**3GPP TSG-RAN WG1 Meeting #108-eR1-22XXXXX**

e-Meeting, February 21st – March 3rd, 2022

**Agenda item: 8.3.1**

**Source: Moderator (Nokia)**

**Title: Moderator summary #X on HARQ-ACK feedback enhancements for NR Rel-17 URLLC/IIoT**

**Document for: Discussion and Decision**

# Introduction

As per chairman’s guidance, the email discussion is planned according to the following schedule:

[108-e-R17-IIoT-URLLC-01] Email discussion on UE feedback enhancements for HARQ-ACK – Klaus (Nokia)

* 1st check point: February 25
* Final check point: March 3

**This document is structured as follows:**

* Sections 2 to 6 include the topics to be specified or at least further studied based on previous agreements, including sub-sections for the related email discussion rounds
* Section 7 describes discussions on joint operation with Rel-17 Intra-UE multiplexing enhancements and some of the HARQ-ACK enhancement features
* There are two appendices, Appendix A containing the RAN1 agreements reached in AI 8.3.1 so far and Appendix B summarizing the companies’ proposals for easier referencing.

# SPS HARQ-ACK deferral for TDD

In this section, the proposed Rel-17 enhancements to prevent SPS HARQ-ACK deferral for TDD operation are summarized. The following related agreements from previous meetings are available on this topic:

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

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| Agreements:  Support Rel-17 enhancements to avoid SPS HARQ-ACK dropping for TDD due to PUCCH collision with at least one DL or flexible symbol.   * This topic is to be considered as high priority * FFS detailed solution(s) |

**RAN1#103-e (Oct./Nov. 2021)**

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| Agreements: To address the issue of SPS HARQ-ACK dropping for TDD systems, focus on the following two options:   * Option 1: Deferring HARQ-ACK until a next (e.g., first) available PUCCH   + FFS: Details including the definition of a next (e.g, first) available PUCCH, CB construction / multiplexing * Option 2: Dynamic triggering of a one-shot / Type-3 CB type of re-transmission   FFS: Details on triggering and/or CB construction (incl. potential Type-3 CB optimizations) / multiplexing |

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

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| Agreements:   * Support deferring SPS HARQ-ACK dropped due to TDD specific collisions until a next available PUCCH in Rel-17 based on semi-static configuration of slot format   + FFS: Details (including possible conditions for such a deferring, whether or not to consider semi-statically configured flexible symbols for PUCCH availability, etc.)   + Aim for minimal standardization efforts and UE complexity in implementation   Agreements:  Further down-select between the following two options for SPS HARQ-ACK deferral:   * Option 1: Joint RRC configuration of the SPS HARQ-ACK deferral per PUCCH cell group   + *Note: any SPS HARQ-ACK within a PUCCH cell group in principle is subject to deferral* * Option 2: The SPS HARQ-ACK deferral is configured per SPS configuration   + *Note: part of sps-config, only HARQ-ACK of SPS PDSCH configurations configured for deferral is in principle subject to deferral*   Agreements: Rel-16 UCI multiplexing  / PUCCH overriding rules are reused for deferred SPS HARQ-ACK in the target slot, if applicable.  Agreements: For SPS HARQ-ACK, the deferral from the initial slot/sub-slot determined by *k1* in the activation DCI to the target slot/sub-slot determined by *k1*+ *k1def*, the UE will check the validity of a target slot/sub-slot evaluating from one slot/sub-slot to the next sub/sub-slot (i.e. in principle *k1def* granularity is 1 slot/sub-slot)   * FFS: if there is a limit on the minimum deferral considered the required UE processing (*k1def* ≥0) * FFS: if there is a limit on the maximum deferral   Agreements: For SPS HARQ-ACK deferral, for the determination of valid symbols in the initial slot/sub-slot a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’ or ‘no symbols for UL transmission’. |

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

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| Agreements: For SPS HARQ-ACK deferral, for the determination of valid symbols in the target slot/sub-slot a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’ or ‘no symbols for UL transmission’.  Agreements: For SPS HARQ-ACK deferral, support a limit on the maximum deferral of SPS HARQ in terms of *k1def* or *k1*+ *k1def*   * + FFS: limitation given by a maximum value of *k1def* or a maximum of *k1eff* =*k1*+ *k1def*   + FFS how the limitation is determined (e.g. by K1 set(s) or RRC configured limit)   Agreements: For SPS HARQ-ACK deferral, there is no lower limit defined for *k1def*  Agreement: Restrict the further discussions on the initial slot handling for SPS HARQ-ACK deferral to the identified alternatives Alt. 1, Alt. 1A and 2.  Agreement: For SPS HARQ-ACK deferral, the limit on the maximum deferral of SPS HARQ is defined in terms of *k1eff =k1*+ *k1def.*  Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:   * In case the UE receives PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.   Agreement: For SPS HARQ-ACK deferral, the initial HARQ-ACK transmission occasion is considered to determine the out-of-order HARQ condition |

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

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| **Agreement**  The SPS HARQ-ACK deferral is enabled per SPS configuration   * Note: part of sps-config, only HARQ-ACK of SPS PDSCH configurations enabled for deferral is in principle subject to deferral   **Agreement**  Definition of when to defer from the initial slot:   * Alt1: Deferral only, if the SPS HARQ-ACK in the initial slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using the PUCCH by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN is not valid   **Agreement**  For SPS HARQ-ACK deferral, the maximum deferral value in terms of k1+k1def is RRC configured per SPS configuration.  **Agreement**  For SPS HARQ-ACK deferral, only SPS HARQ bits subject to deferral from HARQ-ACK codebook from an initial PUCCH slot are deferred to the target PUCCH slot  **Agreement**  For SPS HARQ-ACK deferral, deferred SPS HARQ bits from more than one ‘initial PUCCH slot’ can be jointly deferred to a target PUCCH slot  **Agreement**  For SPS HARQ-ACK deferral, the target PUCCH slot is defined as the next PUCCH slot where *sps-PUCCH-AN-List-r16* or*n1PUCCH-AN* PUCCH resource is regarded as valid*,*or a PUCCH resource*(from PUCCH-ResourceSet, i.e. DG PDSCH HARQ multiplexed*) is dynamically indicated   * The target PUCCH slot determination is based on the total HARQ-ACK payload size including deferred SPS HARQ-ACK information and non-deferred HARQ-ACK information (if any) of a candidate target PUCCH slot * The final PUCCH resource selection in the target PUCCH slot in terms of PUCCH resource set and PUCCH resource ID follows the Rel-16 procedures.   **Agreement**  For SPS HARQ-ACK deferral, if after the target PUCCH slot determination the deferred SPS HARQ-ACK cannot be transmitted, the deferred SPS HARQ-ACK bits are not further deferred and are dropped.  **Agreement**  For SPS HARQ-ACK deferral, in the target PUCCH slot the deferred SPS HARQ-ACK bits are appended to the initial HARQ bits / Type 1 or Type 2 codebook.  **Agreement**  For SPS HARQ-ACK deferral, confirm the RAN1#104b-e working assumption with the following updates in RED:  (working assumption) To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:   * In case the UE is expected to receive~~s~~ PDSCH of a certain HARQ Process ID according to TS 38.214 Sec. 5.1, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.   + Note: there is no further discussion on specific handling for the case of DG PDSCH with the same HARQ process ID |

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

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| **Conclusion**  For SPS HARQ-ACK deferral, only SPS HARQ-ACK bits subject to deferral from one or more initial slots which have not reached the maximum deferral value are jointly deferred to the next available PUCCH (other SPS HARQ-ACK is dropped).  **Agreement**  For SPS HARQ-ACK deferral, the bit ordering of deferred SPS HARQ-ACK information from one or more initial slots in the target PUCCH slot is based on the Rel.16 SPS HARQ-ACK bit order principle as in clause 9.1.2 of TS38.213 is applied, i.e., based on serving cell index, SPS configuration index, SPS PDSCH slot index.  **Conclusion**  For SPS HARQ-ACK deferral, the operation in the ‘initial’ slot is further clarified as:   * The UE performs first the (Rel-16) UCI multiplexing operation. If after the UCI multiplexing operation into a PUCCH or PUSCH if any, and if the UE would be transmitting SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN which is not valid, the SPS HARQ-ACK configured for deferral is deferred.   **Agreement**  The RAN1#106-e agreement on the target slot definition is updated as follows (in RED):   |  | | --- | | **Agreement (from RAN1#106-e)**  For SPS HARQ-ACK deferral, the target PUCCH slot is defined as the next PUCCH slot, where after performing the (Rel-16) UCI multiplexing operation into a PUCCH or PUSCH if any, the UE would be either (i) transmitting HARQ-ACK using a PUCCH/PUSCH other than the PUCCH determined from *PUCCH SPS-PUCCH-AN-List-r16* or *n1PUCCH-AN* or (ii) would be transmitting HARQ-ACK using a PUCCH resource configured in *PUCCH SPS-PUCCH-AN-List-r16* or *n1PUCCH-AN* being regarded as valid.  *~~sps-PUCCH-AN-List-r16~~*~~or~~*~~n1PUCCH-AN~~*~~PUCCH resource is regarded as valid~~*~~,~~*~~or a PUCCH resource~~*~~(from PUCCH-ResourceSet, i.e. DG PDSCH HARQ multiplexed~~*~~) is dynamically indicated~~   * The target PUCCH slot determination is based on the total HARQ-ACK payload size including deferred SPS HARQ-ACK information and non-deferred HARQ-ACK information (if any) of a candidate target PUCCH slot * The final PUCCH resource selection in the target PUCCH slot in terms of PUCCH resource set and PUCCH resource ID follows the Rel-16 procedures. |   **Conclusion**  If the UE is not configured with Rel-17 Intra-UE multiplexing, SPS HARQ for deferral of different PHY priorities can be separately deferred with the target PUCCHs separately determinated according to their respective PHY priorities.   * FFS on the PHY priority handling for SPS HARQ deferral if the UE configured with Rel-17 Intra-UE multiplexing |

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

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| **Agreement**  The maximum SPS HARQ-ACK deferral value in terms of k1+k1def per SPS configuration is RRC configured from a value range of {1…32}.  **Conclusion**  For SPS HARQ-ACK deferral, if a UE is not configured with Rel-17 intra-UE multiplexing but configured with Rel-16 PHY prioritization, the UE first performs Rel-16 UCI multiplexing and PHY prioritization in both initial slot and target slot and if a LP SPS HARQ-ACK PUCCH is deprioritized, the LP SPS HARQ-ACK is not deferred.   * Note: If the SPS HARQ-ACK is deprioritized in any slot, no further deferral.   **Agreement**  Support simultaneous configuration of SPS HARQ-ACK deferral and PUCCH cell switching based on the semi-static time domain pattern:  For the target slot determination of SPS HARQ-ACK deferral,   * Step 1: the UE first determines a next PUCCH slot on the cell for PUCCH transmission using the semi-static time-domain PUCCH cell pattern and the related rules for semi-static PUCCH cell switching, followed by * Step 2: the UE determines based on the SPS HARQ-ACK deferral rules if this PUCCH slot on the PUCCH cell for transmission is the target PUCCH slot or not. * Note: In step 1, k is increased on PCell/PScell/PUCCH-Scell. “The next PUCCH slot” represents the slot on the PUCCH cell based on PUCCH cell pattern, which is mapped from the PCell/PScell/PUCCH-Scell slot with increased K1. * Note: The maximum deferral limitation checking is based on the effective k + kdef value based on the granularity of PCell / PScell/PUSCCH-Scell   **Agreement**  The earlier RAN1 agreements on the valid symbol definition in the initial and target PUCCH slot for SPS HARQ-ACK deferral are further clarified as:   * For SPS HARQ-ACK deferral, for the determination of valid symbols in the initial and target PUCCH slot/sub-slot a collision with semi-static DL symbols, SSB and symbols indicated by *pdcch-ConfigSIB1* in *MIB* for a CORESET for Type0-PDCCH CSS set is regarded as ‘invalid’ or ‘no symbols for UL transmission’.   **Agreement**  Support simultaneous configuration of Rel-16 Type 3 HARQ-ACK codebook or enhanced Type 3 HARQ-ACK codebook triggering and SPS HARQ-ACK deferral.   * In case a R16 Type 3 HARQ-ACK CB or an enhanced Type 3 HARQ-ACK codebook is triggered for transmission in a PUCCH slot, the UE stops the deferral procedure of pending SPS HARQ-ACK in that PUCCH slot and that PUCCH slot is not considered as a potential target slot for SPS HARQ-ACK deferral anymore. |

**RAN1#107bis-e (Jan. 2022)**

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| **Conclusion**  There is no consensus to support SPS HARQ-ACK deferral for half-duplex CA UEs in Rel-17.  **Conclusion**  There is no consensus to support joint operation of SPS HARQ-ACK deferral and PUCCH repetition in Rel-17.  **Conclusion**  The operation of simultaneous configuration of Rel-16 Type 3 HARQ-ACK codebook or enhanced Type 3 HARQ-ACK codebook triggering and SPS HARQ-ACK deferral is further clarified as:   * If the UE detects a DCI format in a PDCCH reception that triggers a PUCCH transmission with a Type-3 or enhanced Type-3 HARQ-ACK codebook in a slot, the UE stops the procedure to determine the earliest second slot in that slot. * The pending SPS HARQ information for deferral is not appended to the Type-3 or enhanced Type 3 CB in that slot.   **Conclusion**  There is no consensus to support joint configuration of PUCCH cell switching based on dynamic indication and SPS HARQ-ACK deferral in Rel-17.  **Agreement**  The following TP to 38.213 is endorsed for the editor’s CR.   |  | | --- | | 9.2.5.4   UE procedure for deferring HARQ-ACK for SPS PDSCH  If a UE is provided *spsHARQdeferral* and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs in a first slot, the UE determines a PUCCH resource for a PUCCH transmission with first HARQ-ACK information bits for SPS PDSCH receptions that the UE would report for a first time, and the PUCCH resource   * is provided by *SPS-PUCCH-AN-List* as described in clause 9.2.1, or by *n1PUCCH-AN* if *SPS-PUCCH-AN-List* is not provided * overlaps with a symbol indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigDedicated*, or indicated for a SS/PBCH block by *ssb-PositionsInBurst*, or belonging to a CORESET associated with a Type0-PDCCH CSS set   the UE   * determines an earliest second slot and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs, a PUSCH or a PUCCH in the earliest second slot to multiplex HARQ-ACK information bits that include second HARQ-ACK information bits from the first HARQ-ACK information bits * if the UE detects a DCI format in a PDCCH reception that triggers a PUCCH transmission with a Type-3 HARQ-ACK codebook in a slot as described in clause 9.1.4, the UE stops the procedure to determine the earliest second slot **in the slot** * if the UE is provided a periodic cell switching pattern for PUCCH transmissions by *pucch-sSCellPattern*, the UE determines the earliest second slot and a corresponding cell based on the periodic cell switching pattern as described in clause 9.A |   **Agreement**  Support the simultaneous configuration of one-shot triggering of HARQ re-transmission and SPS deferral   * One-shot HARQ-ACK re-transmission can trigger re-transmission SPS HARQ-ACK enabled with deferring from the initial SPS HARQ deferral slot. * If the PUCCH slot indicated by the *HARQ\_retx\_offset* is the ‘target’ or earliest ‘second’ slot for SPS HARQ-ACK deferral, the HARQ-ACK CB including the deferred SPS HARQ-ACK bits will be retransmitted in the new retransmission PUCCH triggered by one-shot triggering DCI. * For the SPS HARQ-ACK deferral procedure, the PUCCH slot with a one-shot triggered HARQ-ACK CB is regarded as a valid potential target PUCCH slot for SPS HARQ-ACK deferral with same PHY priority (at least for operation with Rel-16 PHY prioritization) as the PHY priority of the triggered one-shot HARQ-ACK re-transmission.   + - If the PUCCH slot with a one-shot triggered HARQ-ACK CB is determined by the UE as target or earliest second PUCCH slot for SPS HARQ-ACK deferral, the deferred SPS HARQ-ACK in a target slot is appended to the re-transmitted HARQ-ACK CB and initial, new HARQ-ACK (if any) following the operation of SPS HARQ-ACK deferral procedure. |

* 1. Summary of companies input in their contributions

**‘Stand-alone’ SPS HARQ deferral**

* **ZTE [6] on Type 1 CB for deferred SPS PDSCH:** If the UE needs to generate a Type1 codebook in slot n, and the target slot of the delayed SPS HARQ-ACK is also slot n, then the following rules are proposed:
  + If the slot with SPS PDSCH is contained in the slots corresponding to a Type 1 codebook for the DG PDSCHs, then UE only generates the Type 1 codebook.
    - Note the Type 1 codebook can naturally include the deferred SPS HARQ-ACK of the SPS PDSCH and HARQ-ACKs of the DG PDSCHs according to the current Type 1 codebook mechanism.
  + Otherwise, the UE generates the Type 1 codebook according to the current Type 1 codebook mechanism and concatenates the deferred SPS HARQ-ACK after the Type 1 codebook for DG PDSCHs.
  + *Moderator comment*: This would overturn earlier RAN1 agreement. Can be checked but would clearly require consensus to have such change.
* **OPPO [7] raises a needed clarification on the timeline for the SPS HARQ dropping in case of HARQ process re-use:** 
  + If SPS HARQ-ACK corresponding to a SPS PDSCH with a certain HARQ process number is deferred to a target PUCCH/PUSCH, and a later PDSCH with the same HARQ process number is received prior to the target PUCCH/PUSCH,
    - If the later PDSCH and the target PUCCH/PUSCH satisfy Rel-15 multiplexing timeline, the deferred SPS HARQ-ACK is dropped;
    - Otherwise, the deferred SPS HARQ-ACK is transmitted in the target PUCCH/PUSCH.
* **ETRI [14]:** It is allowed to multiplex deferred SPS HARQ-ACK bits onto a HARQ codebook from any usage scenario (e.g. multicast broadcast, sidelink, non-terrestrial network, etc can be considered)
  + *Moderator comment:* Based on the current specifications (38.213 v17.0.0) there seems to be not really any restrictions there. @ETRI, if you think some agreement & related specification change would be needed, please contact the moderator offline to include this in a later email discussion round (with the related needed change to the current specs version).

**SPS deferral and semi-static PUCCH cell switching**

* ZTE [6] on clarification for the initial slot handling:
  + For the initial slot in PCell, if the UE performs UCI multiplexing to determine whether the SPS HARQ-ACK is deferred, it should consider multiplexing the SPS HARQ-ACK to the overlapping PUCCH slot of the Scell based on the PUCCH cell switching pattern.
    - If the multiplexed PUCCH is valid in Scell slot, the SPS HARQ-ACK is transmitted in the multiplexed PUCCH slot; otherwise, the SPS HARQ-ACK is deferred.
  + *Moderator comment:* thought it should be clear the target PUCCH cell is applied here directly, but maybe worth clarifying that the initial slot handling is performed on the target PUCCH cell.

**SPS deferral and Type 3 CB operation**

* Change of operation suggested by QC [19]:
  + In case of joint SPS HARQ Deferral and Rel. 17 Type 3 HARQ CB and after the Rel. 17 Type 3 HARQ CB transmission, the UE
    - Stops/cancels the transmission of pending/ongoing SPS HARQ bits to be deferred at the first available uplink resource, if at least a part of the SPS HARQ bits to be deferred is already transmitted via Rel. 17 Type 3 HARQ CB,
    - transmits the SPS HARQ bits to be deferred at the first available uplink resource after the Rel. 17 Type 3 HARQ CB transmission, if none of the deferred SPS HARQ bits is transmitted via Rel. 17 Type 3 HARQ CB.
  + *Moderator comment:* this would overturn the RAN1#107bis-e agreement and require additional handling
* Timeline clarification requested by QC [19]: Adopt the existing timeline in terms of uplink cancellation for the SPS HARQ deferral cancellation/stopping: Tproc,2.
  + *Moderator comment:* As discussed when taking the decision, there is already the timeline for the Type 3 CB triggering present. And the cancelation of the SPS deferral would not happen before the PUCCH slot with the Type 3 CB anyhow. So don’t we have a timeline given already by the minimum processing timeline of the DCI triggering the Type 3 CB transmission and the PUCCH carrying the Type 3 CB?

**SPS deferral and PUCCH repetitions**

* The following is suggested by QC [19]:
  + Following the #107bis-e conclusion not allowing joint configuration of SPS HARQ Deferral and PUCCH repetitions, the UE is not expecting to be configured with both SPS HARQ deferral and PUCCH repetitions; such a joint configuration is treated as an error case.
  + RAN 1 to clarify that the maximum deferral time, k1def\_max, is applicable only for SPS configured with deferral and without SPS PUCCH repetitions.
    - *Moderator comment:* If we agree the QC proposal in the earlier bullet, wouldn’t this be then clear already (i.e. there would not be any deferral or maximum deferral value anyhow applicable, as such configuration is not expected)?

**Identified needed specification changes based on available agreements / operation**

***Nokia/NSB [3] on joint operation of SPS deferral and HARQ-ACK re-tx:***

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| 9.1.5 HARQ-ACK codebook retransmission ….  If in slot the UE performs a procedure for deferring first HARQ-ACK information for SPS PDSCH receptions, as described in clause 9.2.5.4, and the first HARQ-ACK information has same priority value as a priority value indicated by the DCI format triggering the PUCCH transmission in slot , the UE multiplexes in the PUCCH transmission in slot second HARQ-ACK information with the priority value that results in slot according to the procedure in this clause. If the UE would also multiplex in the PUCCH transmission in slot third HARQ-ACK information with the priority value, the UE appends the second HARQ-ACK information to the third HARQ-ACK information before multiplexing the first HARQ-ACK information into the PUCCH transmission as described in clause 9.2.5.4. The UE determines to multiplex the third HARQ-ACK information in the PUCCH transmission in slot as described in clause 9.2.3. |

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| 9.2.5.4 UE procedure for deferring HARQ-ACK for SPS PDSCH …  - the second HARQ-ACK information bits, generated as described in clause 9.1.2, are appended in a HARQ-ACK codebook the UE generates as described in clauses 9.1.2, 9.1.2.1, ~~or~~ 9.1.3.1 or 9.1.5  - if the UE would receive a PDSCH providing a TB for a same HARQ process as a HARQ-ACK information bit from the second HARQ-ACK information bits prior to transmitting the PUCCH or the PUSCH, the UE does not include the HARQ-ACK information bit in the HARQ-ACK information bits. |

***ZTE [6] on the case there is no other UCI in the PUCCH slot and/or no PUSCH overlapping:***

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| TS38.213h00  9.2.5.4 UE procedure for deferring HARQ-ACK for SPS PDSCH  If a UE is provided *spsHARQdeferral* and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs in a first slot if any, the UE determines a PUCCH resource for a PUCCH transmission with first HARQ-ACK information bits for SPS PDSCH receptions that the UE would report for a first time, and the PUCCH resource  - is provided by *SPS-PUCCH-AN-List* as described in clause 9.2.1, or by *n1PUCCH-AN* if *SPS-PUCCH-AN-List* is not provided  - overlaps with a symbol indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigDedicated*, or indicated for a SS/PBCH block by *ssb-PositionsInBurst*, or belonging to a CORESET associated with a Type0-PDCCH CSS set  the UE  - determines an earliest second slot and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs if any, a PUSCH or a PUCCH in the earliest second slot to ~~multiplex~~transmit HARQ-ACK information bits that include second HARQ-ACK information bits from the first HARQ-ACK information bits  ... |

* 1. 1st round of email approvals

**Remaining issues on SPS HARQ-ACK deferral**

ZTE [6] requesting a change in the SPS HARQ-ACK deferral procedure when being configured with Type 1 HARQ-ACK codebook, namely, to have separate treatment in case the SPS HARQ-ACK for deferral is included already in the Type 1 HARQ-ACK codebook or not. Based on current agreements and the related 38.213, the SPS HARQ-ACK for deferral would be appended independently if all the SPS HARQ-ACK is also already contained in the Type 1 HARQ-ACK codebook.

**Proposal 2.1.1: For SPS HARQ-ACK deferral and Type 1 HARQ-ACK codebook operation, the RAN1#106-e agreement is changed to (with changes in red):**

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| Agreement  For SPS HARQ-ACK deferral, in the target PUCCH slot the deferred SPS HARQ-ACK bits are appended to the initial HARQ bits of a ~~/ Type 1 or~~ Type 2 codebook.  For SPS HARQ-ACK deferral, in the target PUCCH slot the deferred SPS HARQ-ACK bits are appended to a Type 1 codebook, if the deferred SPS HARQ-ACK are not already included in the Type 1 codebook. |

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| Supporting companies | QC, ZTE |
| Objecting companies | Nokia/NSB, Intel, Ericsson, Lenovo Huawei/Hisi, New H3C, DOCOMO,OPPO, CATT, LG, ETRI, Sony, Samsung |

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| *Company* | *Comments* |
| Nokia/NSB | No need to change the earlier agreement, unnecessary optimization in the maintenance phase. |
| Intel | We don’t think this is a typical case for SPS HARQ-ACK deferral scenarios. |
| Ericsson | We understand ZTE’s proposal that tries to resue existing procedures for Type-1 CB constructions involding HARQ-ACK for DL SPS. However, at this stage it is better to leave the existing procedures for DL SPS HARQ-ACK without deferral.  That makes less complications by isolating the DL SPS HARQ-ACK deferral and consider it as an “add-on feature” without touching the base feature. Otherwise, we need to add some conditions for Type-1 HARQ-ACK codebook. |
| QC | The case is indeed a corner case and very unlikely to happen. However, if it happens, having the UE transmitting the HARQ feedback for a given HARQ Process in the Type 1 HARQ CB and in the deferred SPS HARQ CB is a total waste of resources. The fact that ZTE’s proposal changes a previous agreement is not an understandable argument. This group has been repeatedly changing/modifying previous agreements in other cases. The treatment is not fair. The next proposal in this document, Proposal 2.1.2, is a proposal for changing a previous agreement. The addressed case in Proposal 2.1.2 is even less likely than this case discussed here.  The term “optimization” is unfortunately constantly misused by the moderator. ZTE’s suggestion tries to improve the operation of an inefficient feature with very low likelihood to be used. This group has consistently agreed in several useless/pointless agreements. However, once decision to specify a feature – independently of its value – is taken, the group should be specified in a way that it is implementable and its operation does not waste resources. |
| Huawei/Hisi | We have discussed this issue in 106-e, and achieved consensus that no optimization is applied (refer to Question 2.8/ Proposal CP2.7: of R1-2108546).   |  | | --- | | **Agreement**  For SPS HARQ-ACK deferral, in the target PUCCH slot the deferred SPS HARQ-ACK bits are appended to the initial HARQ bits / Type 1 or Type 2 codebook. | |
| DOCOMO | It is not fundamental issue but codebook size reduction optimization issue. Even though the SPS PDSCH can be included in candidate PDSCH occasions for the type 1 HARQ-ACK CB, NACK should be reported for the candidate PDSCH occasion based on existing Rel-16 procedure. Therefore, impact on legacy type 1 HARQ-ACK CB procedure is needed if such optimization is adopted. We don’t prefer such complete handling for optimization. |
| CATT | We share the same view as Huawei that the proposal was discussed but not agreed. There is no point to reopen the discussion at this stage. |
| LG | We think the issue had been discussed already and it was concluded to the current agreement. |
| ZTE | The motivation as Ericsson pointed out is to reuse procedures for Type-1 CB constructions. The overhead reduction is only a side effect. If majority view is not willing to rediscuss the issue, we can live up with the previous agreement. |
| NEC | We understand the intention of the proposal for Type-1 HARQ-ACK codebook optimization, we are aslo fine with no optimaztion if the time is limited for other critical issues. |
| ETRI | The current agreement already captures this behavior though it might be not very efficient. |
| Sony | I do not think we expect a lot of deferred SPS HARQ-ACK bits to be appended onto a HARQ-ACK CB.  Also the reason to use Type 1 CB is for robustness rather than for resource efficiency, where it is expected to feedback HARQ-ACKs for unscheduled PDSCH. So, this optimisation or improvement may not provide substantial gain. |
| Samsung | There is no meaningful benefit from further optimization for Type-1 & HARQ-ACK deferring as the considered situation is atypical. Also, the proposal from ZTE increases UE implementation complexity since a UE needs to check whether or not deferred SPS HARQ-ACK is included in Type-1 HARQ-ACK CB. |
| Moderator | Looking at the input received, it seems to be not just some minor wording issues, but some more essential disagreement with the proposal.  The moderator therefore does not plan to continue discussions on the proposal. |

OPPO [7] raises a needed clarification on the timeline for the SPS HARQ dropping in case of HARQ process re-use, namely at which point of time the UE should drop the deferred SPS HARQ-ACK based on the earlier RAN1 agreement and current specifications:

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| Agreement  For SPS HARQ-ACK deferral, confirm the RAN1#104b-e working assumption with the following updates in RED:  (working assumption) To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:   * In case the UE is expected to receive~~s~~ PDSCH of a certain HARQ Process ID according to TS 38.214 Sec. 5.1, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.   + Note: there is no further discussion on specific handling for the case of DG PDSCH with the same HARQ process ID   From 38.213:  9.2.5.4 UE procedure for deferring HARQ-ACK for SPS PDSCH  ......  the UE  - determines an earliest second slot and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs, a PUSCH or a PUCCH in the earliest second slot to multiplex HARQ-ACK information bits that include second HARQ-ACK information bits from the first HARQ-ACK information bits  ……  - the second HARQ-ACK information bits, generated as described in clause 9.1.2, are appended in a HARQ-ACK codebook the UE generates as described in clauses 9.1.2, 9.1.2.1, or 9.1.3.1  - if the UE would receive a PDSCH providing a TB for a same HARQ process as a HARQ-ACK information bit from the second HARQ-ACK information bits prior to transmitting the PUCCH or the PUSCH, the UE does not include the HARQ-ACK information bit in the HARQ-ACK information bits. |

The OPPO proposed timeline of satisfying the Rel-15 timeline seems to be reasonable, so let’s check directly if such timeline clarification is acceptable to the group.

