and the latency of HP PUSCH can be reduced. Companies please check the following proposal from Samsung.

**Proposed Conclusion 2.3.2:**

The timeline conditions of intra-UE multiplexing/prioritization of PUCCHs and PUSCHs with different priorities do not apply to a PUSCH supporting simultaneous PUSCH and PUCCH transmissions.

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|  | **Company** |
| Support | Lenovo, Samsung, Ericsson, Nokia/NSB Huawei/Hisi |
| Not support | QC |

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| **Company** | **Comments** |
| QC | It is not clear how to define “a PUSCH supporting simultaneous PUSCH and PUCCH transmissions”. Does this mean each PUSCH will have a RRC parameter to configure it support simultaneous Tx or not? Or UE would have to figure it out based on PUCCH/PUSCH overlapping? If it is the latter, then the PUSCH should also be involved in the timeline as the overlapping is pairwise, which includes the PUCCH and PUSCH. |
| Lenovo | The proposal can be modified as follows:  “If the simultaneous PUCCH/PUSCH transmission is enabled, the timeline conditions of intra-UE multiplexing/prioritization of PUCCHs and PUSCHs with different priorities is not applicable to a PUSCH that can be simultaneously transmitted with a PUCCH.” |
| Samsung | The proposal doesn’t change the RRC parameter for configuration simultaneous transmission. Simultaneous transmission is supported per band, UE knows which PUSCHs support simultaneous transmission based on the scheduled cells. For UCI multiplexing in a PUSCH, UE only needs to check the PUSCH NOT supporting simultaneous transmission.  Could QC clarify a bit more why the timeline is required? |
| Ericsson | We agree with the principle that mux timeline conditions only apply to those channels that are involved in multiplexing. |
| Nokia/NSB | Agree with Ericsson comment. |
| Huawei/Hisi | Intra-UE multiplexing and simultaneous PUCCH/PUSCH Tx should be different UE capabilities. UE only considers the multiplexing of intra-band in Step 2, if simultaneous PUCCH/PUSCH Tx is enabled.  If there is no consensus, we are also fine not to support simultaneous configuration of both features. |
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#### **2nd round discussion**

### Maximum number of supported CCs for simultaneous PUCCH and PUSCH transmission

#### **1st round discussion**

DOCOMO [10] raised the issue that the maximum number of supported CCs for simultaneous PUCCH and PUSCH transmission per UE needs to be discussed.

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| Another aspect to be considered is that the maximum number of supported CCs for simultaneous PUCCH and PUSCH transmission per UE. As UE is able to support simultaneous PUCCH and PUSCH transmission on different PUCCH groups, the number of supported CCs should be defined based on UE capabilities related to PUCCH groups and the new capability. For example, if the new capability is reported per FS with X CCs and two PUCCH groups with different numerology are supported at the same time, the total number of supported CCs that UE can simultaneously transmit PUCCH and PUSCH across CCs can be maximum number of either reported value, i.e. max(X, 2). Note that the number should depend on how the number of supported CCs is reported by the new capability.  **Proposal 18:**  *Discuss the interaction between capabilities for two PUCCH groups and the new capability for simultaneous PUCCH/PUSCH transmission on different carriers.* |

Moderator would like to propose to discuss the issue in UE feature session. Please provide your comments if any.

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| **Company** | **Comments** |
| Nokia/NSB | Agree with FL / moderator |
| Intel | We share same view with FL. |
| ZTE | Agree |
| DOCOMO | Fine with the FL proposal. |
| OPPO | Fine with the FL proposal. |
| LG | We also agree with FL. |
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# Reference

1. R1-2112761 List of agreements of Rel-17 URLLC/IIoT WI (post RAN1#107-e) Rapporteur (Nokia)
2. R1-2200012 Intra-UE multiplexing and prioritization New H3C Technologies Co., Ltd.
3. R1-2200018 On UL intra-UE prioritization and multiplexing enhancements Nokia, Nokia Shanghai Bell
4. R1-2200039 Intra-UE multiplexing enhancements Huawei, HiSilicon
5. R1-2200082 Remaining issues on intra-UE Multiplexing/Prioritization for Rel-17 URLLC vivo
6. R1-2200109 Discussion on enhanced intra-UE multiplexing ZTE
7. R1-2200148 Remaining issues on intra-UE multiplexing and prioritization CATT
8. R1-2200180 Remaining issues in intra-UE multiplexing & prioritisation Sony
9. R1-2200199 Remaining issues for Intra-UE Multiplexing/Prioritization Samsung
10. R1-2200233 Discussion on intra-UE multiplexing/prioritization for Rel.17 URLLC NTT DOCOMO, INC.
11. R1-2200275 Discussion on intra-UE multiplexing/prioritization Spreadtrum Communications
12. R1-2200296 Intra-UE multiplexing and prioritization for IOT and URLLC Qualcomm Incorporated
13. R1-2200320 Discussion on intra-UE multiplexing with different priorities Panasonic Corporation
14. R1-2200344 Enhancements on intra-UE multiplexing/prioritization OPPO
15. R1-2200358 Intra-UE Multiplexing/Prioritization ETRI
16. R1-2200365 Intra-UE multiplexing and prioritization InterDigital, Inc.
17. R1-2200374 Remaining Open Details of Intra-UE Uplink Channel Multiplexing and Prioritization Intel Corporation
18. R1-2200416 Rel-17 intra-UE Multiplexing/Prioritization Apple
19. R1-2200442 Intra-UE Multiplexing/Prioritization Enhancements for IIoT/URLLC Ericsson
20. R1-2200485 Discussion on some remaining issues for intra-UE multiplexing and prioritization China Telecom
21. R1-2200492 Remaining Issues on Intra-UE Multiplexing/Prioritization Quectel, Langbo
22. R1-2200497 Intra-UE UCI multiplexing and channel collision resolution with different priorities Sharp
23. R1-2200517 Discussion on Intra-UE prioritization and multiplexing NEC
24. R1-2200531 Intra-UE multiplexing enhancement for IIoT/URLLC Lenovo, Motorola Mobility
25. R1-2200562 Discussion on intra-UE multiplexing and prioritization ITRI
26. R1-2200573 Discussion on Intra-UE multiplexing/prioritization LG Electronics
27. R1-2112712 Summary #2 of email thread [107-e-NR-R17-IIoT-URLLC-03] Moderator (CATT)

# Appendix: Agreements in RAN1#107bis-e

**Conclusion**

For resolving collision of PUCCHs and/or PUSCHs with different priorities in step 2, a resultant PUCCH with HP and LP UCI is not expected to be overlapped with a HP PUCCH.

* FFS whether a resultant PUCCH with HP and LP UCI can be overlapped with a HP PUSCH.

**Agreement**

For resolving collision of LP PUCCHs and HP PUCCHs in step 2.1, a HP PUCCH with HARQ-ACK is not expected to be overlapped with multiple LP PUCCHs with HARQ-ACK.

* It’s up to the editor whether/how to capture this

**Agreement**

For resolving collision of PUCCHs and PUSCHs of different priorities in step 2.2, LP PUSCH(s) overlapping with HP PUCCH including positive SR are dropped.

**Agreement**

*simultaneousPUCCH-PUSCH-secondaryPUCCHgroup* is supported to enable simultaneous PUCCH and PUSCH transmissions with different priorities within the secondary PUCCH cell group separately from primary PUCCH cell group.