**Proposal 2.2.2: For SPS HARQ-ACK deferral, further clarify the timeline behavior on top of the earlier RAN1#105-e agreement with the following additions in red:**

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| Agreement: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:   * In case the UE is expected to receive PDSCH of a certain HARQ Process ID according to TS 38.214 Sec. 5.1, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped from a PUCCH or PUSCH in the target /earliest second slot if the PUCCH or PUSCH satisfies the Rel-15 multiplexing timeline for the PDSCH.   + Note: there is no further discussion on specific handling for the case of DG PDSCH with the same HARQ process ID |

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| Supporting companies | Nokia/NSB, vivo, OPPO, CATT (in principle), Sony (maybe not PDSCH mux timeline) |
| Objecting companies | Ericsson, QC (clarification needed for the term “Rel. 15 multiplexing timeline for the PDSCH”, Lenovo Huawei/Hisi, New H3C, DOCOMO, LG, ZTE, NEC, Samsung |

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| *Company* | *Comments* |
| Intel | It would be preferrable to formulate a standalone agreement w/o modifying the old one, for better tracking of the progress.  In addition, we are wondering what is meant by “multiplexing timeline for the PDSCH”?  We are also wondering what happens if the multiplexing timeline is not met: is it an error case, or the bits are not dropped? |
| Ericsson | We have similar comment as Intel to understand the need for multiplexing timeline.  Here, the intention is to construct a CB and whether to include or not, the deferred HARQ-ACK bits, is about CB construction. That is different when a PUCCH transmission with its own CB is subject to drop or its CB to be multiplexed in another channel, PUSCH.  Therefore, we don’t see the relevance of timeline issue in this case. |
| QC | The term “if the PUCCH or PUSCH satisfies the Rel-15 multiplexing timeline for the PDSCH” is not clear. Is “PDSCH processing time” targeted?  Especially, since this is the last Rel. 17 meeting of this agenda item, a polite request even now not to waste the group’s time with features/mechanisms addressing problems of extremily low likelihoo. |
| Lenovo | In our view, UCI multiplexing timeline is not relevant to the referred agreement. |
| Huawei/Hisi | The R15 timeline is specified for the gNB to perform the scheduling, but not for the UE to generate HARQ-ACK. The UE will perform the PDSCH decoding and HARQ-ACK generation based on its own time order, not necessarily start with the HARQ-ACK generation immediately after the scheduled PDSCH. |
| DOCOMO | In our understanding, the intention of the agreement is to handle HARQ process number collision of deferred SPS HARQ-ACK bit and new **SPS** PDSCH. Therefore, there is no need to define any timeline since UE can predict HPN of new SPS PDSCH before the new SPS PDSCH reception. |
| OPPO | This proposal is to address timeline issue for SPS HARQ-ACK dropping. One example is shown in the following, a SPS PDSCH with HARQ process number X is transmitted in slot n, and the corresponding SPS HARQ-ACK is deferred to slot n+3. Another PDSCH 1 with the same HARQ process number is transmitted in slot n+2. The gap between the ending of PDSCH 1 and the starting of target PUCCH for SPS HARQ-ACK deferral is less than Rel-15 multiplexing timeline. In this case, UE has no time to reconstruct the HARQ-ACK codebook to be transmitted in slot n+3. So the timeline restriction is necessary for SPS HARQ-ACK dropping. Accurately, the timeline refers to HARQ-ACK codebook reconstruction and even PUCCH preparation, however, it is not feasible to define new timeline value at this stage. So we suggest to reuse R15 multiplexing timeline, i.e. Tproc,1, to restrict gap between the ending of latter PDSCH triggering SPS HARQ-ACK dropping and the the starting of PUCCH which would carry the dropping SPS HARQ-ACK.    @Intel , QC, Huawei/Hisi “multiplexing timeline for the PDSCH” means reuse Rel15 multiplexing timeline value, i.e. Tproc,1, covering HARQ-ACK codebook contruction and PUCCH preparation, to restrict gap between the ending of latter PDSCH triggering SPS HARQ-ACK dropping and the the starting of PUCCH which would carry the dropping SPS HARQ-ACK.  If timeline is not satisfied, we prefer to keep SPS HARQ-ACK transmission, not dropping, to avoid reconstruction of HARQ-ACK codebook.  @ Ericsson, timeline restriction is applied to ensure enough time for reconstruction of HARQ-ACK codebook. And existing Rel-15 multiplexing timeline value, i.e. Tproc,1, covering HARQ-ACK codebook contruction and PUCCH preparation, can be reused directly to avoid discussion on new timeline value. |
| CATT | We understand the intention of the proposal and support the proposal in principle.  For “the Rel-15 multiplexing timeline for the PDSCH”, our understanding is that it means that the time gap between the end of PDSCH and the start of the earliest overlapping channel should not be shorter than Tproc,1\_mux. But we are wondering what if the PUCCH does not overlap with other PUCCH/PUSCH. |
| LG | The agreement is to handle HARQ process collision in the same way in Rel-15. We are not sure that this case could be a part of cancelation handling. It is almost similar to CGtimer handling, which prohibits to transmit due to prior scheduling on the same HARQ process, but we didn’t need to specify any timeline for the case. |
| NEC | For the HARQ process collision handling, we don’t see the need for multiplexing timeline. |
| Huawei/Hisi2 | The time point for the UE to drop the original HARQ-ACK bit can be the PUCCH (PUCCH2 in the figure) corresponding to the received PDSCH (PDSCH2 in the figure), at which time it is clear for UE to have finished generating the new HARQ-ACK. Before that time, the UE will not drop that bit to avoid misalignment with gNB, but can update its information up to implementation (gNB only reads the updated HARQ information at PUCCH2).   * In case the UE is expected to receive PDSCH of a certain HARQ Process ID according to TS 38.214 Sec. 5.1, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped at the PUCCH/PUSCH that would carry the HARQ-ACK associated with the PDSCH expected to be received ~~from a PUCCH or PUSCH in the target /earliest second slot if the PUCCH or PUSCH satisfies the Rel-15 multiplexing timeline for the PDSCH~~.   + Note: there is no further discussion on specific handling for the case of DG PDSCH with the same HARQ process ID |
| Sony | We support this argument for a need of processing time but we are not sure if it should be the time between end of PDSCH and start of target PUCCH. It should be the time when the UE is aware that a HPN collision has occurred. That may be the start of the DL Grant or whenever UE realise a SPS PDSCH has the same HPN. |
| Samsung | The proposal seems to be trying to define Rel-15 timeline between new PDSCH of a certain HPN and a PUCCH (or a PUSCH) including the deferred SPS HARQ-ACK bit(s). If that is the case, we don’t see at least SPS PDSCH case since a UE already know which SPS PDSCH is associated with a certain HPN. For the DG PDSCH, a DCI including HPN information is transmitted before the PDSCH. A new processing timeline does not need to be defined for this case. Otherwise, the whole meaning of timeline needs to be re-discussed. |
| Moderator | There seems to be some resistance on this proposal here. Let’s try in the 2nd round to check if the suggested version by HW could maybe be agreeable. |

**Semi-static PUCCH carrier switching and SPS HARQ-ACK deferral**

We clearly defined the operation for the target slot handling in the last meeting, but ZTE [6] suggests to also still clarify the behaviour in the initial slot. Although it should be clear, having an agreement or at least a related conclusion would not hurt here. The red parts below are additions to the earlier conclusion on the initial slot handling.

**Mod Proposed conclusion 2.1.3: For simultaneous configuration of SPS HARQ-ACK deferral and PUCCH cell switching based on the semi-static time domain pattern, the ‘initial' PUCCH slot (i.e. PUCCH slot determined by n+k1) handling is further clarified as:**

* **The UE performs first the (Rel-16) UCI multiplexing operation based on the determined target PUCCH cell using the semi-static time domain pattern. If after the UCI multiplexing operation into a PUCCH or PUSCH if any, and if the UE would be transmitting SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN which is not valid, the SPS HARQ-ACK configured for deferral is deferred.**

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| Supporting companies | Nokia/NSB, Ericsson Huawei/Hisi, New H3C, vivo, DOCOMO,OPPO, CATT, LG, ZTE, NEC, ETRI, Sony |
| Objecting companies | QC |

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| *Company* | *Comments* |
| Intel | We are wondering what would be the other interpretation if this part is not clarified? |
| Ericsson | We share the same view as Moderator that although it should have been clear, but it doesn’t hurt to clarify in case there is a risk for misunderstanding. |
| QC | The proposal can not be accepted since it goes against the goal of both i) SPS HARQ deferral and ii) PUCCH cell switching. Both of these two features (SPS HARQ deferral and PUCCH cell switching) are introduced with the goal to reduce latency in URLLC applications. With this proposal, the latency can increase. See example below:  Example   * first available PUCCH resource in Pcell in slot N * first available PUCCH resource in Scell in slot N-1; PUCCH resource enough to accommodate new SPS HARQ or new DG HARQ CBs and deferred SPS HARQ CB * SPS HARQ Collision with DL in Pcell in slot N – K in Pcell; PUCCH resource not sufficient for the total HARQ payload (new and deferred HARQ CBs) * UE tries to find the target slot in Pcell * UE switches PUCCH transmission to Scell according to the semi-static PUCCH cell switching pattern * UE tries to transmit in slot N – 1 in Scell. The UE does not find PUCCH resource for all HARQ bits. The UE defers further the transmission of deferred HARQ bits to slot N + 1 or N + 2. * The UE could have transmitted new and deferred HARQ bits in slot N in Pcell, if the UE had stayed in the same cell.   The solution would have been in this case above, that the UE looks jointly the available PUCCH resource in both cells. However, since this is not a desired and easily implemented option, the proposal is the UE drops the ongoing deferred HARQ bits. The UE makes use of the #106e agreement  **Agreement**  For SPS HARQ-ACK deferral, if after the target PUCCH slot determination the deferred SPS HARQ-ACK cannot be transmitted, the deferred SPS HARQ-ACK bits are not further deferred and are dropped. |
| Huawei/Hisi | We are fine with the proposal itself (though the previous agreement is clear enough). But as a clarification question for the term ‘initial slot’: does it mean the PUCCH slot as per the k1 value, or any candidate target/intermediate slot during the SPS deferral procedure? In my understanding here it means the candidate target/intermediate slot, right? E.g., the SPS PDSCH is slot n, the ‘first slot’ for SPS HARQ-ACK is n+k1, the ‘earliest second slot’ is n+k1+X; the ‘initial slot’ here means any slot from n+k1 to n+k1+X. |
| DOCOMO | Fine with clarification, but agree with Huawei that it should not be restricted to “initial slot”, but also for candidate and target slot.  **@QC**, with regarding your comments, our understanding is that we have already agreed on joint operation of SPS HARQ-ACK deferring and semi-static PUCCH cell switching. |
| CATT | We think it is a clarification. For QC’s comment, we share the same view as DOCOMO.  Please refer to the following agreement.   |  | | --- | | **Agreement**  Support simultaneous configuration of SPS HARQ-ACK deferral and PUCCH cell switching based on the semi-static time domain pattern:  For the target slot determination of SPS HARQ-ACK deferral,   * Step 1: the UE first determines a next PUCCH slot on the cell for PUCCH transmission using the semi-static time-domain PUCCH cell pattern and the related rules for semi-static PUCCH cell switching, followed by * Step 2: the UE determines based on the SPS HARQ-ACK deferral rules if this PUCCH slot on the PUCCH cell for transmission is the target PUCCH slot or not. * Note: In step 1, k is increased on PCell/PScell/PUCCH-Scell. “The next PUCCH slot” represents the slot on the PUCCH cell based on PUCCH cell pattern, which is mapped from the PCell/PScell/PUCCH-Scell slot with increased K1. * Note: The maximum deferral limitation checking is based on the effective k + kdef value based on the granularity of PCell / PScell/PUSCCH-Scell |   Regarding Huawei’s question, we have a different understanding. Our understanding is that the proposal address the initial slot determined by k1 only. For intermediate slots, our understanding is that it is already covered by the above agreement. |
| Moderator | @HW: initial slot here means the slot determined by n+k1. For all other slots we have the earlier agreement in place on the determination of the earliest second slot, which runs from slot n+k1+1 to the final target slot. Tried to clarify this. |
| LG | It would be good to clarify, however, we have similar view to intel’s since there seems no other interpretation. Even if SPS deferral is not configured, SPS PUCCH should use PUCCH resources on determined target cell.  @Huawai/HiSi, DOCOMO:  We had same understanding as Moderator. Our understanding is that ‘initial slot handling’ means determining whether to perform deferral rather than slot itself. Please correct us if we misses something. |
| ZTE | For the modified version, we are fine.  From CATT’s comment, it seems the target slot has supporte the mechanism.  @Intel @QC, I try to clarify the motivation matching the intention of PUCCH cell switch t reduce the latency of HARQ-ACK.    In above Figure, a semi-static PUCCH cell switching is configured between the PCell and the SCell, and the PUCCH slot is marked in Figure based on the PUCCH cell switching pattern. For the initial slot n in the PCell, when the UE performs UCI multiplexing to determine whether the SPS HARQ-ACK is deferred, it is supported to multiplex the SPS HARQ-ACK in PCell into the PUCCH slot m of the Scell if slot m overlapping with slot n in time domain based on the PUCCH cell switching pattern. If the multiplexing PUCCH is valid in slot m, the SPS HARQ-ACK is transmitted in the multiplexed PUCCH in slot m; otherwise, the SPS HARQ-ACK deferral is determined.  This procedure is valid according to the agreement of supporting the joint processing bwtween semi-static PUCCH cell switching and the SPS HARQ deferral determination.  If it is not clarified, the HARQ-ACK multiplexing into Scell may be skipped and it is not our original intention to apply the PUCCH cell switching. |
| vivo2 | About Huawei’s question, we share the same understanding with CATT anf Moderator. |
| Huawei/Hisi2 | Thanks for Moderator and other companies’ clarifications. The intention and background is now clear for me. |
| ETRI | We are fine to the modified conclusion. |
| Sony | Thanks ZTE for the explanation. We think the intention is to consider whether SCell can is available for SPS HARQ-ACK transmission before deferring. Perhaps the formulation of the agreement isn’t clear, and gave the wrong impression that it is trying to change an existing agreement. |
| Samsung | We don’t see a need for the conclusion but OK if companies prefer to have it. |
| QC 2 | The group has already agreed to support joint configuration of SPS HARQ deferral and semi-static PUCCH cell switching. This agreement is respected and no intention to revert it. However, since the discussion about the modification of a previous agreement is opened up by other companies, useful to agree the following:  **Mod Proposed conclusion 2.1.3 (QC): For simultaneous configuration of SPS HARQ-ACK deferral and PUCCH cell switching based on the semi-static time domain pattern, the ‘initial' PUCCH slot (i.e. PUCCH slot determined by n+k1) handling is further clarified as:**   * **The UE performs first the (Rel-16) UCI multiplexing operation based on the determined target PUCCH cell using the semi-static time domain pattern. If after the UCI multiplexing operation into a PUCCH or PUSCH if any, and if the UE would be transmitting SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN which is not valid, the SPS HARQ-ACK configured for deferral is deferreddropped.**   This is the only UE behavior resulting in lower latency. If the UE switches PUCCH cell and finds the target PUCCH cell, then, the goal is achieved. If not, the UE simply drops the deferred HARQ. |
| Moderator | Actually based on the other agreed conclusion by email:  ***Semi-static PUCCH cell switching, i.e. the PUCCH cell determination based on the time-domain pattern, should be performed before UCI multiplexing/prioritization.***  Which would then also apply for the SPS that used the UCI multiplexing. So maybe no need to clarify this further.  Therefore, not handled anymore in this meeting – if you think differently, please let me know offline. |

**Type 3 HARQ-ACK CB and SPS HARQ-ACK deferral**

We had in the last meeting extensive discussions on the ‘stopping the deferral procedure’ in a PUCCH and a related TP agreed. QC [19] is suggesting further changes to the earlier agreed behavior, namely if none of the deferred SPS HARQ-ACK bits are part of the enhanced Type 3 CB, the SPS HARQ-ACK deferral procedure to determine an earliest second slot continues from the PUCCH slot following the PUCCH slot with the enhanced Type 3 CB transmission.

As this changes an earlier agreement, the proposal here is formulated here directly as a change to the earlier agreement. But let’s check where companies stand here:

**Proposal 2.1.4: The RAN1#107-e agreement is changed to (with changes in red):**

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| Agreement  Support simultaneous configuration of Rel-16 Type 3 HARQ-ACK codebook or enhanced Type 3 HARQ-ACK codebook triggering and SPS HARQ-ACK deferral.   * In case a R16 Type 3 HARQ-ACK CB or an enhanced Type 3 HARQ-ACK codebook is triggered for transmission in a PUCCH slot, the ~~UE stops the deferral procedure of pending SPS HARQ-ACK in that PUCCH slot and that~~ PUCCH slot is not considered as a potential target slot for SPS HARQ-ACK deferral ~~anymore~~.   + If none of the SPS HARQ-ACK bits subject to deferral are included in the enhanced Type 3 HARQ-ACK codebook, the UE resumes / continues to search for an earliest second slot from the PUCCH slot after the enhanced Type 3 CB transmission.   + Otherwise, the UE stops the deferral procedure of pending SPS HARQ-ACK in the PUCCH slot of the enhanced Type 3 CB transmission. |

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| Supporting companies | QC, LG |
| Objecting companies | Nokia/NSB, Intel Huawei/Hisi, New H3C, vivo, DOCOMO,OPPO, CATT, NEC, ETRI, Sony, Samsung |

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| *Company* | *Comments* |
| Nokia/NSB | No need to overturn the earlier agreement. This will just complicate the overall deferral procedure |
| Intel | The agreed joint operation of (e)Type 3 CB and SPS HARQ-ACK deferral is already an optimization. Further clarifications overturning prior agreements are complicating spec stabilization, thus we don’t support this change. |
| Ericsson | We have a different understanding of QC proposal.  We think the issue is how to interpret “the pending SPS HARQ-ACK”.   * Let’s say there is trigger for eType 3 CB is configured for HARQ procees ID 3,4. We have DL SPS deferral for DL SPS transmission occasions corresponding to HARQ process 1,2,3,4. When eType-3 CB is triggered, the pending SPS HARQ-ACK refers to DL SPS HARQ-ACK corresponding to HARQ process ID 3,4. The DL SPS HARQ-ACK corresponding to 1,2 won’t be affected by triggering e Type 3, and continue their deferral. * Also, “stop the deferral procedure” is for the DL SPS HARQ-ACK bits affected by e/Type 3. But the deferral procedure as such is still considered “enabled” and is applied to other DL SPS transmission occasions.   Therefore, we understood the newly added bullets are clarifcations of the previous agreement.  Maybe it is good to check if this understanding is correct. |
| QC | By reading the previous agreement, our understanding is very far from the moderator’s understanding. It seems that QC is not the only company seeing that there is no mentioning of the Rel. 17 Type 3 HARQ CB content. If the moderator’s intention was that the UE stops any ongoing deferral procedure upon reception of Type 3 HARQ CB request, this is also fine. It needs to be clarified though. (Even though the support is the one described in our contribution, QC is fine if the UE stops any ongoing deferral). Hence, no desire to overturn a previous agreement – which apparently is not understood in the same way by several companies.  Request to the moderator to really probe the understanding of companies in the previous request and avoid the pre-arranged with collaborating companies conclusion “There is no consensus …”. The UE behaviour for the cases addressed in our contribution should be clear after the Type 3 HARQ CB transmission.  Ericsson’s interpretation is correct: our goal was to clarify the behavior with regards to the pending deferral. |
| Huawei/Hisi | It is not desired to revert the agreement which clearly captured the UE behaviour, i.e., ‘that PUCCH slot is not considered as a potential target slot for SPS HARQ-ACK deferral anymore’. In addition, splitting the deferring SPS HARQ-ACK payload with only partial keep on deferring is complex for spec and implementation. |
| vivo | In general, we do not prefer to change previous agreement for any optimization at this stage. Based on the previous discussions, considering the eType 3 HARQ codebook have variable sizes, it depends on gNB’s decision on whether it wants the eType 3 HARQ codebook contain the HARQ-ACK corresponding to the SPS HARQ process for which the SPS HARQ-ACK is derferred. If the indicated eType 3 HARQ codebook does not contain the HARQ-ACK corresponding to deferred SPS HARQ-ACK, the deferred SPS HARQ-ACK is dropped and the derferrl procedure is also stopped. So, we do not think further update the agreement is needed. |
| DOCOMO | We don’t think overturning previous agreements is needed. In our understanding, it is clear that “stop the deferreal procedure” means the deferring of the pending SPS HARQ-ACK bits is ended. |
| CATT | For Ericsson’s example, we have a different understanding. Our understanding is that HARQ-ACK corresponding to HARQ process ID 1 and 2 are also dropped and are not further deferred. |
| LG | We had similar concern when the agreement was made. We had been convince by the moderator’s assessment, that gNB should ensure no case (e)type-3 codebook doesn’t contain deferred SPS HARQ-ACK. However, there are a lot of different understanding here, we think it would be meaningful to discuss again. |
| ZTE | As Ericsson mentioned, the agreement need further clarification. In the example from Ericsson, how to handle the DL SPS HARQ-ACK corresponding to 1,2 which is not coverd by eType 3 CB? Continue deferring? Dropping? Or append to the eType 3 CB? From above comments, it seems much of companies think the deferring is ending and the HARQ not coverd by eType 3 CB are dropped? If it is, why not the dropping process to be a clear agreement? |
| vivo2 | For Ericsson’s example, we share the same views with CATT. |
| NEC | We share same view with vivo and we don’t see the need for overturning the previous agreement. |
| ETRI | We share same views with CATT and Docomo. |
| Samsung | Simultaneous configuration of (e)Type 3 CB and SPS HARQ-ACK deferral is to provide HARQ-ACK feedback earlier. There is no motivation such that some HARQ(s) are still deferred or other HARQ(s) are triggered to report via (e)Type 3 CB. This complicate UE implementation for no reason. |
| QC 2 | Unfortunate misunderstanding from the moderator who constantly changes QC’s intentions: no intention to overturn any previous agreement. The intention was to clarify the UE behavior of the ongoing SPS HARQ deferral.  Vivo’s proposal is fine with QC.  “Based on the previous discussions, considering the eType 3 HARQ codebook have variable sizes, it depends on Gnb’s decision on whether it wants the eType 3 HARQ codebook contain the HARQ-ACK corresponding to the SPS HARQ process for which the SPS HARQ-ACK is derferred. If the indicated eType 3 HARQ codebook does not contain the HARQ-ACK corresponding to deferred SPS HARQ-ACK, the deferred SPS HARQ-ACK is dropped and the derferrl procedure is also stopped. So, we do not think further update the agreement is needed.”  Question to Vivo and to other companies with similar views:  Is there any indication in the wording previous agreement that the UE would behave as described by Vivo?  The previous agreement is listed below:  Agreement  Support simultaneous configuration of Rel-16 Type 3 HARQ-ACK codebook or enhanced Type 3 HARQ-ACK codebook triggering and SPS HARQ-ACK deferral.   * In case a R16 Type 3 HARQ-ACK CB or an enhanced Type 3 HARQ-ACK codebook is triggered for transmission in a PUCCH slot, the UE stops the deferral procedure of pending SPS HARQ-ACK in that PUCCH slot and that PUCCH slot is not considered as a potential target slot for SPS HARQ-ACK deferral anymore.   Therefore, the modified proposal:  Proposal for modified Agreement:  Support simultaneous configuration of Rel-16 Type 3 HARQ-ACK codebook or enhanced Type 3 HARQ-ACK codebook triggering and SPS HARQ-ACK deferral.   * In case a R16 Type 3 HARQ-ACK CB or an enhanced Type 3 HARQ-ACK codebook is triggered for transmission in a PUCCH slot, the UE stops the deferral procedure of pending SPS HARQ-ACK in that PUCCH slot. The UE drops all pending SPS HARQ bits. |
| Moderator | Looking at the input received, it seems to be not just some minor wording issues, but some more essential disagreement with the proposal.  The moderator therefore does not plan to continue discussions on the proposal. |
| vivo 3 | Reply to QC.  We tracked the discussion in the RAN1#107-e meeting, see FL summary in R1-2112758.  In the modified **Proposal 3.2.2 copy below in** R1-2112758, the stopping SPS deferral and drop the SPS HARQ-ACK bits was clarified by FL and some companies.  **Mod2 Proposal 3.2.2: Support simultaneous configuration of Rel-16 Type 3 HARQ-ACK codebook or enhanced Type 3 HARQ-ACK codebook triggering and SPS HARQ-ACK deferral.**   * **In case a R16 Type 3 HARQ-ACK CB or an enhanced Type 3 HARQ-ACK codebook is triggered for transmission in a PUCCH slot, the UE stops the deferral procedure of pending SPS HARQ-ACK in that PUCCH slot and that PUCCH slot is not considered as a potential target slot for SPS HARQ-ACK deferral anymore.**  |  |  | | --- | --- | | Supporting companies | vivo (fine in principle), NEC, Panasonic, DOCOMO Huawei/Hisi (~~in principle~~),OPPO, ZTE(with a question), Nokia/NSB, Sony, QC, CATT, Spreadtrum, TCL, Xiaomi | | Objecting companies |  | | *Company* | *Comments* | | Samsung | OK for progress (although no change in opinion). | | vivo | Thanks a lot moderator’s efforts. By reading your explanation, we understand the intention of the proposal is even if the triggered enh. Type 3 HARQ-ACK CB does not include the HARQ process(es) corresponding to the derferred SPS PDSCH, the derferred SPS HARQ-ACK **will not be deferred anymore and dropped.**  We would be fine with it for the sake of progress. | | CATT | With the explanation from moderator, we share the same understanding as vivo. But the wording is still not clear to us since the PUCCH slot with Type 3 HARQ-ACK codebook is not considered as potential target slot does not preclude that the subsequent slot(s) to be potential tareget slot(s). From our understanding, the red part is not needed since we already have “UE stops the deferral procedure…”. | | Moderator | @CATT: the reason for having the red sentence here is to define what it means to ‘stop’ the deferral procedure in that slot which could two interpretations:   * Alt. 1 That slot is the last slot where the UE checks the SPS deferral condition for the target slot  this is not the intention * Alt. 2: that slot is not a potential target slot anymore  clarified here   This is just to not have the discussions on that later and be clear from the beginning. | | CATT2 | Thanks moderator for the clarification. My understanding of the red part is that the deferred SPS HARQ-ACK if not included in the Type 3 HARQ-ACK CB is not transmitted in this slot. For the subsequent slot, it is already clear that there is no further SPS HARQ-ACK defer based on “UE stops the deferral procedure…”. So we are fine with the current wording. | | LG | We can live with the proposal for the sake of the progress. | | Huawei/Hisi | OK with it. |   Hope it clarifies the situation. |

* 1. 1st round of email discussion

**SPS deferral and PUCCH repetitions**

The following conclusion was reached last time in RAN1#107bis-e:

|  |
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| Conclusion  There is no consensus to support joint operation of SPS HARQ-ACK deferral and PUCCH repetition in Rel-17. |

QC [19] raised, that further clarifications would be needed to clarify what is not supported or expected here. QC in [19] specifically raised the following:

* Following the #107bis-e conclusion not allowing joint configuration of SPS HARQ Deferral and PUCCH repetitions, the UE is not expecting to be configured with both SPS HARQ deferral and PUCCH repetitions; such a joint configuration is treated as an error case.
* RAN 1 to clarify that the maximum deferral time, *k1def\_max*, is applicable only for SPS configured with deferral and without SPS PUCCH repetitions.

At least from moderator perspective, there seems to be no further clarifications needed. But let’s check if companies think further clarifications, e.g., the two issues raised by QC above will need to be clarified.

**Question 2.3.1: Do you see a need for further clarification (in the specifications) regarding the following RAN1#107bis-e Conclusion? (Yes /No). If yes, please provide further details below…**

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| Conclusion  There is no consensus to support joint operation of SPS HARQ-ACK deferral and PUCCH repetition in Rel-17. |

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| --- | --- |
| Yes | Intel, QC, vivo, DOCOMO, CATT, LG, NEC, ETRI |
| No | Nokia/NSB, Lenovo,OPPO, Sony, Samsung |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Intel | We prefer clarification of this precluded joint operation. The first type of clarification is preferred. |
| QC | Simple note that a joint configuration of SPS HARQ deferral and PUCCH repetitions is not accepted and treated as error case, should be enough. |
| Huawei/Hisi | No consensus here implies no simultaneous configuration for the two features, which is the default status unless an explicit agreement supports that simultaneous configuration. |
| vivo | From our understanding, the conclusion actually means that the joint configuration of SPS HARQ deferral and PUCCH repetitions is not allowed. More specifically, our understanding is as long as one PUCCH format is configured with the number of slot that is larger than 1 (for semi-static PUCCH repetition) or the HARQ-ACK PUCCH resource is configured with repetition factor (for dynamic PUCCH repectition) for dynamic PDSCH, SPS HARQ-ACK deferral cannot be configured simultaneously. |
| DOCOMO | We share same view as Intel that joint operation precluding can be clarified from configuration perspective, i.e. not allowing joint configuration of SPS HARQ Deferral and PUCCH repetitions for PUCCH resource by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN. |
| CATT | Our understanding is also that the two features cannot be configured simultaneously. |
| Moderator | There seems to be interest from companies to clarify this. So let’s check this in 2nd round email approval. |

2.4 2nd round of email approvals

**Remaining issues on SPS HARQ-ACK deferral**

Update to 2.2.2, based on the suggestion by HW/HiSi.

**Mod Proposal 2.2.2: For SPS HARQ-ACK deferral, further clarify the timeline behavior on top of the earlier RAN1#105-e agreement with the following additions in green:**

|  |
| --- |
| Agreement: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:   * In case the UE is expected to receive PDSCH of a certain HARQ Process ID according to TS 38.214 Sec. 5.1, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped at the PUCCH/PUSCH that would carry the HARQ-ACK associated with the PDSCH expected to be received.   + Note: there is no further discussion on specific handling for the case of DG PDSCH with the same HARQ process ID |

|  |  |
| --- | --- |
| Supporting companies | Huawei/Hisi, vivo, Samsung, Nokia/NSB, Sony, Ericsson, CATT, New H3C |
| Objecting companies | LG, OPPO (Further clarification), ZTE, QC |

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| --- | --- |
| *Company* | *Comments* |
| LG | We prefer leave tha agreement as it is.  We understand that PUCCH for new PDSCH is the safest timeline, thus UE shoud drop deferred HARQ-ACK until that time point so that UE behaviors becomes more deterministic. However, as some companies commented, timeline is not necessary at least for SPS PDSCH case since SPS PDSCH is already deterministic. For DG PDSCH, we wonder that we can discuss that due to the note. If possible, in our view, we think that defining specific cancelation time could bring additional UE complexity as well. |
| OPPO | Our understanding on Mod Proposal 2.2.2 is that the time point for UE to drop deferred SPS HARQ-ACK is at the PUCCH/PUSCH that would carry the HARQ-ACK associated with the PDSCH expected to be received. In the following example, the time point for UE to drop HARQ-ACK for PDSCH 1 is at the PUCCH2. Concretely, HARQ-ACK for **PDSCH1** is transmitted in **PUCCH3**. HARQ-ACK for **PDSCH 2** is transmitted in **PUCCH2**.  However, after dotted line, UE has decoded PDSCH2 and produced HARQ-ACK for PDSCH2. For the same HARQ process ID, only one HARQ-ACK bit, i.e. HARQ-ACK for PDSCH 2, can be stored. In other words, HARQ-ACK for PDSCH 1has to be dropped.    The intention of agreement is to solve collision of HARQ-ACK information for the same HARQ process ID, when the later PDSCH with the same HARQ process ID is decoded. |
| ZTE | From my understanding of the agreement, the PUCCH with the deferred SPS HARQ bit(s) doesn’t need to be same with the PUCCH of the carry the HARQ-ACK associated with the PDSCH expected to be received. The additional green part narrow down the cases of dropping.  When UE receives a DCI including HPN information, UE knows there is collision of HARQ process ID, if UE hasn't finish the transmission of deferred SPS HARQ, the deferred SPS HARQ should be dropped. |
| Intel | Fine with the proposal |
| Nokia/NSB | We think the proposal is a good and simple way to define the related dropping in more detail (i.e. have a defined behavior with the same assumption on gNB & UE side) and not having any processing issues (as this is not done before the new HARQ is to be reported 🡪 sufficient time for the UE) |
| QC | Second OPPO’s clarification. Moreover, there are also issues with the storage of the newly received PDSCH, which might not be correctly decoded and hence has to be stored immediately for future combining. |
| Ericsson | Agree with Nokia’s assessment above. |
| CATT | We support the proposal to define a deterministic time point to drop HARQ-ACK.  For the comment from OPPO, our understanding is that it is up to UE to set ACK or NACK for PDSCH1 in PUCCH3, i.e. UE does not need to store two HARQ-ACK information for the same HARQ process.  For the comment from QC, our understanding is that UE does not need to store the previous PDSCH when receiving new PDSCH of the same HARQ process. |
| Huawei/Hisi | @OPPO @QC Maybe the text caused some misunderstandings. The meaning of “the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped” is, the payload is dropped from generating a HARQ CB, e.g., not appended to other DG HARQ CBs, if any, colliding with the deferred SPS.  Actually from gNB side, it does not care when the UE updates the HARQ ID buffer (as anyway it will ignore HARQ for PDSCH1 after transmitting PDSCH 2 and expect to read the accurate/updated HARQ ID information for PDSCH2 at PUCCH2), but it minds the ambiguity of the total payload. E.g., if the gNB schedules another DG PUCCH (payload = X bis) between the red dotted line and the PUCCH 2, it does not know if the 1 bit SPS HARQ-ACK payload has been dropped or not, so it is faced with two hypotheses: X bits (UE decoded PDSCH2) or X+1 bits (UE has not decoded PDSCH2). The proposal here is, the UE always transmits X+1 bits at DG PUCCH (if UE has decoded PDSCH2, it can transmit updated HARQ bit). Only when the slot comes to PUCCH2, the UE will drop that additional bit, since both sides ensure UE has finished the decoding. |
| New H3C | We support this clarification |

**SPS deferral and PUCCH repetitions**

Based on the discussions in Question 2.3.1, a majority of companies seem to prefer to have some more clarification there.

Based on this, the following is brought forward:

**NEW Proposal 2.3.1: For SPS HARQ-ACK deferral, a UE is not expecting to be configured with both, SPS HARQ deferral for any of the SPS configurations, and PUCCH repetitions for any PUCCH format or associated with any PUCCH resource.**

|  |  |
| --- | --- |
| Supporting companies | Huawei/Hisi, DOCOMO, vivo, LG, ZTE, [Samsung], Intel, NEC, Spreadtrum, Nokia/NSB, Sony, QC [with Samsung’s clarifications], Ericsson, CATT, New H3C |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | We suggest the following update to be accurate (we assume that is the intention)  **For SPS HARQ-ACK deferral, a UE is not expecting to be configured with both, SPS HARQ deferral for any of the SPS configurations, and PUCCH repetitions for ~~any PUCCH format associated with~~ any PUCCH resource****in*****SPS-PUCCH-AN-List* or *n1PUCCH-AN*.** |
| Ericsson | We are fine with Samsung’s update. |
| Moderator | @Samsung, QC (& Ericsson)  On of the reasons in the target slot if there is DG PDSCH with PUCCH repetition is, that if that is not the first PUCCH repetition, based on the target slot rules we identified this may be regarded as a valid target slot, but still the SPS HARQ-ACK would not be transmitted.  So could we have the proposal as is, i.e. there cannot be any PUCCH repetition (neither for SPS nor for PUCCH resource set) as a clarification. Restricting this to *SPS-PUCCH-AN-List* or *n1PUCCH-AN* only will again create issues to be solved. |
|  |  |

2.5 3rd round of email approvals

**SPS deferral and PUCCH repetitions**

There had been discussions in the 2nd round, and Samsung requested a change – I just copy below the suggested Samsung comment here. Based on email discussion (on reflector), vivo raised the issue that this will again create some of the issues that we tried to prevent by not supporting the combination. Let’s have some further discussion below and see if the original proposal is acceptable to companies:

**Mod2 NEW Proposal 2.3.1: For SPS HARQ-ACK deferral, a UE is not expecting to be configured with both, SPS HARQ deferral for any of the SPS configurations, and PUCCH repetitions for ~~any PUCCH format or associated with~~ any PUCCH resource.**

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| --- | --- |
| Supporting companies | Huawei/Hisi, DOCOMO [prefer Samsung’s version, also accept current version], vivo, LG, ZTE, [Samsung], Intel, NEC, Spreadtrum, Nokia/NSB, Sony, QC [with Samsung’s clarifications], Ericsson, CATT, New H3C, Lenovo |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | We suggest the following update to be accurate (we assume that is the intention)  **For SPS HARQ-ACK deferral, a UE is not expecting to be configured with both, SPS HARQ deferral for any of the SPS configurations, and PUCCH repetitions for ~~any PUCCH format associated with~~ any PUCCH resource****in*****SPS-PUCCH-AN-List* or *n1PUCCH-AN*.** |
| Ericsson | We are fine with Samsung’s update. |
| Moderator | @Samsung, QC (& Ericsson)  On of the reasons in the target slot if there is DG PDSCH with PUCCH repetition is, that if that is not the first PUCCH repetition, based on the target slot rules we identified this may be regarded as a valid target slot, but still the SPS HARQ-ACK would not be transmitted.  So could we have the proposal as is, i.e. there cannot be any PUCCH repetition (neither for SPS nor for PUCCH resource set) as a clarification. Restricting this to *SPS-PUCCH-AN-List* or *n1PUCCH-AN* only will again create issues to be solved. |
| vivo (from email) | Does it mean we can support to configure the SPS deferral and the PUCCH repetition for any PUCCH resource used for dynamic PDSCH?  Then UE behavior still needs to be discussed for the target slot since the target slot determination is also based on intra-UE multiplex? |
| ZTE (from email) | For the proposal 2.3.1, the new part of "**in** SPS-PUCCH-AN-List**or n1PUCCH-AN**" may not forbid the joint processing completely if there is DG PDSCH with PUCCH repetition is, as you said in the response, "Restricting this to SPS-PUCCH-AN-List or n1PUCCH-AN only will again create issues to be solved. ". I think your comment is valid. Please all interested check the below proposal. |
| HW (from email) | For the Mod NEW Proposal 2.3.1, we echo with Junfeng that the modified wording deviate from our understanding and does not preclude the interaction between DG PUCCH repetition and  SPS deferral. We think even this limited interaction may leave the door open for further discussions. Thus we recommend to go back to the original version. |
| LG (from email) | For new proposal 2.3.1, we have similar opinion. We had decided not to support joint operation between deferral and PUCCH repetition in order to avoid discussing how to handle them. For our understanding, the modified new proposal can remove issues in the initial slot, but would remain an issue on target slot handling (e.g., how to apply maximum deferral limit or target PUCCH selection). Considering that, we also suggest to go back to previous one. |
| Moderator (start of 3rd round) | @Samsung @QC  Would you be fine with the original wording here? |
| vivo | We prefer original FL’s wording to avoid further discussions. |
| Samsung | Yes – the addition of “SPS-PUCCH-AN-List or n1PUCCH-AN” had the unintended consequence mentioned above. The actual purpose was to remove “PUCCH format” as it is anyway part of “PUCCH resource” and hence redundant in the proposal.  We think it should be OK to remove “… for any PUCCH format or …” from the above proposal to be accurate and avoid any possible confusion. No other concern. |
| Moderator | Thanks Samsung for the clarification. As the PUCCH format is specifically configured for a PUCCH resource, I guess that change can be accommodated. |
| Intel | Agree with the issues caused by the update. Prefer the original wording. |
| Ericsson | Thanks Moderator! Yes, we are fine with your original wording. |
| DOCOMO | Our first preference is to add "**in** SPS-PUCCH-AN-List**or n1PUCCH-AN**" as proposed by Samsung. While we can also accept the current latest version.  Regarding companies’ concern on handling target slot determination for joint operation of DG PUCCH repetition and SPS HARQ-ACK deferring, we don’t think further discussions are needed based on current rules specified.  Case 1: If SPS HARQ-ACK overlaps with DG HARQ-ACK in initial slot, no SPS HARQ-ACK deferring based on the current rule.  Case 2: If SPS HARQ-ACK overlaps with DG HARQ-ACK in target slot,   * Case 2-1: If DG HARQ-ACK of first repetition in the target slot, SPS HARQ-ACK and DG HARQ-ACK are multiplexed. * Case 2-2: If DG HARQ-ACK of other than the first repetition in the target slot, deferred SPS HARQ-ACK is dropped due to collision with PUCCH repetition.   Above handling is straightforward based on current SPS HARQ-ACK deferring rule. There is no need to further discuss handling issues.  As we understand, the deferred SPS HARQ-ACK dropping is moderator/Nokia’s concern. However, the dropping is not caused by joint operation, but caused by PUCCH repetition collision handling rule defined in Rel-15. For case 2-2, the initial SPS HARQ-ACK is after first DG PUCCH repetition, even though there is no UL collision and no SPS HARQ-ACK deferring, the latter SPS HARQ-ACK PUCCH should be dropped when colliding with a former DG PUCCH repetition. Therefore, we don’t think it good to say the joint operation of DG PUCCH repetition and SPS HARQ-ACK deferring should not be supported due to deferred SPS HARQ-ACK dropping in the target slot. |
| QC | Ok with the updated wording. |
| Samsung2 | In previous discussion, we didn't discuss the priority impact, by default it should be restricted to the same priority. Otherwise, it is too restrictive. So, we would like to suggest adding “for a given PHY priority” as follows.  For SPS HARQ-ACK deferral, a UE is not expecting to be configured with both, SPS HARQ deferral for any of the SPS configurations, and PUCCH repetitions for ~~any PUCCH format or associated with~~ any PUCCH resource **for a given PHY priority**. |

**Remaining issues on SPS HARQ-ACK deferral**

Let’s continue the discussions from the 2nd round on Proposal 2.2.2 here, as it seems having some defined behaviour will provide the same understanding on gNB and UE side, and therefore prevent ambiguity between gNB and UE on the number of SPS HARQ-ACK bits for deferral.

There had been some comments by objecting companies in the 2nd email approval round, the moderator tries to clarify here still a few things – LG, OPPO, ZTE & QC – can you maybe reconsider, see at least moderator replies below:

* @LG: clearly this is the most conservative, but will prevent ambiguity on the number of SPS HARQ-ACK bits that are still deferred at gNB side. It is only about storing the SPS HARQ-ACK bits, but does not mean the soft bits need to be stored.
* @OPPO: Why can there be only the new HARQ-ACK bit be stored? Please note, we have a similar situation now with the HARQ-ACK re-transmission right?
* @ZTE: As noted above, this is to prevent ambiguity for the network at which time / in which slot the HARQ bit is dropped by the UE (i.e. preventing multiple hypothesis decoding at the gNB side).
* @QC: The UE would not continue to store the soft-bits (i.e. the PDSCH cannot be re-transmitted anymore, no soft-combining possible – as the soft-buffer is flushed), but the gNB will be made aware if the earlier SPS PDSCH had been correctly received. So only the HARQ-ACK bit will still need to be stored till the transmission slot of the updated HARQ information from the HARQ process.

As I tried to address the concerns of companies – not by changing the proposal but trying to clarify the questions, I only keep the supporting companies here – as the moderator hopes for compromise from LG, OPPO, ZTE and QC side to prevent ambiguity there.

**Mod Proposal 2.2.2: For SPS HARQ-ACK deferral, further clarify the timeline behavior on top of the earlier RAN1#105-e agreement with the following additions in green:**

|  |
| --- |
| Agreement: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:   * In case the UE is expected to receive PDSCH of a certain HARQ Process ID according to TS 38.214 Sec. 5.1, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped at the PUCCH/PUSCH that would carry the HARQ-ACK associated with the PDSCH expected to be received.   + Note: there is no further discussion on specific handling for the case of DG PDSCH with the same HARQ process ID |

|  |  |
| --- | --- |
| Supporting companies | Huawei/Hisi, vivo, Samsung, Nokia/NSB, Sony, Ericsson, CATT, New H3C, NEC, Panasonic |
| Objecting companies | QC |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| LG | We prefer leave tha agreement as it is.  We understand that PUCCH for new PDSCH is the safest timeline, thus UE shoud drop deferred HARQ-ACK until that time point so that UE behaviors becomes more deterministic. However, as some companies commented, timeline is not necessary at least for SPS PDSCH case since SPS PDSCH is already deterministic. For DG PDSCH, we wonder that we can discuss that due to the note. If possible, in our view, we think that defining specific cancelation time could bring additional UE complexity as well. |
| OPPO | Our understanding on Mod Proposal 2.2.2 is that the time point for UE to drop deferred SPS HARQ-ACK is at the PUCCH/PUSCH that would carry the HARQ-ACK associated with the PDSCH expected to be received. In the following example, the time point for UE to drop HARQ-ACK for PDSCH 1 is at the PUCCH2. Concretely, HARQ-ACK for **PDSCH1** is transmitted in **PUCCH3**. HARQ-ACK for **PDSCH 2** is transmitted in **PUCCH2**.  However, after dotted line, UE has decoded PDSCH2 and produced HARQ-ACK for PDSCH2. For the same HARQ process ID, only one HARQ-ACK bit, i.e. HARQ-ACK for PDSCH 2, can be stored. In other words, HARQ-ACK for PDSCH 1has to be dropped.    The intention of agreement is to solve collision of HARQ-ACK information for the same HARQ process ID, when the later PDSCH with the same HARQ process ID is decoded. |
| ZTE | From my understanding of the agreement, the PUCCH with the deferred SPS HARQ bit(s) doesn’t need to be same with the PUCCH of the carry the HARQ-ACK associated with the PDSCH expected to be received. The additional green part narrow down the cases of dropping.  When UE receives a DCI including HPN information, UE knows there is collision of HARQ process ID, if UE hasn't finish the transmission of deferred SPS HARQ, the deferred SPS HARQ should be dropped. |
| Intel | Fine with the proposal |
| Nokia/NSB | We think the proposal is a good and simple way to define the related dropping in more detail (i.e. have a defined behavior with the same assumption on gNB & UE side) and not having any processing issues (as this is not done before the new HARQ is to be reported 🡪 sufficient time for the UE) |
| QC | Second OPPO’s clarification. Moreover, there are also issues with the storage of the newly received PDSCH, which might not be correctly decoded and hence has to be stored immediately for future combining. |
| Ericsson | Agree with Nokia’s assessment above. |
| CATT | We support the proposal to define a deterministic time point to drop HARQ-ACK.  For the comment from OPPO, our understanding is that it is up to UE to set ACK or NACK for PDSCH1 in PUCCH3, i.e. UE does not need to store two HARQ-ACK information for the same HARQ process.  For the comment from QC, our understanding is that UE does not need to store the previous PDSCH when receiving new PDSCH of the same HARQ process. |
| Huawei/Hisi | @OPPO @QC Maybe the text caused some misunderstandings. The meaning of “the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped” is, the payload is dropped from generating a HARQ CB, e.g., not appended to other DG HARQ CBs, if any, colliding with the deferred SPS.  Actually from gNB side, it does not care when the UE updates the HARQ ID buffer (as anyway it will ignore HARQ for PDSCH1 after transmitting PDSCH 2 and expect to read the accurate/updated HARQ ID information for PDSCH2 at PUCCH2), but it minds the ambiguity of the total payload. E.g., if the gNB schedules another DG PUCCH (payload = X bis) between the red dotted line and the PUCCH 2, it does not know if the 1 bit SPS HARQ-ACK payload has been dropped or not, so it is faced with two hypotheses: X bits (UE decoded PDSCH2) or X+1 bits (UE has not decoded PDSCH2). The proposal here is, the UE always transmits X+1 bits at DG PUCCH (if UE has decoded PDSCH2, it can transmit updated HARQ bit). Only when the slot comes to PUCCH2, the UE will drop that additional bit, since both sides ensure UE has finished the decoding. |
| New H3C | We support this clarification |
| Moderator | Start of 3rd round - @OPPO, ZTE, QC, LG – are the answers provided above (and copied here) clarifying this sufficiently to no object in 3rd round?   * @LG: clearly this is the most conservative, but will prevent ambiguity on the number of SPS HARQ-ACK bits that are still deferred at gNB side. It is only about storing the SPS HARQ-ACK bits, but does not mean the soft bits need to be stored. * @OPPO: Why can there be only the new HARQ-ACK bit be stored? Please note, we have a similar situation now with the HARQ-ACK re-transmission right? * @ZTE: As noted above, this is to prevent ambiguity for the network at which time / in which slot the HARQ bit is dropped by the UE (i.e. preventing multiple hypothesis decoding at the gNB side). * @QC: The UE would not continue to store the soft-bits (i.e. the PDSCH cannot be re-transmitted anymore, no soft-combining possible – as the soft-buffer is flushed), but the gNB will be made aware if the earlier SPS PDSCH had been correctly received. So only the HARQ-ACK bit will still need to be stored till the transmission slot of the updated HARQ information from the HARQ process. |
| LG | Thanks for the response. We would like to ask some questions since there seems mis-aligned understanding.  According to the modertor’s response, it seems that UE stores deferred HARQ-ACK bits but does not maintain soft buffer, so that UE tranmit deferred HARQ-ACK correctly even when new PDSCH is scheduled before the transmission.  Meanwhile, based on the Huawei’s comment, the main issue is codebook size ambiguity. Since the HARQ-ACK dropping is per HARQ processes, only few part of deferred HARQ-ACK can be omitted, which can affect PUCCH selection but target slot selection as well. We think the point is valid. However, Huawei seems to assume that the HARQ-ACK doesn’t need to be correct deferred HARQ-ACK, since HARQ process can be flushed and status can be overridden by new PDSCH decoding. We think it is different from moderator’s understanding.  Before re-consider to accept, we would like to clarify whether UE need to store deferred HARQ-ACK, or leave it to UE implementation as long as codebook size is maintained. |
| OPPO | Thanks for response. For the same HARQ process, only one HARQ-ACK buffer is reserved. For HARQ-ACK retransmission, we need to add new buffer, which increases UE cost. And that’s is why we care about min\_HARQ\_retx\_offset\_value and max\_HARQ\_retx\_offset\_value. However, original SPS HARQ-ACK deferral does not require additional buffer. If Mod Proposal 2.2.2 is supported, additional buffer maybe required or HARQ-ACK information will be not accurate before PUCCH corresponding to latter PDSCH.  The intention of deferral SPS HARQ-ACK dropping is to reduce HARQ-ACK payload by dropping useless information. From perspective of HARQ-ACK payload, original proposal in the first round is more effective. |
| NEC | We are fine with the proposal. |
| ZTE | The earliest dropping can be after the UE receives the HPN for PDSCH2, and when gNB schedules the PDSCH2 with the same HARQ process ID, gNB is assumed not intending to receive the dropping HARQ. There is no ambiguity issue.  If we restrict the dropping only on the PUCCH2 in HW’s figure, absolutely, the buffer requirement increases. |
| Samsung | OK to discuss further the arguments raised by OPPO and LGE. |
| Sony | I share similar view with ZTE. The HARQ buffer is flushed when UE receives a DL Grant with NDI toggled for a specific HPN. That is HARQ buffer is flused for PDSCH1 in HW’s diagram when DL Grant for PDSCH2 is received. I don’t quite understand OPPO’s argument about having to reserve extra HARQ buffers. |
| Spreadtrum | We share the same view as OPPO, ZTE, QC, and LG. If SPS deferral bit is only dropped at PUCCH2, but still transmitted at DG PUCCH, it absolutely needs extra buffer. |
| Huawei/Hisi2 | @LG @OPPO@Spreadtrum Our understanding is, the UE will not specifically introduce a buffer for storing SPS deferral bits, but still stores it in the HARQ buffer of the corresponding HARQ ID (this is why this original agreement was motivated). It will flush the HARQ buffer of PDSCH1 at the time (between PDSCH2 and PUCCH2) up to implementation, of which gNB is unaware (nor cares). The intention of dropping the payload of the extra bit at PUCCH2 is only due to ambiguity of total payload (which impacts rate matching and PUCCH resource selection) as also mentioned by LG. |
| QC | The new wording cannot be accepted. The explanations are understood but the motivation for increasing UE and network complexity is lame. The motivation of the proposal is to have no ambiguity at the gNB on when the UE drops the stored SPS HARQ bits in deferral. This costs extra memory in the UE side, since the UE needs to have an extra memory space for the same HARQ process. One memory space for the deferred SPS HARQ about to be dropped and another one for the new HARQ. Moreover, the UE waists power by transmitting SPS HARQ that is going to be ignored by the network. Furthermore, uplink interference is generated, which is not good for the system performance. If the problem is the ambiguity at the network on the HARQ CB size transmitted by the UE after the replacement of the deferred SPS HARQ with new HARQ bits, there can be a handshake between the UE and the network with a defined timeline per UE. The case new HARQ replacing deferred SPS HARQ is of extremely low likelihood. The case can be avoided with appropriate maximum deferral time setting. Moreover, SPS HARQ deferral has minimal chances of being ever implemented. |
| Moderator | A sizeable number of companies indicated to not support the change in the GTW session 🡪 no follow-up |

2.6 3rd round of email discussions

**Identified needed specification changes based on available agreements / operation**

Nokia in [5] identified, that for the joint operation of SPS HARQ-ACK deferral and HARQ-ACK codebook retransmissions some further clarifications on top of the editor CR will be needed:

* TP1 below is there to clarify the order of the HARQ appending of ‘initial HARQ’, HARQ CB re-transmission and deferred SPS HARQ, which according to Nokia is not fully clear there yet (what is appended first). Argumentation from Nokia:
  + *We think that it would still be good for the combination of deferred SPS HARQ information (i.e. first HARQ-ACK information), ‘HARQ-ACK re-tx’ (i.e. second HARQ-ACK information) and ‘new, initial HARQ-ACK’ (i.e. third HARQ-ACK information) and to clarify the appending procedures of HARQ-ACK re-tx (appended to the initial HARQ-ACK CB) and SPS deferral (appending the deferred SPS HARQ last, i.e. to the combined HARQ information from HARQ re-tx and initial HARQ-ACK).*

*The current description is not clear on which one (in case of first to third HARQ information) is to be appended first – the re-tx HARQ CB or the deferred SPS HARQ-ACK CB.*

* TP2 below is linking also the HARQ-ACK CB re-transmission clause with the SPS HARQ-ACK deferral procedure, which currently seems to be still missing.

**Proposal 2.6.1: TP1 (Nokia) The following TP to 38.213 is endorsed for the editor’s CR:**

|  |
| --- |
| 9.1.5 HARQ-ACK codebook retransmission  ….  If in slot the UE performs a procedure for deferring first HARQ-ACK information for SPS PDSCH receptions, as described in clause 9.2.5.4, and the first HARQ-ACK information has same priority value as a priority value indicated by the DCI format triggering the PUCCH transmission in slot , the UE multiplexes in the PUCCH transmission in slot second HARQ-ACK information with the priority value that results in slot according to the procedure in this clause. If the UE would also multiplex in the PUCCH transmission in slot third HARQ-ACK information with the priority value, the UE appends the second HARQ-ACK information to the third HARQ-ACK information before multiplexing the first HARQ-ACK information into the PUCCH transmission as described in clause 9.2.5.4. The UE determines to multiplex the third HARQ-ACK information in the PUCCH transmission in slot as described in clause 9.2.3. |

|  |  |
| --- | --- |
| Supporting companies | Vivo, LG, NEC, ZTE, Samsung Huawei/Hisi (in principle), Intel, Ericsson, Spreadtrum, DOCOMO, CATT, QC, Nokia/NSB |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| vivo | We support the order of ‘new, initial HARQ-ACK’ (i.e. third HARQ-ACK information), followed by ‘HARQ-ACK re-tx’ (i.e. second HARQ-ACK information)’ , followed by deferred SPS HARQ information (i.e. first HARQ-ACK information). |
| LG | Fine with the TP |
| NEC | We are fine with the TP in general. But we think it would be more clearly with following minor update.  “… and the first HARQ-ACK information has same priority value as a priority value indicated by the DCI format triggering the PUCCH transmission in slot for second HARQ-ACK information…” |
| Samsung | Fine with the TP |
| Huawei/Hisi | The appending order may be before/after? Shall we specify the execution order?  If in slot the UE performs a procedure for deferring first HARQ-ACK information for SPS PDSCH receptions, as described in clause 9.2.5.4, and the first HARQ-ACK information has same priority value as a priority value indicated by the DCI format triggering the PUCCH transmission in slot , the UE multiplexes in the PUCCH transmission in slot second HARQ-ACK information with the priority value that results in slot according to the procedure in this clause. If the UE would also multiplex in the PUCCH transmission in slot third HARQ-ACK information with the priority value, the UE appends the second HARQ-ACK information to the third HARQ-ACK information before/after multiplexing the first HARQ-ACK information into the PUCCH transmission as described in clause 9.2.5.4. The UE determines to multiplex the third HARQ-ACK information in the PUCCH transmission in slot as described in clause 9.2.3. |
| Moderator | @HW: The motivation for this is exactly to specify the oder of the handling, as the order will define the order of the HARQ bits. And we need to have a defined order – cannot be left to UE implementation.  @NEC: the TP was initially only there to have define the order of the bits for the case of 3 types of HARQ information here. Let’s try to focus on this issue in this TP. Of course there could be still plenty of other changes (by different companies) envisioned in this clause as well. |
| Huawei/Hisi2 | @Moderator Yes, the mapping order of initial HARQ🡪Retx HARQ🡪SPS deferral HARQ needs to be specified of course. What we pointed out is whether the UE 1) first appends Retx HARQ to initial HARQ then appends SPS deferral HARQ to Retx HARQ (which is already in the multiplexing chain of initial HARQ🡪Retx HARQ), or UE 2) first appends SPS deferral HARQ to Retx HARQ then appends Retx HARQ to initial HARQ (which is already in the multiplexing chain of Retx HARQ🡪SPS deferral HARQ) can be up to UE implementation, as the eventual result is the same. |
| QC | Fine with the proposal. Useful to add a note that this is the order independently of the time of arrival/generation of first, second or third HARQ CB. |

**Proposal 2.6.2: The following TP to 38.213 is endorsed for the editor’s CR:**

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| --- |
| 9.2.5.4 UE procedure for deferring HARQ-ACK for SPS PDSCH  …  - the second HARQ-ACK information bits, generated as described in clause 9.1.2, are appended in a HARQ-ACK codebook the UE generates as described in clauses 9.1.2, 9.1.2.1, ~~or~~ 9.1.3.1 or 9.1.5  - if the UE would receive a PDSCH providing a TB for a same HARQ process as a HARQ-ACK information bit from the second HARQ-ACK information bits prior to transmitting the PUCCH or the PUSCH, the UE does not include the HARQ-ACK information bit in the HARQ-ACK information bits. |

|  |  |
| --- | --- |
| Supporting companies | vivo, LG, NEC, ZTE, Samsung Huawei/Hisi, Intel, Ericsson, Spreadtrum, DOCOMO, CATT, Nokia/NSB |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| LG | Fine with the TP |
| NEC | Fine with the TP |
| Samsung | OK |
|  |  |

ZTE in [6] raised the issues, that there may not be any overlapping among PUCCH or PUSCHs actually that need to be resolved and therefore suggest to at least include ‘if any’ in the related clauses. And in addition ZTE suggesting the current wording from ‘multiplex’ to ‘transmit’. Let’s check if the ZTE TP could be agreeable here:

**Proposal 2.6.3: The following TP to 38.213 is endorsed for the editor’s CR:**

|  |
| --- |
| TS38.213h00  9.2.5.4 UE procedure for deferring HARQ-ACK for SPS PDSCH  If a UE is provided *spsHARQdeferral* and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs in a first slot if any, the UE determines a PUCCH resource for a PUCCH transmission with first HARQ-ACK information bits for SPS PDSCH receptions that the UE would report for a first time, and the PUCCH resource  - is provided by *SPS-PUCCH-AN-List* as described in clause 9.2.1, or by *n1PUCCH-AN* if *SPS-PUCCH-AN-List* is not provided  - overlaps with a symbol indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigDedicated*, or indicated for a SS/PBCH block by *ssb-PositionsInBurst*, or belonging to a CORESET associated with a Type0-PDCCH CSS set  the UE  - determines an earliest second slot and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs if any, a PUSCH or a PUCCH in the earliest second slot to ~~multiplex~~transmit HARQ-ACK information bits that include second HARQ-ACK information bits from the first HARQ-ACK information bits  ... |

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| Supporting companies | vivo [with comment], LG, NEC Huawei/Hisi, Intel, Ericsson(comment on “multiplex”), Spreadtrum, DOCOMO, ZTE, CATT |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| vivo | We support the change of “if any”; But we prefer to keep “multiplex” instead of “transmit", since to determine the target slot, the operation can be regarded as multiplexing. |
| LG | We are fine with keeping the word of “multiplex”. |
| NEC | We share same view with vivo. |
| ZTE | For more companies to understand the intention, I try to clarify why these changes are needed.  From the current specification, UE behavior is given only for the presence of PUCCHs and/or PUSCH multiplexing, i.e., PUCCHs and/or PUSCH overlap each other in the time domain. We believe that the UE behavior is still unclear and need clarification in case no UCI multiplexing needs to be performed for SPS deferral. For example, the lack of UCI multiplexing is that in case only one SPS HARQ-ACK needs to be transmitted in the initial slot and only one SPS HARQ-ACK is deferred to the target slot.  Comment from vivo is also reasonable, then how can we add ‘or transmit’ after the ‘multiplex’, i.e., *multiplex or transmit* to cover the difference cases? |
| Samsung | The TP is not really needed but OK with adding “if any” if a majority prefers – the “multiplex” should stay as is. |
| Ericsson | We are fine with the intention of the TP. Maybe one can uses “if applicable”, instead of “if any”. But most important we think we should keep “multiplex” and not change it to “transmit”. |
| Spreadtrum | OK with “if any”, prefer “multiplex” |
| ZTE2 | Thanks for the good comments. As the majority view, only “if any” is added. Or replace with “if applicable”. Both are fine. |
| CATT | We agree with vivo and others to keep “multiplex”. |
| QC | The TP is not needed, but if companies feel more comfortable with the updated wording, this is fine. |
| Nokia/NSB | We agree with vivo – so ‘if any’ is OK, but no other changes seen as needed. |

2.7 4th round of email approvals

Proposals 2.6.1 and 2.6.2 received only support in the 3rd email discussion round, so let’s try to agree these by email:

**Proposal 2.6.1: The following TP to 38.213 is endorsed for the editor’s CR:**

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| --- |
| 9.1.5 HARQ-ACK codebook retransmission  ….  If in slot the UE performs a procedure for deferring first HARQ-ACK information for SPS PDSCH receptions, as described in clause 9.2.5.4, and the first HARQ-ACK information has same priority value as a priority value indicated by the DCI format triggering the PUCCH transmission in slot , the UE multiplexes in the PUCCH transmission in slot second HARQ-ACK information with the priority value that results in slot according to the procedure in this clause. If the UE would also multiplex in the PUCCH transmission in slot third HARQ-ACK information with the priority value, the UE appends the second HARQ-ACK information to the third HARQ-ACK information before multiplexing the first HARQ-ACK information into the PUCCH transmission as described in clause 9.2.5.4. The UE determines to multiplex the third HARQ-ACK information in the PUCCH transmission in slot as described in clause 9.2.3. |

|  |  |
| --- | --- |
| Supporting companies | Vivo, LG, NEC, ZTE, Samsung ~~Huawei/Hisi (in principle),~~ Intel, Ericsson, Spreadtrum, DOCOMO, CATT, QC, Nokia/NSB, Sony, New H3C |
| Objecting companies | [Huawei/Hisi] |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Huawei/Hisi | We are still not convinced about why we need to specify the “order of actions” of appending. As our comments in the 3rd round receives no clarification yet, I copy that in below. In our understanding, either way of “order of actions” can work with the same result, but the proposed TP seems to force to order 1) in below.  ============================================================  The mapping order of initial HARQ🡪Retx HARQ🡪SPS deferral HARQ needs to be specified of course. What we pointed out is whether the UE 1) first appends Retx HARQ to initial HARQ then appends SPS deferral HARQ to Retx HARQ (which is already in the multiplexing chain of initial HARQ🡪Retx HARQ), or UE 2) first appends SPS deferral HARQ to Retx HARQ then appends Retx HARQ to initial HARQ (which is already in the multiplexing chain of Retx HARQ🡪SPS deferral HARQ) can be up to UE implementation, as the eventual result is the same. |
| ~~Moderator~~ | ~~@Huawei: Clearly, it can be ‘before’ or ‘after’ Both are possible.~~  ~~But if we don’t define the order it could be that two UEs implementing either ‘before’ or ‘after’ resulting in a different order of the HARQ-ACK bits. If this is not clarified, how should the UE interprate the bit order of the HARQ-ACK information – if it does not know if ‘before’ or ‘after’ is implemented by the UE. 🡪 feature is broken~~  ~~So either we clarify the ‘before’ or we clarify based on’after’, but having no clarification means the gNB has no clue on the order of the HARQ-ACK bits.~~ |
| Moderator | @Huawei: on the order as you point out based on the paragraph of your 2) interpretation, based on which parts of the specs do you see this is actually clarified? i.e. based on which parts of the current specs text do you see this as described in the current specs already? |
| QC 2 | Huawei’s comment is understood and supported:   1. It seems we all agree that in case UCI for a given PUCCH is consisted of i) new HARQ CB, ii) HARQ CB retransmission and iii) deferred SPS HARQ CB, then, the UE transmits a HARQ CB like the one below.   Retransmitted HARQ CB  Deferred SPS  HARQ CB  New HARQ CB   1. How the UE will end up forming the final HARQ CB of the figure above is up to UE’s implementation. Agreement with HW on this.   Therefore, the TP should be rewritten with the goal to define a HARQ CB generation with HARQ CBs in the order   1. New HARQ bits (if any) 2. Retransmitte HARQ CB 3. Deferred SPS HARQ CB   And not what the steps of UE multiplexing/appending of various HARQ CBs would be. This is irrelevant to the specifications here, since only the outcome (final HARQ CB) matters. |

**Proposal 2.6.2: The following TP to 38.213 is endorsed for the editor’s CR:**

|  |
| --- |
| 9.2.5.4 UE procedure for deferring HARQ-ACK for SPS PDSCH  …  - the second HARQ-ACK information bits, generated as described in clause 9.1.2, are appended in a HARQ-ACK codebook the UE generates as described in clauses 9.1.2, 9.1.2.1, ~~or~~ 9.1.3.1 or 9.1.5  - if the UE would receive a PDSCH providing a TB for a same HARQ process as a HARQ-ACK information bit from the second HARQ-ACK information bits prior to transmitting the PUCCH or the PUSCH, the UE does not include the HARQ-ACK information bit in the HARQ-ACK information bits. |

|  |  |
| --- | --- |
| Supporting companies | vivo, LG, NEC, ZTE, Samsung Huawei/Hisi, Intel, Ericsson, Spreadtrum, DOCOMO, CATT, Nokia/NSB, QC, New H3C |
| Objecting companies |  |

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| --- | --- |
| *Company* | *Comments* |
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On proposal 2.6.2, companies seemed to be fine with the ‘if any’ but not to change the multiplexing. **So let’s try to check if we can agree only on the ‘if any’. As there had been some comments to use a different wording to ‘if any’, please note that we use this formulation in the current specifications already.**

**Mod Proposal 2.6.3: The following TP to 38.213 is endorsed for the editor’s CR:**

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| --- |
| TS38.213h00  9.2.5.4 UE procedure for deferring HARQ-ACK for SPS PDSCH  If a UE is provided *spsHARQdeferral* and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs in a first slot if any, the UE determines a PUCCH resource for a PUCCH transmission with first HARQ-ACK information bits for SPS PDSCH receptions that the UE would report for a first time, and the PUCCH resource  - is provided by *SPS-PUCCH-AN-List* as described in clause 9.2.1, or by *n1PUCCH-AN* if *SPS-PUCCH-AN-List* is not provided  - overlaps with a symbol indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigDedicated*, or indicated for a SS/PBCH block by *ssb-PositionsInBurst*, or belonging to a CORESET associated with a Type0-PDCCH CSS set  the UE  - determines an earliest second slot and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs if any, a PUSCH or a PUCCH in the earliest second slot to multiplex HARQ-ACK information bits that include second HARQ-ACK information bits from the first HARQ-ACK information bits  ... |

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| --- | --- |
| Supporting companies | Nokia/NSB, vivo, Spreadtrum, NEC, DOCOMO, ZTE, New H3C |
| Objecting companies |  |

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| --- | --- |
| *Company* | *Comments* |
| Samsung | No need but OK. |
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2.8 5th round of email discussions

Proposal 2.6.1 could not be agreed in the 4th round, as Huawei had some reservations on the 2nd part of the edits here. Let’s check which version companies prefer here.

**Question 2.8.1: Which of the two versions (Alt. 1 or Alt. 2) do you prefer to clarify the interaction of SPS HARQ-ACK deferral and HARQ-ACK re-transmission:**

**Alt. 1: Earlier proposal 2.6.2**

|  |
| --- |
| 9.1.5 HARQ-ACK codebook retransmission  ….  If in slot the UE performs a procedure for deferring first HARQ-ACK information for SPS PDSCH receptions, as described in clause 9.2.5.4, and the first HARQ-ACK information has same priority value as a priority value indicated by the DCI format triggering the PUCCH transmission in slot , the UE multiplexes in the PUCCH transmission in slot second HARQ-ACK information with the priority value that results in slot according to the procedure in this clause. If the UE would also multiplex in the PUCCH transmission in slot third HARQ-ACK information with the priority value, the UE appends the second HARQ-ACK information to the third HARQ-ACK information before multiplexing the first HARQ-ACK information into the PUCCH transmission as described in clause 9.2.5.4. The UE determines to multiplex the third HARQ-ACK information in the PUCCH transmission in slot as described in clause 9.2.3. |

**Alt. 2: Proposal by Huawei (from RAN1 reflector)**

|  |
| --- |
| 9.1.5 HARQ-ACK codebook retransmission  ….  If in slot the UE performs a procedure for deferring first HARQ-ACK information for SPS PDSCH receptions, as described in clause 9.2.5.4, and the first HARQ-ACK information has same priority value as a priority value indicated by the DCI format triggering the PUCCH transmission in slot , the UE multiplexes in the PUCCH transmission in slot second HARQ-ACK information with the priority value that results in slot according to the procedure in this clause, by appending the first HARQ-ACK information to the second HARQ-ACK information. If the UE would also multiplex in the PUCCH transmission in slot third HARQ-ACK information with the priority value, the UE appends the second HARQ-ACK information and the first HARQ-ACK information to the third HARQ-ACK information. The UE determines to multiplex the third HARQ-ACK information in the PUCCH transmission in slot as described in clause 9.2.3. |

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| --- | --- |
| Alt. 1 | Sony |
| Alt. 2 | Samsung |
| Other |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Sony | Although Alt.2 formulation is neater, the order seems to have disappeared when the 3rd HARQ-ACK is involved, that is:  If the UE would also multiplex in the PUCCH transmission in slot third HARQ-ACK information with the priority value, the UE appends the second HARQ-ACK information and the first HARQ-ACK information to the third HARQ-ACK information. The UE determines to multiplex the third HARQ-ACK information in the PUCCH transmission in slot as described in clause 9.2.3.  That is in this sentence (yellow highlight), it says the 2nd HARQ-ACK info and the 1st HARQ-ACK infor are appended to the 3rd HARQ-ACK info without saying what the order is between the 2nd HARQ-ACK and 1st HARQ-ACK.  Alt. 1 may not be as clean but it tells clearly what the order is with and without the presence of 3rd HARQ-ACK info. |
| Samsung | Alt. 2 is clearer and more accurate – fine to support it.  Alt. 1 has the ambiguity that the “first HARQ-ACK” may be separately multiplexed in the PUCCH instead of being in the same codeword as the other HARQ-ACKs. |
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# Retransmission of cancelled HARQ

In this section, the proposed Rel-17 enhancements on retransmission of cancelled HARQ are summarized. The following related agreements from previous meetings are available on this topic:

**Generic agreements**

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

|  |
| --- |
| Working Assumption: For at least HARQ-ACK re-transmission:   * Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16) in Rel-17   + *Definition of enhanced Type 3 CB:*      - *The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration*     - *The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)* * Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17   + *Details are FFS* * Enhanced Type 3 HARQ-ACK CB and/or one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB are subject to separate UE capabilities |

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

|  |
| --- |
| **Agreement**  Confirm the following RAN1#105-e working assumption:  For at least HARQ-ACK re-transmission:   * Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16) in Rel-17   + Definition of enhanced Type 3 CB:     - The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration     - The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells) * Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17   + Details are FFS * Enhanced Type 3 HARQ-ACK CB and/or one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB are subject to separate UE capabilities |

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

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| --- |
| **Conclusion**  There is no consensus to support the simultaneous configuration of the Rel-16 Type 3 HARQ-ACK CB and Rel-17 one-shot re-tx HARQ triggering for a UE in Rel-17.  **Conclusion**  There is no consensus to support the simultaneous configuration of the Rel-17 Enhanced Type 3 HARQ-ACK CB and Rel-17 one-shot HARQ re-tx triggering for a UE in Rel-17. |

**(Enhanced) Type-3 HARQ-ACK CB related**

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

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| **Agreement**  Support PHY priority handling for a PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size.   * The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size. * The A/N of HARQ processes is mapped to the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size irrespective of the PHY priority of the ‘A/N’ of the HARQ processes. * FFS: If the HARQ-ACK codebook size or structure is dependent on the PHY priority (e.g. separate configuration of CBG/NDI usage, separate configuration of HARQ IDs / CCs per priority, SPS HARQ-ACK process IDs of specific priority only for a SPS HARQ-ACK only codebook, …).   **Agreement**  Support PHY priority handling for a PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB in Rel-17.   * The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB. * The A/N of HARQ processes is mapped to the Rel-16 Type 3 HARQ-ACK CB irrespective of the PHY priority of the ‘A/N’ of the HARQ processes. * The support is subject to a Rel-17 UE capability and a UE supporting this capability can be configured in Rel-17 with Rel-16 Type 3 HARQ-ACK CB and PHY prioritization.   **Agreement**  For the PHY priority handling of the enhanced Type 3 CB(s) of smaller size, the enhanced Type 3 HARQ-ACK has the same structure, size and content (in terms of HARQ-IDs, CCs) irrespective of the PHY priority.  **Agreement**  Support Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size triggering using DCI format 1\_2 for a UE supporting DCI format 1\_2.   * The triggering support for DCI format 1\_2 is independently (from triggering using DCI format 1\_1) RRC configured to the UE.   **Agreement**  Support Rel-16 Type 3 HARQ-ACK CB triggering using DCI format 1\_2 in Rel-17 for a UE supporting DCI format 1\_2.   * The support is subject to a Rel-17 UE capability and a UE supporting this capability can be configured with DCI format 1\_2 triggering of the Rel-16 Type 3 HARQ-ACK CB.   **Agreement**  For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook.  **Agreement**  For enh. Type 3 HARQ-ACK CB(s), support dynamic selection based on indication in the triggering DCI of one of at least one enh. Type 3 HARQ-ACK CB(s).   * Each of the at least one enh. Type 3 HARQ-ACK CBs is at least defined by RRC configuration This includes the option to configure all DL HARQ processs of all configured CCs as one enh. Type 3 HARQ-ACK CB (resulting in same structure and size as the Rel-16 Type 3 HARQ-ACK CB) * This includes UE capability signaling (value range {1…X}) on the maximum number of supported simultaneously configured enh. Type 3 HARQ-ACK CBs that can be dynamically indicated * Details including the value of X are FFS   **Agreement**  The following enhanced Type 3 CB types of smaller size are supported, the CB to contain either:   * the HARQ processes of a subset of configured CCs, or * a subset of configured HARQ processes (specific to CCs)   FFS: additional enh. Type 3 CB types |

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

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| **Conclusion**  No additional enhanced Type 3 CB ‘types’ (such as activated CCs, of specific SPS configurations, etc.) in terms of RRC configuration are supported.  **Agreement**  For one enhanced Type 3 HARQ-ACK CB, the same CBG and NDI configuration applies to both PHY priorities following the RAN1#106-e agreement.  **Agreement**  The same set of enhanced Type 3 CBs (incl. CBG and NDI configuration) is applied for triggering using DCI format 1\_1 and 1\_2.  **Agreement**  Reuse the legacy 1-bit ‘*one-shot HARQ-ACK request*’ for triggering indication of the enhanced Type 3 HARQ-ACK CB of smaller size.   * At least if only a single enhanced Type 3 HARQ-ACK CB is configured, the triggering DCI with the triggering bit set to ‘1’ is also able to schedule PDSCH.   **Agreement**  The CBG and NDI usage can be independently configured for different enhanced Type 3 HARQ-ACK CBs.  **Agreement**  The maximum number of simultaneously configurable enhanced Type 3 CB is indicated by the UE through UE capability signaling from the set of {1, 2, 4, 8}. |

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

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| **Agreement**  The list enhanced Type 3 HARQ-ACK codebooks is configured per PUCCH cell group (i.e., separately configurable for primary and secondary PUCCH cell group).  **Agreement**  Support simultaneous configuration of enhanced Type 3 CB triggering and PUCCH cell switching.  **Agreement**  One enhanced Type 3 HARQ-ACK codebook is RRC configured either as:   * + - * 1. a subset of CC, i.e., all HARQ processes of the subset of CCs are part of the codebook, OR  |  |  |  | | --- | --- | --- | | pdsch-HARQ-ACK-enhType3perCC | Configure the one enhanced Type 3 HARQ-ACK codebook using per CC configuration | (1..maxNrofServingCells) of Integer (0,1) |  * + - * 1. a subset of configured HARQ processes per CC, i.e., different subsets of HARQ processes can be configured for each CC.  |  |  |  | | --- | --- | --- | | pdsch-HARQ-ACK-enhType3perHARQ | Configure the one enhanced Type 3 HARQ-ACK codebook using a per HARQ process and CC configuration | (1..maxNrofServingCells) of Bit String (Size (16)) |   **Agreement**  If more than one (M>1) enhanced Type 3 HARQ-ACK codebook is configured and the triggering DCI with the *‘one-shot HARQ-ACK request’* set to ‘1’,   * If the FDRA field is not valid, i.e. all “1s” or all “0s” as per Rel-16, then PDSCH is not scheduled:   + If a new field with N=ceiling(log2 (M)**)** bits is configured in the triggering DCI, the UE uses this new field to indicate one of M configured e-Type 3 HARQ-ACK CBs   + If the new field is not configured in the triggering DCI, the UE uses the MCS field to indicate one of M configured e-Type 3 HARQ-ACK CBs * If the FDRA field is valid, then a PDSCH is scheduled   + If a new field with N=ceiling(log2 (M)**)** bits is configured in the triggering DCI, the UE uses this new field to indicate one of M configured e-Type 3 HARQ-ACK CBs   + If the new field is not configured in the triggering DCI, the UE selects the 1st indexed e-Type 3 HARQ-ACK CB in the M configured e-Type 3 HARQ-ACK CBs |

**RAN1#107bis-e (Jan. 2022)**

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| **Agreement**  Re-add the RRC parameter for the DCI field configuration in row 17 of the Enh. Type-3 HARQ-ACK codebook for the primary PUCCH cell group (that was lost when moving from v006 to v007 in the final RRC parameter discussions in RAN1#107-e, currently we only have the configuration for the secondary PUCCH cell group) i.e.,   |  |  |  | | --- | --- | --- | | pdsch-HARQ-ACK-enhType3DCIfield | Enables the enhanced Type 3 CB through a new DCI field to indicate the enhanced Type 3 HARQ-ACK codebook in the primary cell group if the more than one enhanced Type 3 HARQ-ACK codebook is configured for the primary PUCCH cell group. | Enabled |     **Agreement**  Support separate configuration of the DCI field presence for enh. Type 3 HARQ-ACK CB for DCI format 1\_2 (i.e. *pdsch-HARQ-ACK-enhType3DCIfieldDCI-1-2*as discussed in RAN1#107-e) |

**One-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource**

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

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| **Agreement**  A single DCI triggering the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB can trigger the re-transmission of HARQ-ACK information of only a single HARQ-ACK CB.  **Agreement**  The Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB is done through an explicit triggering indication in the DCI through a DCI field.  **Agreement**  Support PHY priority handling for the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB.   * The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the re-transmitted HARQ-ACK information. * The indicated PHY priority in the triggering DCI is used to determine the HARQ-ACK information to be re-transmitted corresponding to the indicated PHY priority.   **Agreement**  For Rel-17 one-shot triggering for HARQ-ACK re-transmission, the UE does not expect more than one triggering DCI for Rel-17 one-shot feedback indicating the same PUCCH slot for the re-transmission of HARQ-ACK CBs of different PUCCH slots to be re-transmitted   * Note: i.e. only a single HARQ-ACK codebook / PUCCH occasion can be re-transmitted in a PUCCH slot |

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

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| **Agreement**  Support triggering of one-shot HARQ re-transmission on PUCCH using DCI format 1\_2.  **Agreement**  For one-shot HARQ re-transmission on PUCCH, the triggering DCI dynamically indicates a ‘HARQ re-tx offset’ which is used to define the offset in number of PUCCH slots/sub-slots between the triggering DCI and the PUCCH slot/sub-slot of the HARQ-ACK codebook to be re-transmitted. For the triggering DCI received in slot/sub-slot m, indicating the HARQ-ACK re-tx in slot/sub-slot m+k and indicating HARQ\_retx\_offset, the PUCCH slot/sub-slot n of the HARQ-ACK codebook to be re-transmitted is determined as either:   * Alt. 1: n = m - HARQ\_retx\_offset * Alt. 2: n = m + k - HARQ\_retx\_offset * FFS: value range of the HARQ-retx\_offset   **Agreement**  For one-shot triggering of HARQ-ACK re-transmission on PUCCH,   * in case the dynamic Type 2 HARQ-ACK codebook is configured, the HARQ-ACK codebook per PHY priority on the indicated PUCCH is constructed by appending the Type 2 HARQ-ACK codebook to be re-transmitted to the Type 2 HARQ-ACK codebook of the indicated PUCCH (carrying new, initial HARQ-ACK information) per PHY priority. * in case the semi-static Type 1 HARQ-ACK codebook is configured, the HARQ-ACK codebook per PHY priority on the indicated PUCCH is constructed by appending the Type 1 HARQ-ACK codebook to be re-transmitted to the Type 1 HARQ-ACK codebook of the indicated PUCCH (carrying new, initial HARQ-ACK information) per PHY priority. |

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

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| **Agreement**  The one-shot HARQ re-transmission on PUCCH is configured per PUCCH cell group (i.e., separately configurable for primary and secondary PUCCH cell group).  **Agreement**  For one-shot HARQ re-transmission on PUCCH, the ‘HARQ re-tx offset’ is determined as Alt. 1: *n = m - HARQ\_retx\_offset*  **Conclusion**  There is no consensus to support the simultaneous configuration of one-shot HARQ-ACK re-transmission and dynamic PUCCH cell switching in Rel-17.  **Agreement**  Support simultaneous configuration of one-shot HARQ-ACK re-transmission and semi-static PUCCH cell switching:   * the ‘backward HARQ-ACK slot-offset’ is interpreted with the granularity of a PUCCH slot of the respective PHY priority of PCell /PSCell / PUCCH SCell   **Agreement**  Apply a 1-bit triggering DCI field for triggering indication of one-shot HARQ re-transmission on PUCCH.   * The triggering DCI with the triggering bit set to ‘1’ is not able to schedule PDSCH. * Some unused bit field in the DCI is used to indicate the HARQ slot offset. * FFS: if the ‘one-shot HARQ-ACK request’ field can be reused * FFS: which unsed DCI field in the DCI is used for HARQ slot offset indication * FFS: The indication of whether the PDSCH is not scheduled will reuse Rel-16 type-3 HARQ ACK CB UE behavior   **Agreement**  For one-shot triggering of HARQ re-transmission, introduce a new 1-bit DCI field in DCI format 1\_1 and in DCI format 1\_2 (if DCI format 1\_2 is configured with one-shot triggering of HARQ-ACK re-transmission).  **Working Assumption**  For one-shot triggering of HARQ re-transmission, in addition to one-shot triggering of HARQ re-transmission after the initial PUCCH transmission slot, the triggering is supported before the initial PUCCH transmission slot   * Re-transmission triggering does not change processing for the initial PUCCH transmission (i.e., HARQ multiplexing / dropping / transmission) * The UE expects the PUCCH carrying the HARQ-ACK re-transmission to be scheduled in a slot/sub-slot after the initial PUCCH transmission slot/sub-slot. * The support for the triggering before the initial PUCCH transmission slot is subject to separate UE capability indication   **Agreement**  For one-shot HARQ-ACK re-transmission, the value range for HARQ re-tx offset is fixed in the specification |

**RAN1#107bis-e (Jan. 2022)**

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| **Agreement**  For one-shot HARQ-ACK re-transmission, the value range for HARQ re-tx offset is given by [*min\_HARQ\_retx\_offset\_value*, *max\_HARQ\_retx\_offset\_value*] with an indication of 1 slot / sub-slot within that range.   * FFS the fixed value of *min\_HARQ\_retx\_offset\_value* * FFS the fixed value of *max\_HARQ\_retx\_offset\_value*   **Conclusion**  For one-shot HARQ re-transmission on PUCCH, the UE determines no PDSCH is scheduled when the triggering bit is set to ‘1’ (i.e. the UE does not need to in addition check any specific resource allocation setting).  **Agreement**  RAN1 confirms the following RAN1#107-e working assumption:   |  | | --- | | **Working Assumption**  For one-shot triggering of HARQ re-transmission, in addition to one-shot triggering of HARQ re-transmission after the initial PUCCH transmission slot, the triggering is supported before the initial PUCCH transmission slot   * Re-transmission triggering does not change processing for the initial PUCCH transmission (i.e., HARQ multiplexing / dropping / transmission) * The UE expects the PUCCH carrying the HARQ-ACK re-transmission to be scheduled in a slot/sub-slot after the initial PUCCH transmission slot/sub-slot. * The support for the triggering before the initial PUCCH transmission slot is subject to separate UE capability indication |   **Agreement**  For one-shot HARQ-ACK re-transmission,   * the minimum value for the HARQ re-tx offset *min\_HARQ\_retx\_offset\_value* is -7. * the maximum value for the HARQ re-tx offset *max\_HARQ\_retx\_offset\_value* is 24. * *Note: UE capability reporting on the UE supported value range for HARQ\_retx\_offset* *in the scope of [min\_HARQ\_retx\_offset\_value, max\_HARQ\_retx\_offset\_value ]* *that can be indicated by the gNB for the UE can be further discussed in UE capabilities*   **Agreement**  For one-shot triggering of HARQ-ACK re-transmission, the *HARQ\_retx\_offset* is indicated by the bits of the MCS field for transport block 1.  **Conclusion**  There is no consensus on the support of HARQ-ACK CB size indication in the triggering DCI for HARQ-ACK re-transmission  **Conclusion**  There is no consensus to support the following in Rel-17:   * For one-shot HARQ re-transmission on PUCCH, if certain HARQ process IDs of the requested HARQ CB to be retransmitted is replaced by new HARQ bits, the UE transmits the new content of HARQ process(es) being updated.   **Agreement**  For PUCCH repetition and one-shot HARQ-ACK re-transmission, if the gNB triggers the HARQ-ACK CB re-transmission from a PUCCH slot indicated by *HARQ\_retx\_offset* where a HARQ-ACK in a first PUCCH is dropped due to overlapping with another, second PUCCH, where the first PUCCH and second PUCCH have the same L1 priority, and at least one of the first PUCCH and the second PUCCH is subject to a repetition, the UE re-transmits the HARQ-ACK CB of the second PUCCH from the slot. |

* 1. Summary of companies input in their contributions

**Enhanced Type 3 CB:**

* HW/HiSi [1]: Joint operation between PUCCH repetition and Type 3 CB / enhanced Type 3 CB can be straightforwardly supported with negligible spec impact
* OPPO [7]: If an eType 3 HARQ-ACK CB is triggered in a given subslot, the HARQ-ACK information in a Type 1/2 HARQ-ACK CB to be transmitted in a slot/subslot overlapping with the given subslot should be mapped to the eType 3 HARQ-ACK CB.
  + See details in Sec. 3 of [7]
* Intel [15]: For phy prioritization between LP/HP PUCCH carrying (e)Type3 CB and HP/LP PUCCH carrying HARQ-ACK using Release 16 dropping
  + UE may expect eType3 CB to not contain a HARQ process for a bit overlapping with the same PUCCH resource as the eType3 CB
  + LP PUCCH is dropped according to Release 16 procedures

**Identified required changes the current specifications (TS 38.213)**

* vivo [5]: The two different ways to configure one enh. Type 3 CB (using either *pdsch-HARQ-ACK-enhType3perCC* or *pdsch-HARQ-ACK-enhType3perHARQ*) are currently not captured:

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| **9.1.4 Type-3 HARQ-ACK codebook determination**  If a UE is provided *pdsch-HARQ-ACK-OneShotFeedback*, the UE determines HARQ-ACK information bits, for a total number of HARQ-ACK information bits, of a Type-3 HARQ-ACK codebook according to the following procedure. If the UE is provided *pdsch-HARQ-ACK-enhType3List* and a DCI format scheduling PDSCH reception and triggering the Type-3 HARQ-ACK codebook includes a Type3-subcodebook-index field that provides a value for *pdsch-HARQ-ACK-enhType3Index*, the UE determines for each configured serving cell if at least one configured HARQ process for it is involved in the Type-3 HARQ-ACK codebook determination, and when applicable, determines if HARQ process number for serving cell is involved in the Type-3 HARQ-ACK codebook determination,  ~~a number of indicated serving cells and a number of indicated HARQ processes for each indicated serving cell~~ from the entry in *pdsch-HARQ-ACK-enhType3List* corresponding to the *pdsch-HARQ-ACK-enhType3Index* value. If the DCI format does not include the Type3-subcodebook-index field, the *pdsch-HARQ-ACK-enhType3Index* value is zero.  Set to the number of configured serving cells ~~or, when applicable, to~~  Set to the value of *nrofHARQ-ProcessesForPDSCH* for serving cell , if provided; else, set ~~. When applicable, set to~~  Set to the value of *maxNrofCodeWordsScheduledByDCI* for serving cell if *harq-ACK-SpatialBundlingPUCCH* is provided and , or if *harq-ACK-SpatialBundlingPUCCH* is not provided, or if *maxCodeBlockGroupsPerTransportBlock* is provided for serving cell ; else, set  Set to the number of HARQ-ACK information bits per TB for PDSCH receptions on serving cell as described in clause 9.1.1 if *maxCodeBlockGroupsPerTransportBlock* is provided for serving cell and *pdsch-HARQ-ACK-OneShotFeedbackCBG* or *pdsch-HARQ-ACK-enhType3CBG* is provided; else, set  Set if *pdsch-HARQ-ACK-OneShotFeedbackNDI* or *pdsch-HARQ-ACK-enhType3NDI* is provided; else set  Set – serving cell index  Set – HARQ process number  Set – TB index  Set – CBG index  Set  while  if the UE is not provided *pdsch-HARQ-ACK-enhType3List*, or, if the UE is provided *pdsch-HARQ-ACK-enhType3List* and the UE determines that for serving cell at least one configured HARQ process is involved in the Type-3 HARQ-ACK codebook determination  while  if the UE is not provided *pdsch-HARQ-ACK-enhType3List*, or, if the UE is provided *pdsch-HARQ-ACK-enhType3List* and the UE determines that HARQ process number for serving cell is involved in the Type-3 HARQ-ACK codebook determination  ……  end if    end while  end if      end while  ……  If  - a UE detects a DCI format that includes a One-shot HARQ-ACK request field with value 1, and  - the CRC of the DCI is scrambled by a C-RNTI or an MCS-C-RNTI, and  - *resourceAllocation* = *resourceAllocationType0* and all bits of the frequency domain resource assignment field in the DCI format are equal to 0, or  - *resourceAllocation* = *resourceAllocationType1* and all bits of the frequency domain resource assignment field in the DCI format are equal to 1, or  - *resourceAllocation = dynamicSwitch* and all bits of the frequency domain resource assignment field in the DCI format are equal to 0 or 1  the DCI format provides a request for a Type-3 HARQ-ACK codebook report and does not schedule a PDSCH reception. If the UE is provided *pdsch-HARQ-ACK-enhType3List* and the DCI format includes a Type3-subcodebook-index field that provides a value for *pdsch-HARQ-ACK-enhType3Index*, the UE determines for each configured serving cell if at least one configured HARQ process for it is involved in the Type-3 HARQ-ACK codebook determination, and when applicable, determines if HARQ process number for serving cell is involved in the Type-3 HARQ-ACK codebook determination,~~a number of indicated serving cells and a number of indicated HARQ processes for each indicated serving cell~~  from the entry in *pdsch-HARQ-ACK-enhType3List* corresponding to the *pdsch-HARQ-ACK-enhType3Index* value. If the DCI format does not include the Type3-subcodebook-index field, the *pdsch-HARQ-ACK-enhType3Index* value is provided by the value of MCS field in the DCI format. The UE is expected to provide HARQ-ACK information in response to the request for the Type-3 HARQ-ACK codebook after symbols from the last symbol of a PDCCH providing the DCI format, where the value of for is provided in clause 10.2 by replacing "SPS PDSCH release" with "DCI format".  ……  --------------------------------------------------------End text proposal---------------------------------------------------------- |

**One-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource**

**Clarification on invalid / not available CB discussed in RAN1#107bis-e already:**

* vivo [5], Intel [15], QC [19]: Clarify the following as a conclusion:
  + *When a UE receives a one-shot triggering DCI for HARQ-ACK re-transmission, and did not generate an HARQ-ACK codebook with the indicated PHY priority for corresponding PUCCH transmission in the original PUCCH slot, the UE ignores the triggering DCI, without determining corresponding PUCCH transmission in the PUCCH slot designated for HARQ-ACK re-transmission.*

**Multi-DCI configuration in M-TRP:**

* QC [19]: For “triggered HARQ CB reTx” in case of multi-DCI configuration in multi-TRP, and for multiple HARQ CBs in the same slot, the UE identifies the requested HARQ CB for retransmission through the TRP from which the request originates; the TRP issuing the request for HARQ CB retransmission is identified via the CORESET index used in DCI transmission.

**Further one-shot HARQ re-tx restrictions:**

* The maximum number for keeping HARQ codebooks can be configured: ETRI [14]
* If the content of one or more HARQ process of the requested for retransmission HARQ CB has changed, i.e. is replaced by new HARQ bits, the UE considers the request for HARQ CB retransmission void and transmits nothing: QC [19]
* The CRC of the DCI triggering HARQ CB retransmission is not scrambled with CS-RNTI: QC [19]
* UE capability on how many HARQ-ACK CBs can be stored: LG [20]
  + UE reports the number X, which indicates the maximum number of HARQ-ACK codebooks stored simultaneously in the UE side.
    - gNB would be able to trigger one-shot HARQ-ACK retransmission for one of latest X scheduled HARQ-ACK codebooks.
  + *Moderator comment*: better to bring this up in the UE capability session (where the discussions on UE capability components etc. are handled). And one addition here still: wouldn’t it be the same for the UE to indicate the maximum offset (as we have in our agreement with the following note:
    - *Note: UE capability reporting on the UE supported value range for HARQ\_retx\_offset* *in the scope of [min\_HARQ\_retx\_offset\_value, max\_HARQ\_retx\_offset\_value ]* *that can be indicated by the gNB for the UE can be further discussed in UE capabilities*

**Other than enh. Type 3 & One-shot Triggering:**

**NEC [17] on DRX enhancements -** see further details in Sec. 3 of [17]:*Further study the enhancements on current DRX mechanism to better support dynamic requested HARQ-ACK retransmission. E.g.,*

* *Start drx-RetransmissionTimerDL in the first symbol after the corresponding cancelled PUCCH transmission to ensure that UE has chance to receive the PDCCH for triggering HARQ-ACK retransmission.*
  1. 1st round of email approvals

**Joint operation of enhanced Type 3 CB with PUCCH repetition:**

HW/HiSi [1] discusses that joint operation between PUCCH repetition and Type 3 CB / enhanced Type 3 CB can be straightforwardly supported with negligible spec impact. According to moderator understanding, the Rel-16 Type 3 HARQ-ACK codebook re-transmission combined with PUCCH repetition is supported in Rel-16 already. So in case we need some decision here, it seems that the decision would need to be limited to the Rel-17 enhanced Type 3 CB.

**Proposal 3.2.1: Joint operation between PUCCH repetition and Rel-17 enhanced Type 3 HARQ-ACK CB triggering is supported in Rel-17.**

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| Supporting companies | Nokia/NSB, Intel, Ericsson, QC Huawei/Hisi New H3C, vivo, DOCOMO,OPPO, Panasonic, CATT, ZTE, LG, NEC, ETRI, Samsung, Sony |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Intel | Don’t see motivation to preclude this type of joint operation |
| Ericsson | We also share the view the joint operation is straightforward and no neeed for special handling, or tp be precluded. |
| Huawei/Hisi | It can be a conclusion to mark the common understanding, and there is no need of additional RAN1 spec impact. |
| ZTE | Natural consequence, no more open issues are needed. |

**RRC configurable maximum number of HARQ-ACK codebooks to be stored (RRC impact)**

ETRI [14] proposes to make the maximum number of HARQ-ACK codebooks the UE needs to store configurable. They then suggest that the UE stores only the last X HARQ-ACK codebooks (and the assumption is, that the UE does not expect to be triggered for a re-transmission of an earlier HARQ-ACK CB then). Please note, there is also the ongoing parallel UE feature discussions based on the RAN1 agreement, the UE could be indicating the min. and max. supported value (and thereby reduce the storage burden there):

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| Agreement  For one-shot HARQ-ACK re-transmission,   * the minimum value for the HARQ re-tx offset *min\_HARQ\_retx\_offset\_value* is -7. * the maximum value for the HARQ re-tx offset *max\_HARQ\_retx\_offset\_value* is 24. * *Note: UE capability reporting on the UE supported value range for HARQ\_retx\_offset* *in the scope of [min\_HARQ\_retx\_offset\_value, max\_HARQ\_retx\_offset\_value ]* *that can be indicated by the gNB for the UE can be further discussed in UE capabilities* |

Therefore, this proposed RRC signaling would be on top of the potential UE capability signaling.

**Proposal 3.2.2 (RRC impact): For one-shot HARQ-ACK re-transmission on PUCCH, the UE can be configured with a maximum number of HARQ-ACK codebooks it needs to keep / store**.

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| Support companies | ETRI |
| Objecting companies | Nokia/NSB, Intel, Ericsson, Lenovo Huawei/Hisi New H3C,OPPO, Panasonic, CATT, ZTE, NEC, Samsung, Sony |

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| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | No need for such an RRC parameter. If UE can only handle limited number of CBs, this should be taken into account in the UE capability reporting. |
| Intel | Prefer to discuss such limitations as part of UE capability. |
| Ericsson | We also believe this discussion belongs to UE feature. |
| QC | The group needs to agree first on what exactly the UE stores. |
| Lenovo | We think UE capability reporting is sufficient. |
| Huawei/Hisi | Maximum number of HARQ-ACK codebooks is reflected by reported range from the minimum value to the maximum value of HARQ re-tx offset |
| vivo | We think UE capability for [min\_HARQ\_retx\_offset\_value, max\_HARQ\_retx\_offset\_value] can achieve similar purpose. So, there is no need for such capability. |
| DOCOMO | We also think it’s better to be discussed in UE feature. |
| OPPO | Store buffer can be determined by min\_HARQ\_retx\_offset\_value, max\_HARQ\_retx\_offset\_value. No additional parameter is required. |
| Panasonic | We agree to the comments from Nokia and Intel. |
| ZTE | Can be discussed in UE feature. |
| LG | We support this feature but we also think it would be good to discuss in the UE feature. |
| NEC | We agree to the comments that UE capability is suffiecient to limit the number of HARQ-ACK codebooks. |
| ETRI | For the current formulation based on *HARQ\_retx\_offset\_value,* the UE stores all HARQ-ACK bits for those slots in the range (case 1), or the UE can re-construct the HARQ-ACK codebook in the indicated slot (case 2).  We would like to clarify which case 1 of case 2 is applied. If case 1 is considered, then we note that, for easier implementation, the maximum number of HARQ-ACK bits can be also considered to avoid worst case. However, if case 2 is considered, the current *HARQ\_retx\_offset\_value* may be sufficient.  We understand the majority view and we might interpret the case 2 (re-construct the codebook only) can be the group’s understanding. |
| Samsung | Can be part of UE capability and can be taken care by the gNB. |
| Moderator | Looking at the input received, it seems to be not just some minor wording issues, but some more essential disagreement with the proposal.  There is discussion in UE features already. Do not plan to continue discussing this! |

**Clarification on invalid / not available CB (discussed in RAN1#107bis-e already):**

In RAN1#107bis-e, we concluded to not support indication of HARQ-ACK CB size in the triggering DCI. We discussed at that time already a potential conclusion on the handling if the HARQ-ACK CB in the initial slot is not valid /has not been generated.

Vivo, Intel & QC again thought a related conclusion would be good to have.

Therefore, the following is brought forward (with slight rewording compared to RAN1#107bis-e):

**Proposed conclusion 3.2.3: When a UE receives a one-shot triggering DCI for HARQ-ACK re-transmission, and did not generate an HARQ-ACK codebook with the indicated PHY priority for corresponding PUCCH transmission in the original PUCCH slot, the UE ignores the triggering DCI, without determining corresponding PUCCH transmission in the PUCCH slot designated for HARQ-ACK re-transmission.**

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| Support companies | Nokia/NSB, Intel, Ericsson(see comment to change to “Proposed agreement”), QC, Lenovo Huawei/Hisi New H3C, vivo, DOCOMO,OPPO, Panasonic, CATT, LG, NEC, Samsung, Sony |
| Objecting companies | ZTE |

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| --- | --- |
| *Company* | *Comments* |
| Intel | We consider that the discussion on invalid / unavailable CB is still open since the conclusion in the last meeting is related to CB size signaling enhancement.  From that perspective, it is important and straightforward to have such an agreement. Note, we think this needs to be captured somewhere in specs, thus ‘Proposed Conclusion’ should be title as a ‘Proposed Agreement’. |
| Ericsson | We share the same view as Intel and it should be as Proposed agreement to be reflected in specification. Currently, the spec is described as the CB is always present. Therefore, this case is missing and it is important to be captured. |
| Huawei/Hisi | Share the same view that an agreement should be better to align the UE behaviour between gNB and UE. |
| vivo | We think such conclusion is beneficial. Otherwise, we may need to clarify the UE behaviour in future. |
| Moderator | We discussed this in the last meeting already (where it was proposed as a ‘proposed agreement’). At that time there had been companies saying, that such case would be as other cases by the UE – i.e. DCI is to be regarded as a false-positive DCI detection and neglected by the UE and therefore, at maximum this should be a conclusion (see comments by Samsung in Jan. meeting). Maybe we can go for a conclusion here (to have the behavior identified) in a first place. If this has specification impact is then a secondary issue. |
| ZTE | The proposal can specify the UE behaviour, but can not solve the ambiguity on gNB. gNB doesn't judge the non reception of HARQ retransmission is due to the one-shot DCI missing or the missing of DCI for generating the orginal codebook. For gNB, how to handle the case? To retransmit the one-shot DCI or retransmit the scheduling DCI? I think we should have a common sense on this.  Furthermore, if the retransmitted PUCCH is intended to multiplexing in a PUSCH, but as this proposal, it doesn’t transmit, the gNB should prepare the blind decoding for PUSCH, right?  I don’t try to block the proposal, but just think the proposal doesn't solve the issue of gNB, we hope there is an overall agreement/conlcusion both on gNB and UE. Otherwise, we can leave this issue unsolved. |
| Samsung | OK as a conclusion – the specifications already address such issues by the UE ignoring inconsistent DCI. The overall event is marginal as it requires that the UE misses all DCIs and the gNB fails to do DTX detection. |
| QC 2 | Agreement with ZTE, the proposal does not solve the issue. It is just a clarification on the UE behavior. The only solution would have been that the network indicates the requested HARQ CB size. The unfortunate leadership constellation in this group blocked that proposal on the basis of non-technical arguments. Some further work is needed to avoid this in the future. |
| Sony | We don’t think this needs to be captured in the specs as commented by some that this is anyway a natural consequences of a missed DCI. We can have a conclusion if it helps. |

**Handling if new HARQ information is available for a certain HARQ process:**

We had in the last meeting discussions on the handling for this case with the following conclusion:

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| Conclusion  There is no consensus to support the following in Rel-17:   * For one-shot HARQ re-transmission on PUCCH, if certain HARQ process IDs of the requested HARQ CB to be retransmitted is replaced by new HARQ bits, the UE transmits the new content of HARQ process(es) being updated. |

QC in [19] proposes now that for the case that there is an update, this is to be regarded as an error case and the UE would not the HARQ-ACK codebook for re-transmission.

**Proposal 3.2.4: For one-shot HARQ-ACK re-transmission on PUCCH, if the content of one or more HARQ process of the requested for retransmission HARQ CB has changed, i.e. is replaced by new HARQ bits, the UE considers the request for HARQ CB retransmission void and transmits nothing.**

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| Support companies | QC, [Samsung] |
| Objecting companies | Nokia/NSB, Intel, Ericsson Huawei/Hisi New H3C, vivo, DOCOMO, CATT, LG, NEC, ETRI, ~~Samsung,~~ Sony |

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| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | UE can just store the HARQ-ACK CBs and re-transmit them. No need to have such restrictions here (which would somehow defeat the initial purpose of the HARQ-ACK re-transmission operation). |
| Intel | Our understanding of the conclusion from RAN1#107bis-e is that UE does not replace the old bits with the new ones. No further clarification is needed. |
| Ericsson | With respectto UE implemtations and issues with storage, we cannot comment. However, the fact that the HARQ process can be resued for scheduling even when the feedback is not received yet, was one of the benefit of the feature. |
| QC | This proposal is the only feasible way for the feature to be implementable. The reasons are 2:   1. the UE does not have to store ACK/NACK bits – in addition to storing the list of HARQ Processes per HARQ CB. The UE must store the list of HARQ Processes per HARQ CB to keep track of the relevant DRX timers, which are stored per HARQ process. 2. The network does not have to check the content of each HARQ Process contained in the retransmitted HARQ CB for its validity.   There is no proposal to transmit the new HARQ bits. This is already concluded and no intention to revert it.  The modified proposal is the following:  “"**For triggered HARQ CB retransmission, it is not mandatory for UEs to store the HARQ CB to be retransmitted**".”  The UE and the network will have to do extra processing if the UE “simply retransmits” a copy of the initial HARQ CB. Such a solution is a useless complication. The only technically justified procedure would have been that the UE retransmits the latest copy of each HARQ Process contained in the HARQ CB. This other solution being excluded at the last meeting, the only option is that the UE ignores each request for HARQ CB retransmission when the content of at least one HARQ Process in the retransmitted HARQ CB changes.  Nokia’s argument is lacking technical justification and it shows technical ignorance of i) RAN 2 procedures ii) UE processing and iii) gNB processing.   * The statement “UE can just store the HARQ-ACK CBs and re-transmit them” is erroneous; the UE cannot simply store ACK/NACK bits per HARQ CB. The UE needs to store the list of HARQ processes contained in the retransmitted HARQ CB. This information is needed since the UE needs to start the drx-HARQ-RTT-TimerDL per HARQ Process after HARQ CB retransmission. See pending agreement from RAN 2 (proposal sent out in RAN 2 last week and to be endorsed/agreed tomorrow or Wednesday)   **Proposal 3. (13/15) Upon One-shot HARQ-ACK retransmission request, UE starts *drx-HARQ-RTT-TimerDL* for the HARQ process(es) whose ACK/NACK status is reported.**   * If the UE retransmits the previous content of a HARQ process with a retransmitted HARQ CB, the extra tasks the network needs to do are the following: * Keep track of the list of HARQ Processes whose content has changed * Ignore the feeback (ACK/NACK) for this process upon their reception   Before pre-arranging with the group leadership to push the group into a conclusion of the type “There is no consensus to support …”, a technical discussion with RAN 2 colleagues and with implementation teams is necessary.  Despite the incomprehensible statement (“which would somehow defeat the initial purpose of the HARQ-ACK re-transmission operation”), the understanding is that QC’s proposal is the only chance this feature is implementable and be somehow to its initial branding “a simple solution for HARQ retransmission”. Already, the “triggered HARQ CB retransmission” has several issues:   1. Extra memory requirements at the UE and at the gNB 2. DCI waste (no option for new PDSCH scheduling) 3. Ambiguity not solved when the requested HARQ CB is not available   Adding another issue such as retransmitting the initial copy of the HARQ CB will kill any chances of the feature being implemented. Moreover, this procedure was marketed as simple, since “the UE needs to store only the HARQ CB, i.e. ACK/NACK bits”, which is obviously false.  @Ericson: if the HARQ processes are scheduled to new TBs and the previous content is retransmitted, the gNB needs to perform extra processing. |
| Huawei/Hisi | In our understanding, a new buffer needs to be introduced for saving the content of the whole CB, instead of the list of the HARQ IDs of that CB. |
| vivo | Our underatnding for the conclusion is UE does not replace the old bits with the new ones and just transmits the PUCCH as it is in the original PUCCH slot. |
| DOCOMO | We share same view as Intel/vivo that the old bits are not replaced for such case. |
| CATT | We share the same view as Intel, vivo and DOCOMO and prefer not to repeat the discussion. |
| ZTE | Not quite sure about “Nothing”. Does the nothing means the old HARQ or include the new HARQ?  From my understanding, if gNB schedules a new HARQ sharing the same ID with old HARQ, it means gNB will sacrifice the old HARQ.  Then if the nothing only means old HARQ, we can support the proposal. |
| ETRI | Our interpretation of the conclusion is that it is up to gNB whether to ignore the (un)updated HARQ-ACK bit. In this case, this HARQ-ACK bit can be of no use. However, it is still possible to retransmit the HARQ codebook with some incorrect HARQ-ACK bits. |
| Samsung | Discussed and concluded in RAN1#107bis-e. |
| QC 2 | There is no proposal in replacing the old HARQ bits with new HARQ bits when the content of the HARQ CB changes. The conclusion from the previous meeting is respected. The proposal is to introduce a limitation at the network not to change the HARQ CB content of a requested for retransmission HARQ CB. This is the only way with which the complexity of “triggered HARQ CB retransmission” can be kept low. |
| Moderator | Looking at the input received, it seems to be not just some minor wording issues, but some more essential disagreement with the proposal.  The moderator therefore does not plan to continue discussions on the proposal. |
| Samsung2 | After reading again the proposal, it is different than the one discussed/concluded in RAN1#107-e. We are fine to discuss the proposal, at least to clarify whether or not the UE is expected to/needs to also store HARQ processes based on the developments in RAN2 as cited by Qualcomm, and consider any additional impact on UE complexity. |

**Limitation of RNTI usage:**

QC [19] suggesting to not support the HARQ-ACK re-tx triggering using the CS-RNTI (used for SPS operation) in order to not getting conflicts with the SPS release procedure. Therefore, the following proposal is brought forward:

**Proposal 3.2.5: For one-shot HARQ-ACK re-transmission on PUCCH, triggering the HARQ-ACK CB re-transmission with a triggering DCI with CRC scrambled with the CS-RNTI is not supported.**

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| Support companies | Nokia/NSB, Intel, Ericsson, QC, Lenovo Huawei/Hisi New H3C, vivo, DOCOMO,OPPO, Panasonic, CATT, ZTE, LG, NEC, Samsung, Sony |
| Objecting companies |  |

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| *Company* | *Comments* |
| Sony | Thought the triggering DCI is a DL Grant and so the understanding is that it uses C-RNTI. However, no harm concluding this if it provides clarity. |
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**Multi-DCI configuration in M-TRP:**

Qualcomm discussed the joint operation of one-shot HARQ-ACK retransmission on PUCCH and multi-DCI in M-TRP operation, where more than one HARQ-ACK CB in a PUCCH slot is transmitted and therefore additional clarification on the TRP would be needed.

Let’s see if the QC proposal could be agreeable for the joint operation here:

**Proposal 3.2.6: Support joint operation of multi-DCI configuration in multi-TRP and one-shot HARQ-ACK re-transmission on PUCCH in Rel-17**

* **For “triggered HARQ CB reTx” in case of multi-DCI configuration in multi-TRP, and for multiple HARQ CBs in the same slot, the UE identifies the requested HARQ CB for retransmission through the TRP from which the request originates; the TRP issuing the request for HARQ CB retransmission is identified via the CORESET index used in DCI transmission.**

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| Support companies | Intel, Ericsson, QC, [Samsung] |
| Objecting companies | Nokia/NSB, DOCOMO |

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| *Company* | *Comments* |
| Nokia/NSB | Should be handled in multi-TRP (if they think HARQ re-transmission would be useful with multi-DCI configuration) |
| Intel | We are open to considerations of joint multi-TRP and HARQ CB retransmission operation. Differently to Nokia, we think it is R17 URLLC/IIOT responsibility to decide whether to enable/expect such joint operation. |
| Ericsson | Similarly to Intel, we see the benefit in the proposal and ar eopen to discuss if there is any details missing. |
| QC | The fact that the proposal should be handled by another group is not a justification for objecting the proposal here. Lack of technical knowledge to judge if the mTRP – mDCI scenario in URLLC/IIOT is relevant does not justify the objection of the proposal. The group can educate the moderator. Indication of irresponsible/immature behavior by the group leadership. |
| Huawei/Hisi | We can understand the motivation, but more time may be needed to analyse further potential impact to spec as it is a cross-topic issue, so it is preferred to postpone the decision of this proposal rather than making decision in haste. |
| DOCOMO | We are open to discuss joint operation of multi-DCI configuration in multi-TRP and one-shot HARQ-ACK re-transmission on PUCCH. But we don’t support the sub-bullet for the detailed handling.  Joint HARQ feedback and separate HARQ feedback can be supported for multi-DCI based M-TRP case. In our understanding, for joint HARQ feedback case, a PUCCH can include HARQ-ACK information bits for PDSCHs from both TRPs. If HARQ-ACK CB retransmission is triggred, it is straightforward that all HARQ-ACK information bits in the HARQ-ACK CB can be retransmitted. |
| ZTE | We are open to this issue. My primitive thinking is the processing of M-TRP and One-shot retransmission are orthogonal, and no more specific issues to be discussed. |
| LG | Same as Nokia’s view. |
| Samsung | Seems like a straightforward combination of M-TRP and “one-shot”. However, it should be clarified that this is applicable for the case of separate HARQ-ACK reporting to TRPs (separate PUCCHs), it is not applicable for joint reporting (single PUCCH).  Either the MIMO WI or this WI is OK for the discussion/conclusion. |
| QC 2 | It is understood that some companies might need more time to discuss the issue. This is not a reason for objecting the proposal though. |
| Moderator | @QC / Konstantinous: the moderator brought this (single company) proposal forward, so I don’t get the complain here about ‘moderator’ or ‘leadership’.  Companies are encouraged to check if there are any details missing till RAN1#109 (… to give companies a bit more time to check with their M-TRP / MIMO colleagues, as suggested by HW) and bring detailed proposals to the next meeting. |

* 1. 1st round of email discussions

**Enhanced Type 3 CB operation with PHY prioritization:**

Intel [15] suggests specific Rel-16 PHY prioritization handling for the Type 3 and enhanced Type 3 HARQ-ACK CB. The current agreements are not fully clear in terms of PHY priority, where multiplexing of Type 3 HARQ-ACK CB with initial HARQ is not supported that cannot be mapped to the enhanced Type 3 CB. So would be maybe good to clarify this. The following agreement we have in place here:

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| Agreement  For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook. |

Intel is suggesting some specific handling – another option could simply be, that no overlapping PUCCH is to be expected for simplicity (i.e. the UE does not expect a (e)Type 3 CB transmission to be cancelled due to overlapping PUCCH containing HARQ-ACK of a higher or lower priority.

OPPO [7] (see Sec. 3) further discusses, that if an eType 3 HARQ-ACK CB is triggered in a given subslot, the HARQ-ACK information in a Type 1/2 HARQ-ACK CB to be transmitted in a slot/subslot overlapping with the given subslot should be mapped to the eType 3 HARQ-ACK CB.

**Question 3.3.1: For PHY prioritization between LP/HP PUCCH carrying Rel-16 Type 3 HARQ-ACK CB or Rel-17 enhanced Type 3 HARQ-ACK CB and HP/LP PUCCH carrying HARQ-ACK using the Rel-16 PHY prioritization operation:**

* **Alt. 1 (from Intel):** 
  + **UE may expect eType3 CB to not contain a HARQ process for a bit overlapping with the same PUCCH resource as the eType3 CB**
  + **LP PUCCH is dropped according to Release 16 procedures**
* **Alt. 2 (from OPPO)**
  + **If an eType 3 HARQ-ACK CB is triggered in a given subslot, the HARQ-ACK information in a Type 1/2 HARQ-ACK CB to be transmitted in a slot/subslot overlapping with the given subslot should be mapped to the eType 3 HARQ-ACK CB.**
* **Alt. 3:** 
  + **For enhanced Type 3 CB, the restriction on the Type 1 / Type 2 HARQ-ACK CB mapping from the earlier agreement is only applicable to the same PHY priority of the Type 1 / Type 2 CB as the PUCCH for the enhanced Type 3 CB re-transmission. LP PUCCH is dropped according to the Rel-16 PHY prioritization procedures.**
  + **For Rel-16 Type3 CB, as all the HARQ-ACK information is already included in the Type 3 HARQ-ACK CB, there would not be any HP PUCCH overlapping with HARQ-ACK information only that could cancel a potential Type 3 CB transmission using the 1st (LP) PUCCH configuration.**
* **Alt. 4:** 
  + **For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB of any PHY priority to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook.**
    - ***Note: There would not be any cases of the related overlapping with HP HARQ-ACK only.***
  + **For Rel-16 Type3 CB, as all the HARQ-ACK information is already included in the Type 3 HARQ-ACK CB, there would not be any HP PUCCH overlapping with HARQ-ACK information only that could cancel a potential Type 3 CB transmission using the 1st (LP) PUCCH configuration.**
* **Other:**

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| Alt. 1 | Support | Intel |
| Not support |  |
| Alt. 2 | Support | DOCOMO,OPPO |
| Not support |  |
| Alt. 3 | Support | Intel Huawei/Hisi (Alt.3’) |
| Not support |  |
| Alt. 4 | Support | Nokia/NSB, Intel, QC, New H3C, DOCOMO, CATT, ZTE, LG, Samsung, Sony |
| Not support |  |
| Other | Support | vivo |

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| *Company* | *Comments* |
| Nokia/NSB | It seems to be not really good, that e.g. a LP PUCCH with Type 3 CB to be canceled by a HP HARQ operation 🡪 Alt. 4 should be chosen. |
| Intel | We think all alternatives would work. At this point prefer Alt.1 > Alt.3 > Alt.4 |
| Huawei/Hisi | We prefer the 1st bullet of Alt.3, but for the 2nd bullet (which seems a clarification of R16 behaviour), we think the same rule should be applied for Type 3. The reason is that, for a LP PUCCH Type 3 CB, though it includes all HARQ IDs, the reliability of the transmitted LP PUCCH maynot satisfy the HP requrirement, so in that case the UE should still transmit HP PUCCH to cancel the LP Type 3 CB.   * **Alt. 3’:** * **For enhanced Type 3 CB, the restriction on the Type 1 / Type 2 HARQ-ACK CB mapping from the earlier agreement is only applicable to the same PHY priority of the Type 1 / Type 2 CB as the PUCCH for the enhanced Type 3 CB re-transmission. LP PUCCH is dropped according to the Rel-16 PHY prioritization procedures.** * **For Rel-16 Type3 CB, the restriction on the Type 1 / Type 2 HARQ-ACK CB mapping from the earlier agreement is only applicable to the same PHY priority of the Type 1 / Type 2 CB as the PUCCH for the Type 3 CB re-transmission. LP PUCCH is dropped according to the Rel-16 PHY prioritization procedures ~~as all the HARQ-ACK information is already included in the Type 3 HARQ-ACK CB, there would not be any HP PUCCH overlapping with HARQ-ACK information only that could cancel a potential Type 3 CB transmission using the 1~~~~st~~ ~~(LP) PUCCH configuration~~.**   The clarification of R16 behaviour is in the following, where it can be seen that the Type 3 CB overriding Type 1/2 CB only applies for the same priority, while the prioritization between different priorities is performed without taking CB type into account.   |  | | --- | | 9 UE procedure for reporting control information …  When a UE determines overlapping for PUCCH and/or PUSCH transmissions of different priority indexes other than PUCCH transmissions with SL HARQ-ACK reports before considering limitations for UE transmission as described in clause 11.1, including repetitions if any, the UE first resolves the overlapping for PUCCH and/or PUSCH transmissions of smaller priority index as described in clauses 9.2.5 and 9.2.6. Then,  - if a transmission of a first PUCCH of larger priority index scheduled by a DCI format in a PDCCH reception would overlap in time with a repetition of a transmission of a second PUSCH or a second PUCCH of smaller priority index, the UE cancels the repetition of a transmission of the second PUSCH or the second PUCCH before the first symbol that would overlap with the first PUCCH transmission  …  In the remaining of this clause, the multiplexing or prioritization for overlapping channels are for overlapping channels with same priority index or for overlapping channels with a PUCCH carrying SL HARQ-ACK information..  … 9.1.4 Type-3 HARQ-ACK codebook determination …  If a UE detects a DCI format that includes a One-shot HARQ-ACK request field with value 1, the UE determines a PUCCH or a PUSCH to multiplex a Type-3 HARQ-ACK codebook for transmission in a slot as described in clauses 9.2.3 and 9.2.5. The UE multiplexes only the Type-3 HARQ-ACK codebook in the PUCCH or the PUSCH for transmission in the slot. | |
| vivo | Our preference is Alt.5 as below   * **Alt. 5:**    + **For enhanced Type 3 CB and Rel-16 Type3 CB, the restriction on the Type 1 / Type 2 HARQ-ACK CB mapping from the earlier agreement is only applicable to the same PHY priority of the Type 1 / Type 2 CB as the PUCCH for the enhanced Type 3 CB re-transmission. LP PUCCH is dropped according to the Rel-16 PHY prioritization procedures.**   We think the previous agreements apply to the same priority; Besides, if the there is resource overlapping between the Rel-17 enhanced Type 3 CB/ Rel-16 Type3 CB and Type 1 / Type 2 HARQ-ACK CB, Rel-16 PHY prioritization operation is used to protect the HP channel. We do not see the need to have special treatment for Rel-16 Type3 CB.  In addition, we would like to clarify the meaning and reations of the Note with main bullet for Alt.4. Does it mean it does not allow the overlapping between the LP enhanced Type 3 HARQ-ACK CB/Rel-16 HARQ-ACK CB and HP Type 1 / Type 2 CB? In addition, the overlapping means resource overlapping and/or slot/sub-slot overlapping? |
| DOCOMO | According to discussions above, we suggest to split discussions for enhanced type 3 CB and Rel-16 type 3 CB.  Regarding enhanced typte 3 CB, our understanding is that Alt 2 is the same as the first bullet of Alt 4.  Regarding Rel-16 type 3 CB, we are fine to have the restriction as the second bullet of Alt 4. But Huawei’s proposal is also acceptable to us that LP Rel-16 type 3 CB can be cancelled by HP PUCCH.  **@HW**, could you elaborate the motivation of “**For Rel-16 Type3 CB, the restriction on the Type 1 / Type 2 HARQ-ACK CB mapping from the earlier agreement is only applicable to the same PHY priority of the Type 1 / Type 2 CB as the PUCCH for the Type 3 CB re-transmission.**”? In our understanding, Rel-16 type 3 CB includes all HARQ process IDs. Therefore, there is no need to restrict mapping of type 1/2 CB. |
| OPPO | Our proposal intends to clarify on “Type 1 or Type 2 HARQ-ACK CB” in the following agreement, especially when different slot lengths are configured for eType 3/Type 3 HARQ-ACK CB and Type 1 or Type2 HARQ-ACK CB:  Agreement  For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook.  As shown examples in the following Figure 1, whether slot-based Type1/2 HARQ-ACK CB for case a and case b is “Type 1 or Type 2 HARQ-ACK CB” menthioned in the agreement? In our understanding,   * For case a, slot-based Type1/2 HARQ-ACK CB does **NOT** overlap with subslot 1, so slot-based Type1/2 HARQ-ACK CB is not Type 1 or Type 2 HARQ-ACK CB in the agreement. In other words, UE **MAY** expect HARQ-ACK information in a slot-based Type1/2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size. * For case b, slot-based Type1/2 HARQ-ACK CB **overlaps** with subslot 1, so slot-based Type1/2 HARQ-ACK CB is Type 1 or Type 2 HARQ-ACK CB in the agreement. In other words, UE is **NOT** expecting HARQ-ACK information in a slot-based Type1/2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size.      1. (b)   Figure1: A subslot-based eType 3 CB and a slot-based Type1/2 CB  In short, if an eType 3 HARQ-ACK CB is triggered in a given subslot, the HARQ-ACK information in a Type 1/2 HARQ-ACK CB to be transmitted in a slot/subslot **overlapping with the given subslot** should be mapped to the eType 3 HARQ-ACK CB.  Alt 1 overturns the previous agreement and seems to focus on overlapping channel only.  Alt 3 can also address our concern but according to discussion in previous meeting, some companies regarded that it overturns the previous agreement, i.e. content in eType 3 HARQ-ACK CB is independent with priority.  Alt 4 does not address our concern. And clarification is required. For the case a and b in aboving examples,  Q1: Whether should eType 3 HARQ-ACK CB contain HARQ-ACK process in Type 1/2 CB?  Q2: Whether does PUCCH for Type 1/2 CB transmit or not?  In addition, if Alt 2 is applied, there is no overlapping between LP/HP PUCCH carrying Rel-16 Type 3 HARQ-ACK CB or Rel-17 enhanced Type 3 HARQ-ACK CB and HP/LP PUCCH carrying HARQ-ACK due to HP/LP PUCCH carrying HARQ-ACK is always dropped. No further discussion on handling PHY prioritization between LP/HP PUCCH carrying Rel-16 Type 3 HARQ-ACK CB or Rel-17 enhanced Type 3 HARQ-ACK CB and HP/LP PUCCH carrying HARQ-ACK |
| Moderator | @vivo & Huawei on mod. Alt. 3 (by HW) or Alt. 5 (by vivo) for the R16 Type 3 CB: Please note, that the Type 3 CB contains all the HARQ processes of all serving cells – i.e. there cannot be any Type 1 or Type 2 HARQ-ACK CB that contains PDSCH HARQ which is not mapped to the Rel-16 Type 3 CB!? This was the reason to separate the formulations for R17 enh. Type 3 CB and R16 Type 3 CB there. |
| vivo2 | Thanks a lot moderator’s explanation. This is the Rel-16 NR-U behaviour for the same priority between the Rel-16 Type 3 CB and Type 1/2 CB. But for Rel-17, the Rel-16 Type 3 CB includes all the HARQ processes of all serving cells can be indicated as LP and cancelled by HP Type 1/2 CB with smaller CB size for reliability. |
| LG | We support Alt. 4. We think type-3 or e-type-3 HARQ-ACK codebook are a kind of irrespective to priority. |
| Huawei/Hisi2 | @DCM: It is correct that Rel-16 type 3 CB includes all HARQ process IDs. But when the type 3 CB is subject to LP, its reliability is weak, let say, 99%; if a HP type-1/2 CB subject to high reliability of 99.999% colliding with LP type 3 CB has to be dropped due to the NRU rule, then how can the UE guarantee the 5x9s reliability of URLLC? It also deviates the R16 HP/LP prioritization principle.  @Moderator: For the same priority, yes, as UE cannot generate two CBs in one slot. But for two priorities, firstly, R16 URLLC can support two CB generation within one slot separately for HP and LP, so there is no issue for UE to generate both HP CB and LP CB; secondly, the LP type 3 CB cannot satisfy the reliability/latency requirement of URLLC if the HP type 1/2 has to be dropped on the same slot/subslot. So we believe for URLLC, it should follow a unified rule, that HP cancels the LP regardless of CB type. |
| Moderator | Continue the discussion focusing on Alt. 3 and Alt. 4 in round 2. |

3.4 2nd round of email discussions

**Enhanced Type 3 CB operation with PHY prioritization:**

Based on the input to Question 3.3.1, there is a strong majority supporting Alt. 4. But some companies prefer the handling withina single PHY priority only, and then apply the Rel-16 PHY prioritization on top (Alt. 3 without special handling for R16 Type 3 CB, which seems to be also Alt. 1 by Intel) Still some moderator comments:

* @DOCOMO / OPPO: as DOCOMO noted, there seems to be some similarity of Alt. 2 and Alt. 4!?
* @vivo & Huawei: There is no agreed restriction on Type 1 or Type 2 CB overlapping with a full Type 3 CB for the same priority as far as I know. Reformulated Alt. 3 accordingly.

So let’s see if we could focus on Alt. 4 and 3’ by Huawei, and see where companies stand here, in the first round it looked as Alt. 4 would be the winner, but better to check still based on the updates to Alt. 3 below:

**Proposal 3.3.1 : For PHY prioritization between LP/HP PUCCH carrying Rel-16 Type 3 HARQ-ACK CB or Rel-17 enhanced Type 3 HARQ-ACK CB and HP/LP PUCCH carrying HARQ-ACK using the Rel-16 PHY prioritization operation, down-select from:**

* **Mod Alt. 3:** 
  + **For enhanced Type 3 CB, the restriction on the Type 1 / Type 2 HARQ-ACK CB mapping from the earlier agreement is only applicable to the same PHY priority of the Type 1 / Type 2 CB as the PUCCH for the enhanced Type 3 CB re-transmission. LP PUCCH is dropped according to the Rel-16 PHY prioritization procedures in case of overlapping HP channel.**
  + **For Rel-16 Type CB, the UE creates the Rel-16 Type 3 CB for transmission on a PUCCH of the indicated priority. LP PUCCH is dropped according to the Rel-16 PHY prioritization procedures in case of overlapping HP channel.**
* **Alt. 4:** 
  + **For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB of any PHY priority to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook.**
    - ***Note: There would not be any cases of the related overlapping with HP HARQ-ACK only.***
  + **For Rel-16 Type3 CB, as all the HARQ-ACK information is already included in the Type 3 HARQ-ACK CB, there would not be any HP PUCCH overlapping with HARQ-ACK information only that could cancel a potential Type 3 CB transmission using the 1st (LP) PUCCH configuration.**

|  |  |
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| Support the proposal to down select | Huawei/Hisi, DOCOMO, vivo, ZTE, Intel, NEC, Spreadtrum, Nokia/NSB, Sony, QC, Ericsson, CATT, New H3C |
| Objecting companies |  |

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| --- | --- |
| Mod Alt. 3 | Huawei/Hisi, DOCOMO (2nd preference), vivo, Samsung, NEC(2nd preference), Spreadtrum, Intel (preference), Nokia/NSB, Ericsson, CATT, New H3C |
| Alt. 4 | DOCOMO (1st preference), OPPO (modification) , ZTE, NEC(1st preference), Sony |
| Other |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Huawei/Hisi | As the clarification to the R16 spec in the 1st round (also pasted in below), when the R16 Type 3 CB is configured in together with R16 HP/LP prioritization, the UE behaviour is: **the rule of R16 Type 3 CB overriding Type 1/2 CB only applies to the same priority**, **while LP PUCCH of Type 3 HARQ has to be cancelled by an overlapping HP channel**, i.e., the HP/LP prioritization rule will be performed regardless of the CB type. Thus the R16 behavior of Alt.2 is inconsistent with the spec; we think proponent companies of Alt.4, if still stick to that understanding, may rather submit R16 CR than debate in R17.  Moreover, it is weird for the other way around that a LP channel would drop a HP channel, which jeopardizes the URLLC latency/reliability (e.g., reliability reduced from 99.999% to 99%).  The R17 enhanced Type 3 can follow the same spirit of R16, that the HP/LP prioritization is performed regardless of CB type.   |  | | --- | | - if a transmission of a first PUCCH of larger priority index scheduled by a DCI format in a PDCCH reception would overlap in time with a repetition of a transmission of a second PUSCH or a second PUCCH of smaller priority index, the UE cancels the repetition of a transmission of the second PUSCH or the second PUCCH before the first symbol that would overlap with the first PUCCH transmission  …  In the remaining of this clause, the multiplexing or prioritization for overlapping channels are for overlapping channels with same priority index or for overlapping channels with a PUCCH carrying SL HARQ-ACK information..  … 9.1.4 Type-3 HARQ-ACK codebook determination …  If a UE detects a DCI format that includes a One-shot HARQ-ACK request field with value 1, the UE determines a PUCCH or a PUSCH to multiplex a Type-3 HARQ-ACK codebook for transmission in a slot as described in clauses 9.2.3 and 9.2.5. The UE multiplexes only the Type-3 HARQ-ACK codebook in the PUCCH or the PUSCH for transmission in the slot. | |
| DOCOMO | We are fine with either fine, for sake of progress.  We now understand OPPO’s intention by original Alt 2. But we think Alt 4 can cover OPPO’s intention since “**enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot**” in Alt 4 can cover your example case (as following figure). Regardless of whether the e-type 3 CB sub-slot overlaps with type 1/2 CB sub-slot, they are in the same slot, which is covered by Alt 4.     1. (b) |
| vivo | We still do not understand what does the note in Alt.4 mean. Does it mean gNB would ensure that there will be no overlapping between the LP enhanced Type 3 HARQ-ACK CB and HP Type 1/Type 2 CB?  Same question for the 2nd bullet in Alt.4, how to understand the phrase “there would not be any HP PUCCH overlapping with HARQ-ACK information only that could cancel a potential Type 3 CB transmission using the 1st (LP) PUCCH configuration” Does it mean gNB would ensure that there will be no overlapping between the LP Rel-16 HARQ-ACK CB and HP Type 1/Type 2 CB? |
| OPPO | Restriction on Type1 or Type 2 HARQ-ACK CB is still required. Otherwise, it is not clear whether PUCCH with Type1 or Type 2 HARQ-ACK CB **partially** overlapping with the PUCCH slot for enhanced Type 3 HARQ-ACK CB is counted or not. As shown in the following figure, whether eType3 HARQ-ACK CB contains the HARQ-ACK information carried in Type 1/2 CB?    We prefer to that eType3 HARQ-ACK CB contains the HARQ-ACK information carried in Type 1/2 HARQ-ACK CB which partially or fully overlaps with the PUCCH slot for eType3 HARQ-ACK CB. So we suggest to modify Alt.4.   * **Alt. 4:**    + **For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB of any PHY priority overlapping with the PUCCH slot to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook.**     - ***Note: There would not be any cases of the related overlapping with HP HARQ-ACK only.***   + **For Rel-16 Type3 CB, as all the HARQ-ACK information is already included in the Type 3 HARQ-ACK CB, there would not be any HP PUCCH overlapping with HARQ-ACK information only that could cancel a potential Type 3 CB transmission using the 1st (LP) PUCCH configuration.** |
| Samsung | If PUCCH time unit for HARQ-ACK is different for HP and LP, Alt 4 is not clear.  In addition, HP SR PUCCH/HP PUSCH can cancel LP HARQ-ACK PUCCH if the Type-3 is triggered by a DCI indicates LP. The reliability of HP HARQ-ACK may degrade. |
| Intel | Modified Alt.3 is our preference. Alt.4 is also acceptable. |
| NEC | We sliglty prefer Alt.4. In our understanding, (enhanced) Type-3 HARQ-ACK CB is to avoid some unnecessary HARQ-ACK dropping to improve the spectrum effiency, so new HARQ-ACK cancelation due to overlapping with HP PUCCH for the triggered (enhanced) Type-3 HARQ-ACK CB violates the motivation of HARQ-ACK retransmission. For the overlapping between LP PUCCH for the triggered (enhanced) Type-3 HARQ-ACK CB and HP PUCCH for UCI, it can be avoided by gNB implementation. |
| Nokia/NSB | Based on the explanations / discussions by Huawei on the PHY priority handing, it seems that Mod. Alt. 3 is definitely easier to specify, as we as the points by Samsung. So we in contrast to the earlier rounds now are more in favor of Mod. Alt. 3. |
| QC | Either Alt 3 or Alt 4 is fine. Alt 3 is more in-line with Rel. 16 specifications. |
| New H3C | We are fine with Modified Alt.3 and Alt.4. Alt.3 more aligns with Rel.16. |

3.5 3rd round of email approvals

**Enhanced Type 3 CB operation with PHY prioritization:**

In the third round, on Proposal 3.3.1, it seems all companies seemed to be fine to focus on Alt. 3 or Alt. 4 only. Moreover, based on the input received a strong majority seems to prefer Alt. 3, as being more in line with the Rel-16 operation and simplify the operation (i.e. no cross-priority handling for the Rel-16 PHY prioritization operation).

If one asks why to clarify this as soon as possible here (still this week): This may have impact on the related discussions of the joint operation of Type 3 CB with R17 Intra-UE prioritization in Sec. 7.X. Without having this clarified for R16 PHY prioritization proceeding there may be slightly tricky.

So let’s see if we are able to agree on clarifying the handing for PHY prioritization:

**Proposal 3.5.1 : The Rel-16 PHY prioritization operation and Rel-16 Type 3 with PHY priority operation & Rel-17 enhanced Type 3 HARQ-ACK CB with PHY priority operation is further clarified as:**

* **For Rel-17 enhanced Type 3 HARQ-ACK CB operation, the restriction on the Type 1 / Type 2 HARQ-ACK CB mapping from the earlier agreement is only applicable to the same PHY priority of the Type 1 / Type 2 CB as the PUCCH for the enhanced Type 3 CB re-transmission. A LP PUCCH (or PUSCH) carrying the R17 enh. Type 3 CB is dropped according to the Rel-16 PHY prioritization procedures in case of an overlapping HP channel.**
* **For Rel-16 Type HARQ-ACK 3 HARQ-ACK CB operation, the UE creates the Rel-16 Type 3 HARQ-ACK CB for transmission on a PUCCH of the indicated priority. A LP PUCCH (or PUSCH) carrying the R16 Type 3 HARQ-ACK CB is dropped according to the Rel-16 PHY prioritization procedures in case of an overlapping HP channel.**

|  |  |
| --- | --- |
| Supporting companies | Vivo, NEC, Samsung Huawei/Hisi, Intel, Nokia/NSB, Ericsson, New H3C, Spreadtrum, DOCOMO, CATT |
| Objecting companies | OPPO |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| OPPO | Firstly, we do not think Proposal 3.5.1 is line with Rel-16 operation. Contactly. We think Alt 4 is more line with Rel-16 operation. In the Rel16, Type 3 HARQ-ACK CB overrides Type 1 or Type 2 HARQ-ACK CB of any priority. There is not any piroirity restriction in the following spec.   |  | | --- | | 9.1.4 Type-3 HARQ-ACK codebook determination …  If a UE detects a DCI format that includes a One-shot HARQ-ACK request field with value 1, the UE determines a PUCCH or a PUSCH to multiplex a Type-3 HARQ-ACK codebook for transmission in a slot as described in clauses 9.2.3 and 9.2.5. The UE multiplexes only the Type-3 HARQ-ACK codebook in the PUCCH or the PUSCH for transmission in the slot. |   In addition, Proposal 3.5.1 overturns the previous agreement   |  | | --- | | **Agreement**  Support PHY priority handling for a PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size.   * The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size. * The A/N of HARQ processes is mapped to the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size irrespective of the PHY priority of the ‘A/N’ of the HARQ processes. * FFS: If the HARQ-ACK codebook size or structure is dependent on the PHY priority (e.g. separate configuration of CBG/NDI usage, separate configuration of HARQ IDs / CCs per priority, SPS HARQ-ACK process IDs of specific priority only for a SPS HARQ-ACK only codebook, …). |   Proposal 3.5.1 indicates that eType 3 HARQ-ACK CB should contain HARQ-ACK information for some HARQ-ACK process IDs included in Type 1/2 HARQ-ACK CB with **a given priority**. However, agreement shows that “The A/N of HARQ processes is mapped to the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size **irrespective** of the PHY priority of the ‘A/N’ of the HARQ processes.”  In our understanding, Mod Alt 4 is more line with R16 operation and previous agreement. And modification makes it clear.   * **Alt. 4:**    + **For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB of any PHY priority overlapping with the PUCCH slot to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook.**     - ***Note: There would not be any cases of the related overlapping with HP HARQ-ACK only.***   + **For Rel-16 Type3 CB, as all the HARQ-ACK information is already included in the Type 3 HARQ-ACK CB, there would not be any HP PUCCH overlapping with HARQ-ACK information only that could cancel a potential Type 3 CB transmission using the 1st (LP) PUCCH configuration.** |
| NEC | We share same understanding with OPPO that Alt.4 is preferred. But we can live with Alt.3 for progress. |
| ZTE | Either Alt.3 or Alt.4 can work, we are open to both, but slghtly prefer the Alt.4  We can live with Alt.3 if majority support. |
| Samsung | For Alt.4, our previous comment (copied below) has not been addressed by proponents.  If PUCCH time unit for HARQ-ACK is different for HP and LP, Alt 4 is not clear. In addition, HP SR PUCCH/HP PUSCH can cancel LP HARQ-ACK PUCCH if the Type-3 is triggered by a DCI indicates LP. The reliability of HP HARQ-ACK may degrade. |
| Moderator | @OPPO: please note that in Rel-16 multiplexing on PUCCH and PUSCH is only within the same priority, and as there is no PHY priority indication in Rel-16 it means LP PUCCH or LP PUSCH there.  So basically after that multiplexing procedure, there can still be a HP PUCCH with HARQ cancelling the Type 3 CB based on Rel-16 operation – right? |
| Nokia/NSB | Alt. 3 to our reading is the same operation as Rel-16 Type 3 CB operation (where this is limited to be LP). So just an extension here. |
| Sony | We do share the same understanding as OPPO that when we agreed on e-Type 3 CB, the HARQ-ACK that it can carry is independent of L1 priority as per the agreement. It doesn’t make sense why gNB would trigger a PUCCH carrying e-Type 3 CB and give it a LP if that e-Type 3 CB is going to contain HP HARQ-ACKs.  In Alt.4 we have a note stating that we do not expect the PUCCH carrying e-Type 3 CB to overlap with HP HARQ-ACK PUCCHs. So unclear what’s the problem with Alt.4. |
| Lenovo | We think only necessary clarification is the first bullet in Alt 4:   * + **For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB of any PHY priority to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook.**     - ***Note: There would not be any cases of the related overlapping with HP HARQ-ACK only.*** |
| Ericsson | @OPPO: We share same view as Moderator. If I understand, your point is that the Rel-16 Type 3 CB includes all the HARQ-ACK bits , irrespective of the priority. That is correct and that is as Rel-16. But here, now Type-3 CB is carried by a PUCCH resource that this resource has a priority indicated by DCI (no matter the codebook it carries belong to HP or LP). Now, if this PUCCH (even carrying Rel-16 Type-3) is indicated by trigerring DCI to be LP, if it overlaps with a HP PUCCH/PUSCH, it should be dropped.  So, ther eis no conflict with Rel-16. Just because in Rel-17, we add a priority to the PUCCH carrying Type-3, we need to clarify this dropping situation. |
| DOCOMO | We share same understanding as Ericsson that the proposal 3.5.1 doesn’t overturn previous agreement. We are fine with either Alt 3 or Alt 4. |
| Huawei/Hisi2 | @Sony Note that the e-Type3 HARQ ID set is configured (e.g., a set can be HARQ ID{#1~#8}), so gNB, when scheduling e-Type 3 CB to trigger re-tx of a bunch of LP HARQ-ACKs (e.g., associated with HARQ ID {#1,#2,#3,#4,#6}), may inevitably include some other unwanted HARQ ID (e.g., {#7}), which could possibly be corresponding to HP of a previous transmission. |
| CATT | We support the proposal with the following correction of a typo for the second sub-bullet.   * **For Rel-16 Type ~~HARQ-ACK~~ 3 HARQ-ACK CB operation, the UE creates the Rel-16 Type 3 HARQ-ACK CB for transmission on a PUCCH of the indicated priority. A LP PUCCH (or PUSCH) carrying the R16 Type 3 HARQ-ACK CB is dropped according to the Rel-16 PHY prioritization procedures in case of an overlapping HP channel.** |
| LG | Though We prefer Alt. 4, we won’t object this proposal if majority company support Alt. 3. |
| Sony | It will be good to know which “earlier agreement” we are talking about in the proposal since there are hundreds of earlier agreements:   * **For Rel-17 enhanced Type 3 HARQ-ACK CB operation, the restriction on the Type 1 / Type 2 HARQ-ACK CB mapping from the earlier agreement is only applicable to the same PHY priority of the Type 1 / Type 2 CB as the PUCCH for the enhanced Type 3 CB re-transmission. A LP PUCCH (or PUSCH) carrying the R17 enh. Type 3 CB is dropped according to the Rel-16 PHY prioritization procedures in case of an overlapping HP channel.**   The confusion is it seems to refer to this earlier agreement as OPPO commented previous:  **Agreement**  Support PHY priority handling for a PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size.   * The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size. * The A/N of HARQ processes is mapped to the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size irrespective of the PHY priority of the ‘A/N’ of the HARQ processes.   FFS: If the HARQ-ACK codebook size or structure is dependent on the PHY priority (e.g. separate configuration of CBG/NDI usage, separate configuration of HARQ IDs / CCs per priority, SPS HARQ-ACK process IDs of specific priority only for a SPS HARQ-ACK only codebook, …).  Which, suggest we are reverting an earlier agreement rather than clarifying it. Here we clearly say that HARQ-ACK that is mapped to this e-Type 3 HARQ-ACK CB is irrespective of PHY priority. In contrast in this proposal we have:  **For Rel-17 enhanced Type 3 HARQ-ACK CB operation, the restriction on the Type 1 / Type 2 HARQ-ACK CB mapping from the earlier agreement is only applicable to the same PHY priority** |

3.6 3rd and 4th round of email discussions

**Identified required changes the current specifications (TS 38.213)**

vivo [5] identified, that the two different ways to configure one enh. Type 3 CB (using either *pdsch-HARQ-ACK-enhType3perCC* or *pdsch-HARQ-ACK-enhType3perHARQ*) are currently not captured in the specifications. Based on moderator understanding, vivo got a point there that the two different ways to configure this are not captured in the Type 3 CB. So clearly something would need to be done here.

Let’s see if the TP from vivo in [5] is acceptable of if we need adaptations to the TP here.

**Proposal 3.6.1:** **The following TP to 38.213 is endorsed for the editor’s CR:**

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| --- |
| **9.1.4 Type-3 HARQ-ACK codebook determination**  If a UE is provided *pdsch-HARQ-ACK-OneShotFeedback*, the UE determines HARQ-ACK information bits, for a total number of HARQ-ACK information bits, of a Type-3 HARQ-ACK codebook according to the following procedure. If the UE is provided *pdsch-HARQ-ACK-enhType3List* and a DCI format scheduling PDSCH reception and triggering the Type-3 HARQ-ACK codebook includes a Type3-subcodebook-index field that provides a value for *pdsch-HARQ-ACK-enhType3Index*, the UE determines for each configured serving cell if at least one configured HARQ process for it is involved in the Type-3 HARQ-ACK codebook determination, and when applicable, determines if HARQ process number for serving cell is involved in the Type-3 HARQ-ACK codebook determination,  ~~a number of indicated serving cells and a number of indicated HARQ processes for each indicated serving cell~~ from the entry in *pdsch-HARQ-ACK-enhType3List* corresponding to the *pdsch-HARQ-ACK-enhType3Index* value. If the DCI format does not include the Type3-subcodebook-index field, the *pdsch-HARQ-ACK-enhType3Index* value is zero.  Set to the number of configured serving cells ~~or, when applicable, to~~  Set to the value of *nrofHARQ-ProcessesForPDSCH* for serving cell , if provided; else, set ~~. When applicable, set to~~  Set to the value of *maxNrofCodeWordsScheduledByDCI* for serving cell if *harq-ACK-SpatialBundlingPUCCH* is provided and , or if *harq-ACK-SpatialBundlingPUCCH* is not provided, or if *maxCodeBlockGroupsPerTransportBlock* is provided for serving cell ; else, set  Set to the number of HARQ-ACK information bits per TB for PDSCH receptions on serving cell as described in clause 9.1.1 if *maxCodeBlockGroupsPerTransportBlock* is provided for serving cell and *pdsch-HARQ-ACK-OneShotFeedbackCBG* or *pdsch-HARQ-ACK-enhType3CBG* is provided; else, set  Set if *pdsch-HARQ-ACK-OneShotFeedbackNDI* or *pdsch-HARQ-ACK-enhType3NDI* is provided; else set  Set – serving cell index  Set – HARQ process number  Set – TB index  Set – CBG index  Set  while  if the UE is not provided *pdsch-HARQ-ACK-enhType3List*, or, if the UE is provided *pdsch-HARQ-ACK-enhType3List* and the UE determines that for serving cell at least one configured HARQ process is involved in the Type-3 HARQ-ACK codebook determination  while  if the UE is not provided *pdsch-HARQ-ACK-enhType3List*, or, if the UE is provided *pdsch-HARQ-ACK-enhType3List* and the UE determines that HARQ process number for serving cell is involved in the Type-3 HARQ-ACK codebook determination  ……  end if    end while  end if      end while  ……  If  - a UE detects a DCI format that includes a One-shot HARQ-ACK request field with value 1, and  - the CRC of the DCI is scrambled by a C-RNTI or an MCS-C-RNTI, and  - *resourceAllocation* = *resourceAllocationType0* and all bits of the frequency domain resource assignment field in the DCI format are equal to 0, or  - *resourceAllocation* = *resourceAllocationType1* and all bits of the frequency domain resource assignment field in the DCI format are equal to 1, or  - *resourceAllocation = dynamicSwitch* and all bits of the frequency domain resource assignment field in the DCI format are equal to 0 or 1  the DCI format provides a request for a Type-3 HARQ-ACK codebook report and does not schedule a PDSCH reception. If the UE is provided *pdsch-HARQ-ACK-enhType3List* and the DCI format includes a Type3-subcodebook-index field that provides a value for *pdsch-HARQ-ACK-enhType3Index*, the UE determines for each configured serving cell if at least one configured HARQ process for it is involved in the Type-3 HARQ-ACK codebook determination, and when applicable, determines if HARQ process number for serving cell is involved in the Type-3 HARQ-ACK codebook determination,~~a number of indicated serving cells and a number of indicated HARQ processes for each indicated serving cell~~  from the entry in *pdsch-HARQ-ACK-enhType3List* corresponding to the *pdsch-HARQ-ACK-enhType3Index* value. If the DCI format does not include the Type3-subcodebook-index field, the *pdsch-HARQ-ACK-enhType3Index* value is provided by the value of MCS field in the DCI format. The UE is expected to provide HARQ-ACK information in response to the request for the Type-3 HARQ-ACK codebook after symbols from the last symbol of a PDCCH providing the DCI format, where the value of for is provided in clause 10.2 by replacing "SPS PDSCH release" with "DCI format".  ……  --------------------------------------------------------End text proposal---------------------------------------------------------- |

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| Supporting companies | Vivo, Intel, DOCOMO |
| Objecting companies | Samsung, QC |

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| *Company* | *Comments* |
| vivo | For Rel-17 enhanced Type 3 CB, it is understood that the serving cell indexes for the subset of serving cells, as well as HARQ process numbers for the subset of configured HARQ processes for a serving cell, involved in an enhanced Type-3 codebook, may not be consecutive. But according to the corresponding spec text, the configuration of an enhanced Type-3 codebook only provides a number of indicated serving cells and a number of indicated HARQ processes for each indicated serving cell , and the indexes of the indicated serving cells, as well as the numbers of the indicated HARQ processes for each indicated serving cell, are regarded as consecutive, based on the text highlighted in yellow (if the proposed text in red is removed). Without the correction, there is a mismatch between the agreement(s) and corresponding description in the current spec. |
| Samsung | There is no need for the proposed change. All needed is a clarification that the index runs over the set of configured cells or HARQs for the eType3. |
| Huawei/Hisi | Understand the intention, but can we take more time to check the detailed text after the meeting as there are lots of changes in this TP? |
| Intel | We support the intention. This was already spotted in one of CR reviews, but was not accepted yet. |
| Nokia/NSB | We support the intention, but maybe as HW pointed out some more time to check the details may be needed. |
| Ericsson | We also understand the intention. But we also like to check further. |
| LG | We are fine with the intention. But we also like to check further. |
| ZTE | Appreciate the intention, this need more check. |
| Samsung2 | To further elaborate on the previous comment, the issue is a trivial bug. It would be enough to change “a number of indicated serving cells ” to “a size of a set of indicated serving cells ” and clarify that runs through the set of indicated serving cells. Same for the HARQ processes. No other change is needed. |
| QC | The intention is understood and supported. It is good though to maintain the previous wording as much as possible to indicate both cases of consecutive and non-consecutive HARQ Processes in the Rel. 17 Type 3 HARQ CB. |
| NEC | Fine with the intention. But we also like to check further. |
| vivo2 | We are fine to leave more time for companies to check.  Reply to Sumsung: based on your proposed change, it may not be clear enough since in the spec, the serving cell index or HARQ process number is generally not local index in a speficied subset, i.e. it direcly indicates the serving cell ID or HARQ process ID. But if just simply clarifying that the index used here is local index for a set of servcing cells/HARQ processes, it may cause confusion.  Reply to QC: we are open to discuss the proper wording. |
| Moderator | Looking at the comments here, it seems that we may not have a chance to get this somehow approved in this meeting anymore. Therefore, the moderator will not continue the discussions on this TP here.  Companies are encouraged to check this till RAN1#109-e (May meeting) and specifically looking at the comments from ‘Samsung 2’ above, if we find a way for minimum changes here that would lead to the desired effect here. Clearly, the simpler the proposed changes the easier it will be in e-meeting area to receive consensus. |

# PUCCH repetition enhancements (at least for HARQ-ACK), e.g., sub-slot based, etc.

In this section, the company positions on the support of PUCCH repetition enhancements (incl. sub-slot type of PUCCH repetition) are summarized. At RAN#90, the following clarification on the focus was done:

***RAN conclusion on IIoT scope:***

* *For handling of the PUCCH repetitions it is proposed to proceed as follows:*

1. *RAN1 to continue discussion on PUCCH repetition, whether to specify or not, in the IIoT/URLLC WI for single TRP.*
   1. *The following items are not within scope of the continued discussions in the IIoT/URLLC WI:*
      1. *DMRS-less PUCCH with UCI payload up to 11 bits*
      2. *PUSCH-repetition-Type-B like PUCCH repetition*
      3. *DMRS bundling across PUCCH repetitions*
2. *PUCCH repetition issues with multi-TRP to be handled in Fe-MIMO WI.*

* *For the UE CSI/HARQ-ACK feedback enhancements in the IIoT/URLLC WI, RAN1 work to continue the discussions. Status to be checked in March if any RAN level guidance needed.*
  + *RAN1 to continue discussion on A-CSI on PUCCH, whether to specify or not.*

The following related agreements were achieved:

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| --- | --- | --- | --- | --- |
| Agreements: Support sub-slot based PUCCH repetition for HARQ-ACK based on the Rel-16 PUCCH procedure for slot-based PUCCH applied to sub-slot based PUCCH   * Note: the intention is to take the Rel-16 slot-based PUCCH by replacing with “sub-slot” appropriately, without further optimization unless necessary * FFS whether or not there is any restriction for the applicability of sub-slot based PUCCH repetition for HARQ-ACK * Dynamic repetition indication is supported also for sub-slot based PUCCH in Rel-17   + FFS: if the method to be specified in Cov. Enh WI for slot-based PUCCH repetition can be directly applied to sub-slot PUCCH or if changes are needed   Agreements: Support PUCCH repetition for PUCCH formats 0 and 2 at least for sub-slot based PUCCH repetition.   * FFS: Support for slot-based PUCCH repetition   **Conclusion**  The dynamic repetition indication solution for slot-based PUCCH repetition from the RAN1#105-e working assumption from Cov. Enh. WI can be directly applied for dynamic repetition indication for sub-slot based PUCCH repetition.  **Agreement**  For sub-slot based PUCCH repetition for HARQ-ACK, semi-static configured PUCCH repetition (i.e. using *nrofSlots*) and dynamic repetition factor based operation is supported.   * Sub-slot based PUCCH repetition based on semi-static configuration (i.e. using *nrofSlots*) and based on dynamic indication is subject to separate UE capabilities   **Agreement**  Support slot-based PUCCH repetition for PUCCH Format 0 and Format 2 also for single TRP operation.  The support is subject to independent UE capability indication  **Agreement**  To align with Rel-16 slot-based PUCCH repetition operation, support sub-slot based PUCCH repetition configured with / using *nrofSlots* (i.e., not using dynamic indication) of all UCI types (incl. HARQ, SR & CSI).  **Agreement**  For sub-slot based PUCCH repetition, the following agreement from Cov. Enh. WI for slot-based PUCCH repetition is adopted also for sub-slot based PUCCH repetition:   |  | | --- | | *Agreement*   * *for a PUCCH resource, if both a new repetition parameter corresponding to Rel-17 dynamic PUCCH repetition factor indication and the Rel-15/16 nrofSlots are configured, the new repetition parameter overrides nrofSlots.* |   **Agreement**  For sub-slot based PUCCH repetition, the following agreement from Cov. Enh. WI for slot-based PUCCH repetition is adopted also for sub-slot based PUCCH repetition:   |  | | --- | | *Agreement: Dynamic PUCCH repetition factor indication for SR or P/SP-CSI on PUCCH is not supported in Rel-17.* |   **Agreement**  For PUCCH repetition enhancements:   * Support *inter-slotFrequencyHopping* for PUCCH repetition operation of PUCCH Format 0 and Format 2 for slot-based PUCCH configurations. * Support inter-subslot Frequency Hopping for PUCCH repetition operation of PUCCH Formats 0, 1, 2, 3 and 4 for 7OS slot-based PUCCH configurations.   + The UE applies the inter-subslot FH operation from sub-slot to sub-slot, if configured with *inter-slotFrequencyHopping* in the respective PUCCH\_config. * (Working Assumption) Support inter-subslot Frequency Hopping for PUCCH repetition operation of PUCCH Format 0 and Format 2 for 2OS slot-based PUCCH configurations.   + The UE applies the inter-subslot FH operation from sub-slot to sub-slot, if configured with *inter-slotFrequencyHopping* in the respective PUCCH\_config. * Note: As for Rel-15, the configuration / enabling of *inter-slotFrequencyHopping* and *intraSlotFrequencyHopping* is not supported.   **Agreement**  For sub-slot based PUCCH repetition, the following agreement from Cov. Enh. WI for slot-based PUCCH repetition is adopted also for sub-slot based PUCCH repetition:   |  | | --- | | Agreement   * In Rel-17, reuse the Rel-16 PUCCH repetition factors 2, 4, 8. * Do not support PUCCH repetition factor larger than 8 In Rel-17. |   **Agreement**   1. Confirm the following RAN1 working assumption from RAN1#106bis-e with the additional agreement on UE capability (in RED):  |  | | --- | | * (Working Assumption) Support inter-subslot Frequency Hopping for PUCCH repetition operation of PUCCH Format 0 and Format 2 for 2OS slot-based PUCCH configurations.   + The UE applies the inter-subslot FH operation from sub-slot to sub-slot, if configured with *inter-slotFrequencyHopping* in the respective PUCCH\_config. |  * Support single UE capability indication of inter-subslot FH for PUCCH repetition operation. |

* 1. Summary of companies input in their contributions

**No input on PUCCH repetition enhancements received.**

***Moderator comment: therefore, no discussions planned during RAN1#108-e.***

# Type 1 HARQ CB based on sub-slot PUCCH config

In this section, the Type 1 HARQ-ACK codebook support for sub-slot based PUCCH configuration is discussed. The following related agreements from previous meetings are available on this topic:

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| Agreement: Support Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17.   * The properties of the Type-1 HARQ-ACK codebook for sub-slot PUCCH at least includes that a PDSCH TDRA is associated with a UL /PUCCH sub-slot if the end of the PDSCH overlaps with the associated sub-slot determined by a k1 in the set of sub-slot timing values K1. * FFS: whether the PDSCH TDRA grouping is performed per DL slot or sub-slot   + Decide between PDSCH TDRA grouping per DL slot and sub-slot during RAN1#105-e   **Agreement**  For Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17, the TDRA pruning/grouping is performed per DL slot after TDRA determination per sub-slot.   * Strive to minimize the impact on relevant pseudo-code |

* 1. Summary of companies input in their contributions

**No input on Type 1 HARQ CB based on sub-slot PUCCH config received.**

***Moderator comment: therefore, no discussions planned during RAN1#108-e.***

# PUCCH carrier switching for HARQ feedback

In this section, PUCCH carrier switching (at least) for HARQ-ACK feedback is discussed. The following related agreements from previous meetings are available on this topic:

**Generic agreements (applicable to both, dynamic & semi-static PUCCH cell switching)**

**RAN1#103-e (Oct./Nov. 2021)**

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| **Agreements:** In the studies on PUCCH carrier switching for HARQ-ACK, PUCCH carrier switching for different cells operated is considered only for cells that are part of the active UL CA configuration. |

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

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| Agreements: For further study on whether and how to support PUCCH carrier switching in a PUCCH group, focus on the following three alternatives:   * Alt. 1: PUCCH carrier switching is based dynamic indication in DCI * Alt. 2B: PUCCH carrier switching is based on certain (semi-static) rules * Alt. 2C: PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells * *Note: In above alternatives, it is assumed that HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group, can be sent on a PUCCH on an Scell also instead of only on Pcell/PScell/PUCCH-SCell in the same PUCCH group, as opposed to Rel-16 where HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group can only be sent on Pcell/PScell/PUCCH-SCell in the same PUCCH group.* * *Note: Realistic deployment scenarios including TDD configurations should be considered for the study* |

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

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| Agreement: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration   * Details are FFS (including applicability of dynamic and/or semi-static means) * Aim for minimum specification impact * Dynamic indication and/or semi-static configuration are subject to separate UE capabilities * The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and supports PUCCH carrier switching across cells with different numerologies.   + FFS whether additional rules are needed to support PUCCH carrier switching across cells with different numerologies * FFS the maximum number of PUCCH cells * FFS whether and how to support joint operation of dynamic and semi-static carrier switching for a UE * FFS whether and how to support joint operation of PUCCH carrier switching and SPS HARQ-ACK deferral   Agreement: For PUCCH carrier switching, the PUCCH resource configuration is per UL BWP (i.e. per candidate cell and UL BWP of that specific candidate cell). |

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

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| **Agreement**  Update the following RAN1#105-e agreement as (RED):   * RAN1#105-e Agreement: For PUCCH carrier switching, the PUCCH ~~resource~~ configuration (i.e. *pucch-Config / PUCCH-ConfigurationList*) is per UL BWP (i.e. per candidate cell and UL BWP of that specific candidate cell).   + FFS: CSI and SR |

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

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| **Agreement**  For PUCCH carrier switching, support PUCCH carrier switching only among different TDD cells with PUCCH configured on the NUL carrier in Rel-17  **Agreement**  For PUCCH cell switching, support independent TPC per PUCCH cell including   * Separate P0 / TPC configuration per PUCCH cell   + Note: This flexibility is already provided as PUCCH-config is per UL BWP of a PUCCH cell * Accumulating closed loop power control commands only within the same PUCCH target cell by reusing Rel-15 procedure, i.e.   + For dynamic PUCCH cell indication, the TPC command in the DCI scheduling the PUCCH only applies for the dynamically indicated PUCCH target cell   + For semi-static / time-domain pattern, the TPC command in the DCI scheduling the PUCCH only applies for the determined PUCCH target (using the time-domain pattern) * Separate TPC command indication using DCI format 2\_2 for the individual PUCCH cells   + Note: this requires configuration of individual TPC command starting points for each PUCCH cell within DCI format 2\_2   **Agreement**  For semi-static and dynamic indication of PUCCH cell switching, the PUCCH repetition factor is determined based on the PUCCH format or PUCCH resource on the target PUCCH cell for the first repetition.  **Agreement**  PUCCH cell switching between 2 cells is supported in Rel-17. |

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

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| **Conclusion**  For PUCCH cell switching DCI field size alignment is done by:   * For dynamic PUCCH cell switching, the bit width of the PDSCH-to-HARQ\_feedback timing indicator in DCI format 1\_1 and 1\_2 is determined by the largest K1 set among the K1 sets of all candidate PUCCH cells for PUCCH cell switching based on dynamic indication   + i.e., a number of most significant bits with value set to '0' are inserted to smaller field until the bit width of the field for all the PUCCH cells are the same   + *Note: for semi-static PUCCH cell switching only the K1 set of PCell is needed* * For semi-static and dynamic PUCCH cell switching, the bit width of the PRI field in DCI format 1\_2 is determined by the largest value of *numberOfBitsForPUCCH-ResourceIndicatorDCI-1-2* of all PUCCH cells   + i.e., a number of most significant bits with value set to '0' are inserted to smaller field until the bit width of the field for all the PUCCH cells are the same * FFS: If similar handling is applied for *ChannelAccess-CPext* DCI field (0 or 2 bit)   **Agreement**  For PUCCH cell switching and a PUCCH transmission on the alternative PUCCH cell, the alternative PUCCH cell is used to derive the downlink pathloss estimate PLb,f,c(qd), i.e., replace in the main bullet of the PLb,f,c(qd) determination in Sec. 7.2.1 of 38.213 the ‘primary cell’ with ‘cell for PUCCH transmission’  **Conclusion**  There is no consensus to support simultaneous configuration of semi-static PUCCH cell switching and dynamic PUCCH cell switching in Rel-17. |

**RAN1#107bis-e (Jan. 2022)**

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| **Conclusion**  There is no consensus for introducing further specification support for the following   * PUCCH cell switching between cells with shared spectrum channel access (in any mode) * PUCCH cell switching between a cell with licensed spectrum and a cell with shared spectrum channel access (in any mode)   **Conclusion**  There is no consensus to support MAC CE activation indicating a set of values of *pucch-SpatialRelationInfoId* applicable to the alternative PUCCH sSCell for PUCCH cell switching in Rel-17. |

**Semi-static PUCCH cell switching**

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

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| **Agreement**  Semi-static PUCCH carrier switching is applicable to all UCI types incl. HARQ-ACK, SR and CSI. |

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

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| **Agreement**  For semi-static PUCCH cell switching, PCell / PSCell / PUCCH-SCell is reference cell:   * The time domain pattern configurations are based on the numerology of the reference cell. * The PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology and PUCCH configuration of a reference cell to be able to apply the time-domain PUCCH cell switching pattern. * Note: There may not be a need to define a ‘reference cell’ in the specification. This terminology is used for further clarifications of the procedure.   **Agreement**  For semi-static PUCCH cell switching, the time-domain pattern configuration is based on the following properties:   * A single time-domain pattern is configured per PUCCH cell group * The granularity of the time-domain pattern is one slot of the PCell / PSCell / PUCCH-SCell ~~reference cell~~ * The time-domain pattern is applied periodically   + FFS on period / pattern length (e.g., 10ms, RRC configured, …). * The pattern defines for each slot of the PCell / PSCell / PUCCH-SCell ~~reference cell~~ at least the applicable target PUCCH cell   **Agreement**  For semi-static PUCCH cell switching, the PUCCH resource indicator (PRI) is interpreted based on the PUCCH configuration of determined target PUCCH cell.  **Agreement**  The periodicity / length of the time-domain pattern for semi-static PUCCH cell switching is directly determined by the RRC configuraton of the time domain pattern *pucchCellPattern*   * Note: *pucchCellPattern* has a variable length of (1… *maxNrofSlots*)   **Agreement**  Down-select in RAN1#107-e from Alt. 1 & Alt. 3 below:  For PUCCH carrier switching based on semi-static operation, for the case the PCell slot to be longer than the target PUCCH cell slot or sub-slot (i.e. multiple target PUCCH cell slots overlapping with a single PCell slot),  the following PUCCH cell slot is used for UCI transmission:   * Alt. 1: the first target PUCCH slot overlapping with the PCell slot * Alt. 3: using a relative slot-offset within the reference cell slot, the relative slot offset is configured in the time domain pattern (i.e. time domain pattern contains ‘cell index’ & ‘slot\_offset’ for each reference cell slot)   + Note: different relative slot offset can be configured for each reference cell slot in the time domain pattern, details see R1-2108829   **Agreement**  Down-select in RAN1#107-e from Alt. 2 & Alt. 4 below:  For PUCCH carrier switching based on semi-static operation, for the case the PCell slot to be shorter than the target PUCCH cell slot,   * Alt. 2: the UE does not expect the same UCI type (i.e. HARQ-ACK, SR or CSI) from more than one PCell PUCCH slot to be overlapping with a single dynamically indicated PUCCH cell slot   + *Note: there can be e.g. HARQ-ACK only be present in either of the overlapping slots, but not in more than one overlapping slot.* * Alt. 4: the UE does not expect a semi-static PUCC cell configuration, where a single target PUCCH slot / sub-slot would be overlapping with more than one PCell slot/sub-slot. |

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

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| **Agreement**  For PUCCH cell switching based on semi-static operation, for the case the PCell slot to be longer than the target PUCCH cell slot or sub-slot (i.e., multiple target PUCCH cell slots overlapping with a single PCell slot), adopt Alt 1, i.e., the first target PUCCH slot overlapping with the PCell slot is used for UCI transmission.  **Agreement**  The time-domain pattern for semi-static PUCCH cell switching is separately configurable for the primary and secondary PUCCH cell group.  **Agreement**  The time-domain pattern for semi-static PUCCH cell switching is based on the reference SCS configuration provided by *tdd-UL-DL-ConfigurationCommon* and is common to every configured UL BWP (of PCell / SPCell / PUCCH SCell).  **Agreement**  For PUCCH cell switching based on semi-static operation, adopt Alt. 4, i.e., the UE does not expect a semi-static PUCCH cell configuration, where a single target PUCCH slot / sub-slot would be overlapping with more than one PCell slot/sub-slot.    **Agreement**  For semi-static PUCCH cell switching, if the alternative PUCCH cell (i.e. PUCCH sCell) is deactivated or the alternative PUCCH Cell is dormant, the UE does not apply time-domain pattern and the UCI is to be transmitted on PCell / SPCell / PUCCH SCell. |

**RAN1#107bis-e (Jan. 2022)**

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| **Agreement**  For PUCCH cell switching based on semi-static time domain pattern, the Type 1 HARQ-ACK codebook construction is based on the k1 set(s) of the PCell / SPCell / PUCCH SCell. |

**PUCCH cell switching based on dynamic indication**

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

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| Agreement: For PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1), the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology of the dynamically indicated target PUCCH cell. |

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

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| **Agreement**  In addition to HARQ-Ack of PDSCH dynamically scheduled by a DCI indicating a PUCCH carrier, the dynamic target carrier indication also applies to:   * HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI based on the indication in the activation DCI * HARQ-ACK corresponding to the SPS Release DCI based on the indication in the release DCI * triggered PUCCH for Rel-16 Type 3 CB, Rel-17 enh. Type 3 CB of smaller size and Rel-17 one-shot triggering for HARQ-Ack retransmission based on the indication in the triggering DCI * FFS: Additional cases |

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

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| **Agreement**  UE does not expect overlapping PUCCH slots with dynamic PUCCH cell indication on more than one cell, i.e., gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot.  **Agreement**  For PUCCH cell switching based on dynamic indication in the DCI,  introduce a new, dedicated DCI field for the DCI scheduling PDSCH to indicate the target PUCCH cell.  **Agreement**  In addition, the dynamic target PUCCH cell indication also applies to HARQ-ACK corresponding to SCell dormancy indication without scheduling PDSCH.  **Agreement**  Support PUCCH cell switching based on dynamic indication in the DCI using DCI format 1\_2 for a UE supporting DCI format 1\_2.   * The presence of the ‘PUCCH carrier switching’ bitfield in DCI format 1\_2 is RRC configured.   **Conclusion**  There is no consensus to support multiplexing of HARQ-ACK (without dynamic PUCCH cell indication), SR and P/SP-CSI on the dynamically indicated PUCCH cell (other than PCell / PSCell / PUCCH-SCell) in Rel-17.   * FFS: further handling, incl. e.g., UE does not expect overlapping HARQ-ACK (without dynamic PUCCH cell indication), SR and P/SP-CSI or overlapping HARQ-ACK (without dynamic PUCCH cell indication), SR and P/SP-CSI is to be dropped * FFS: overlapping definition for SR and P/SP-CSI in terms of PUCCH slot or PUCCH resource |

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

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| **Conclusion**  For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH PUCCH cell.   * The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the alternative PUCCH cell. |

**RAN1#107bis-e (Jan. 2022)**

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| **Agreement**  For dynamic PUCCH cell switching, the Type 1 HARQ-ACK codebook construction is based on the k1 set(s) of the dynamically indicated PUCCH cell. |

* 1. Summary of companies input in their contributions

**Generic for PUCCH carrier switching:**

**Type 1 CB construction by ZTE [6]:** The Type 1 HARQ-ACK codebook construction for PUCCH cell switching is based on the k1 set(s)

* of the PCell / SPCell / PUCCH Scell for semi-static PUCCH cell switching
  + If the determined PUCCH cell for transmitting the Type 1 codebook is PCell, the determined PUCCH slot is regarded as "slot n", and then UE completes the Type 1 codebook construction based on "slot n" by reusing the current Type 1 codebook construction mechanism.
  + Otherwise, the slot of the PCell that overlaps the determined PUCCH slot is regarded as "slot n", then UE completes the Type 1 codebook construction based on "slot n" by reusing the current Type 1 codebook construction mechanism.
* of the dynamically indicated PUCCH cell for dynamic PUCCH cell switching
  + If the indicated PUCCH cell for transmitting Type 1 codebook is PCell, then UE completes the Type 1 codebook construction based on indicated PUCCH slot by reusing the current Type 1 codebook construction mechanism.
  + Otherwise, the indicated PUCCH cell is regarded as "Nominal PCell", the PCell is regarded as "Nominal Scell", and the indicated PUCCH slot is regarded as "Nominal slot n", then UE completes the Type 1 codebook construction based on "Nominal slot n" by reusing the current Type 1 codebook construction mechanism between the "Nominal PCell" and the "Nominal Scell".
* *Moderator comment*: Did ZTE the change in the latest editor draft CR to 38.214 after RAN1#107bis-e. It seems this is captured there already, or do you see something missing there? If you still see something missing, please contact the moderator offline with a potential TP on what is missing to potentially bring this up in a later email discussion round.

**Clarification on dormant UL/DL active BWP by ETRI [14]:**

* Alt 1: … the PUCCH-sSCell is activated and does not switch into a dormant UL/DL active BWP.
* Alt 2: … the PUCCH-sSCell is activated and is not configured to have a dormant UL/DL active BWP.
* 🡪 Either dormant BWP is allowed to configure or is prohibited to configure to the PUCCH-sSCell.

**Final points on DCI field size alignment by Intel [15]:**

* For PUCCH carrier switching based on dynamic indication and/or semi-static pattern, a UE does not expect the size/presence of ‘ChannelAccess-CPext’ DCI field to vary across PCell / SPCell / PUCCH SCell and sSCell
* For PUCCH carrier switching based on dynamic indication and/or semi-static pattern,pply the same handling for ‘Second TPC command for scheduled PUCCH’ field size determination and zero-bit padding as for PRI and PDSCH-to-HARQ\_feedback

**PUCCH carrier switching based on dynamic indication:**

**SPS operation:**

* **Option 1:** **For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).**
  + ***The UE does not expected to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI in a slot overlapping with a PUCCH slot with UCI on PCell / SPCell / PUCCH-SCell slot.*** 
    - **The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the PUCCH sScell.**
  + **Support:** HW/HiSi [1], New H3C [4],vivo [5], CATT [8], CAICT [12], Panasonic [13], Intel [15], NEC [17],
  + **Further details:**
    - HW/HiSi [1]: For dynamic PUCCH cell switching, if the HARQ-ACK for the first SPS PDSCH is indicated on the PUCCH sSCell based on the activation DCI,
      * the UE determines for the first SPS PDSCH a k1 value from the PUCCH sSCell’s K1 set according to the K1 indicator field in the activation DCI
      * the UE determines for the other SPS PDSCHs without associated DCI a k1 value from PCell’s K1 set according to the K1 indicator field in the activation DCI
    - vivo [5]: When HARQ-ACK corresponding to the PDSCH scheduled by an SPS activation DCI is indicated to be reported on the PUCCH sSCell, the K1 value for SPS PDSCH(s) corresponding to the SPS activation DCI is determined based on the K1 indicator field in the SPS activation DCI, as well as the K1 set for the PCell/PSCell/PUCCH-SCell.
    - CAICT [12]: When dynamic PUCCH cell switching is configured, if the DCI is for SPS PDSCH activation, the PDSCH-to-HARQ\_feedback timing indicator field value maps to the Pcell’s K1 set.
* **Option 2: For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).** 
  + **The UE does not expected to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI.**
  + **Support:** Nokia/NSB [3] (2nd preference), CATT [8], Spreadtrum [10], Intel [15], LG [20]
* **Option 3: For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI (including the first SPS PDSCH activated by Activation DCI) is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI** 
  + ***Note: This changes an earlier agreement in terms of handling for the first SPS PDSCH activated by Activation DCI***
  + **Yes:** Nokia/NSB [3] (1st preference), DOCOMO [9], Samsung [18] (2nd preference, ‘It is also OK…’)
* **Option 4: For dynamic PUCCH cell switching, all PUCCH transmissions with HARQ-ACK for SPS PDSCH receptions of a SPS configuration are on the cell indicated by the DCI format activating the SPS PDSCH receptions.**
  + **Support:** Samsung [18]

**Other:**

* HW/HiSi [1], Intel [15]: Joint operation between PUCCH repetition and dynamic PUCCH carrier switching can be supported
  + HW/HiSi [1]: with negligible spec impact
  + Intel [15]: the cell for PUCCH repetitions transmission is fixed to the same cell as the initial PUCCH repetition
* vivo [5]: Clarify that SR resource configuration(s) and/or CSI report configuration(s) cannot be configured in the PUCCH Config(s) for the PUCCH sSCell (as SR and/or CSI transmission on PUCCH sSCell is not possible).
* Intel [15] suggesting further clarification on the PCell / PUCCH sSCell overlapping as:
  + Clarify that the valid PUCCH resource on Pcell means PUCCH resources before multiplexing on Pcell
  + Clarify that for different priority UCI, any PUCCH resource before multiplexing/prioritization is considered

**PUCCH carrier switching based on semi-static configuration / time-domain pattern:**

**PUCCH repetition operation:**

* **Alt. 1:** **The target cell is determined for each PUCCH repetition individually (i.e., switching within the repetition bundle supported):** 
  + **Support (4):** ZTE [6], Panasonic [13] (1st preference), Samsung [18], QC [19]
  + **Details:**
    - ZTE [6]
      * Supported at least for equal PUCCH length on PCell and PUCCH sSCell
      * PUCCH resources corresponding to PUCCH repetitions other than the first PUCCH repetition are determined from the determined PUCCH cell based on the PRI in the (activated) DCI corresponding to the PUCCH.
      * UE expects that PUCCH resources from PCell/SPCell/PUCCH SCell and PUCCH sScell have the same number of symbols for each PUCCH repetition.
    - Panasonic [13]:
      * The required number of repetition is derived according to the defined number of repetition associated to the cell initiating the PUCCH repetitions.
      * For the other cell, the effective PUCCH transmission is counted towards the required number of repetitions.
    - NEC [17]:
      * UE determines the PUCCH resource for repetition on each target cell based on the same PUCCH resource indicator value from the different PUCCH resource sets of the corresponding PUCCH cells
      * In case of more than one overlapping PUCCH slot on the PUCCH SCell with a single PUCCH slot on PCell, PUCCH repetitions are mapped to each of the overlapping PUCCH slot on the PUCCH sSCell.
    - Samsung [18]
      * If more than one slot on the PUCCH-sSCell overlaps with a slot on the PCell, all slots where the PUCCH can be transmitted on the PUCCH-sSCell are used.
    - QC [19]
      * A UE does not expect different number of REs in the PUCCH resources to transmit the repetitions.
* **Alt. 2A – RAN1#107bis-e Mod Proposal 11:** **For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported** 
  + ***A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions, i.e., the repetition is post-poned as in Rel-16.***
  + **Support (12):** HW/HiSi [1], Ericsson [2], Nokia/NSB [3], New H3C [4], vivo [5] (to retain reliability), CATT [8], Spreadtrum [10], CAICT [12], Panasonic [13] (2nd preference), NEC [17], QC [19], LG [20]
* **Alt. 2B – same cell but drop PUCCH: For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported.** 
  + ***A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and the PUCCH repetition is dropped (i.e. total number of repetitions not guaranteed).***
  + **Support (3):** vivo [5] (to retain latency), DOCOMO [9], Intel [15]
* **Alt. 2C – switching within bundle not expected: For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported.** 
  + ***A UE does not expect the cell switching pattern to indicate a different cell for a PUCCH repetition comparing to the initial PUCCH repetition***
  + **Support (1):** Intel [15]

**SPS PUCCH resource using n1PUCCH-AN (potential RRC impact)**

* vivo [5] raises the issue of *n1PUCCH-AN* being configured in SPS-Config and therefore is not separately available for PCell and PUCCH sSCell. Two alternatives on the handling are presented (where Alt. 2 is having RRC impact):
  + *Alt. 1: SPS-Config->n1PUCCH-AN corresponds to a configured PUCCH resource on the PCell/PSCell/PUCCH-SCell, as well as a configured PUCCH resource on the PUCCH sSCell, where the two configured PUCCH resources have the same resource ID.*
  + *Alt. 2: SPS-Config->n1PUCCH-AN can be extended so that two resource IDs can be configured independently for the PCell/PSCell/PUCCH-SCell and the PUCCH sSCell, respectively.*

**Operation for SR & CSI**

* CSI reporting:
  + When CSI reporting on PUCCH is configured on both PCell/PScell/PUCCH-Scell and alternate Scell, PUCCH cell pattern is applied to determine whether CSI PUCCH will be transmitted or not: DOCOMO [9]
    - *Check discussion in Sec. 2.1.1 of [9] describing the problem / issue*
  + When CSI reporting on PUCCH is configured on both the PCell/PSCell/PUCCH-SCell and the PUCCH sSCell, corresponding CSI PUCCH resource(s) on a PUCCH cell will be validated based on the time domain pattern: vivo [5]
* When an SR configuration is triggered, PUCCH resource(s) of the associated SR resource configuration(s) on corresponding PUCCH cell(s) will be validated based on the time domain pattern: vivo [5]

**Order of semi-static PUCCH cell switching and UCI multiplexing:**

* CATT [8]: Semi-static PUCCH cell switching should be performed before UCI multiplexing/prioritization.

**Time point clarification on the activation / deactivation of Scell:**

* CATT [8]:
  + If UE receives in a PDSCH an activation command for the SCell ending in slot n, UE applies the PUCCH cell switching time-domain pattern from the first slot after SCell is active, where the active timing is determined based on the minimum requirement defined in [10, TS 38.133].
  + If UE receives in a PDSCH a deactivation command for the SCell ending in slot n, the UE would not apply the PUCCH cell switching time-domain pattern from slot n, where slot is defined in section 4.3 of TS38.213.
  + If the sCellDeactivationTimer associated with the SCell expires in slot n, the UE would not apply the PUCCH cell switching time-domain pattern from the first slot that is after slot  where  is the SCS configuration for PDSCH reception on the secondary cell.
  + If UE detects a DCI indicating SCell dormancy, the UE would not apply the PUCCH cell switching time-domain pattern from the first slot after slot , where slot is the slot indicated for PUCCH transmission with HARQ-ACK information corresponding to the DCI and is the SCS configuration for the PUCCH.
  + *Moderator comment:* Are you proposing any additional time point clarifications on top of the current specs, when an Scell is considered as active? If not, is there a need for any additional agreement (i.e. if we don’t agree any additional time point clarification, the ones from Rel-16 should automatically apply – i.e. no further agreements needed)? If still thinking some additional agreement would be needed, please contact the moderator offline.

**Other:**

* Huawei/HiSi [1]: For PUCCH cell switching based on semi-static operation, for the case the PCell slot/sub-slot to be longer than the target PUCCH cell sub-slot and the earliest target PUCCH cell sub-slot is partially overlapping with the PCell slot/sub-slot, the first target PUCCH slot fully overlapping with the PCell slot is used for UCI transmission
  + *Moderator comment:* based on the latest decisions, it seems that such scenario is not supported. The following agreement here is in place that basically removes such cases (see below). If HW thinks still further clarifications are needed, please contact the Moderator offline.   
    *Agreement*

*For PUCCH cell switching based on semi-static operation, adopt Alt. 4, i.e., the UE does not expect a semi-static PUCCH cell configuration, where a single target PUCCH slot / sub-slot would be overlapping with more than one PCell slot/sub-slot.*

* DOCOMO [9]: Keep the same sub-slot/slot configuration for corresponding priority on the multiple PUCCH cells
  + *Moderator comment:* Do we need further any restrictions /decisions – as we have related restrictions already in place? If DOCOMO thinks still further clarifications are needed, please contact the Moderator offline.  
    *Agreement*

*For PUCCH cell switching based on semi-static operation, adopt Alt. 4, i.e., the UE does not expect a semi-static PUCCH cell configuration, where a single target PUCCH slot / sub-slot would be overlapping with more than one PCell slot/sub-slot.*

* QC [19]
  + Support semi-static PUCCH carrier switching per PHY priority.
  + Support semi-static PUCCH carrier switching for SPS HARQ corresponding to SPS occasion about to expire, i.e. N slots prior to the arrival of the new SPS occurrence.

**Identified needed specs changes based on available decisions:**

***HW/HiSi [1] raising the issue of the missing restrictions based on the following agreements:***

|  |
| --- |
| **Agreement:** UE does not expect overlapping PUCCH slots with dynamic PUCCH cell indication on more than one cell, i.e., gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot.  **Conclusion:** For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH PUCCH cell.   * The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the alternative PUCCH cell. |

… and suggest the following TP:

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| **------------------ Text Proposal for 38.213 Clause 9.A ------------------**  9.A PUCCH Cell Switching  This clause is applicable when a UE is provided a PUCCH-sSCell by *pucch-sSCell* and the PUCCH-sSCell is activated and does not have a dormant UL/DL active BWP.  …  If a UE is provided *pucch-sSCellDyn* or *pucch-sSCellDynDCI-1-2*, a corresponding DCI format associated with generation of HARQ-ACK information by the UE can include a PUCCH cell indicator field, as described in [5, TS 38.212], that indicates whether the PUCCH transmission with the HARQ-ACK information by the UE is on the Pcell or on the PUCCH-sSCell.  The UE does not expect to be indicated by a DCI with the PUCCH cell indicator field to transmit HARQ-ACK information on a slot for the active UL BWP of the PUCCH-sSCell to overlap with a slot including another UCI on the active UL BWP of the PCell, unless the UCI on the active UL BWP of the PCell overlaps with a symbol indicated as downlink by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigDedicated, or indicated for a SS/PBCH block by ssb-PositionsInBurst, or belonging to a CORESET associated with a Type0-PDCCH CSS set, and is cancelled according to clause 11.1.  … |

***NEC [17] on the missing UL BWP change on PUCCH sSCell for Type 1 CB construction:***

* While when the target cell is PUCCH-sSCell for Type-1 HARQ-ACK codebook transmission, if the active UL BWP of PUCCH-sSCell changes, the HARQ-ACK for PDSCH reception(s) on the DL BWP prior to the UL BWP switching should be not transmitted. It seems that impact of the active BWP change of PUCCH-sSCell on Type-1 HARQ-ACK codebook construction is not captured in the specification yet. Therefore, we give the following TP to capture impact of the active BWP change of PUCCH-sSCell on Type-1 HARQ-ACK codebook construction.

|  |
| --- |
| 9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel  For a serving cell , an active DL BWP, and an active UL BWP, as described in clause 12, the UE determines a set of occasions for candidate PDSCH receptions for which the UE can transmit corresponding HARQ-ACK information in a PUCCH in slot . If serving cell is deactivated, the UE uses as the active DL BWP for determining the set of occasions for candidate PDSCH receptions a DL BWP provided by *firstActiveDownlinkBWP-Id*. The determination is based:  a) on a set of slot timing values associated with the active UL BWP on the primary cell or, if the PUCCH transmission is indicated by a DCI format to be on the PUCCH-sSCell as described in clause 9A, on a set of slot timing values associated with the active UL BWP on the PUCCH-sSCell  [….]  Set  - index of occasion for candidate PDSCH reception or SPS PDSCH release  Set  Set  Set  to the cardinality of set  Set *k* =0 – index of slot timing values , in descending order of the slot timing values, in set  for serving cell  If a UE is not provided *ca-SlotOffset* for any serving cell of PDSCH receptions and for the serving cell of corresponding PUCCH transmission with HARQ-ACK information  while  if or *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook  Set  – index of a DL slot overlapping with an UL slot  Set to a number of DL slots overlapping with UL slot if *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook; otherwise,  while  Set  to the set of rows  Set  to the cardinality of  Set  – index of row in set  if slot  starts at a same time as or after a slot for an active DL BWP change on serving cell  or an active UL BWP change on the PCell or an active UL BWP change on the PUCCH-sSCell and slot is before the slot for the active DL BWP change on serving cell  or the active UL BWP change on the PCell or an active UL BWP change on the PUCCH-sSCell, or *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook and slot overlaps with UL slot , , where is a DL slot with a smallest index among DL slots overlapping with UL slot ,;  else  [….] |

* 1. 1st round of email approvals

**Final points on DCI field size alignment**

Intel discusses that it should still be clarified, that for NR-U, where no further specification impact has been concluded, it would be good to still conclude that a DCI field size variation is not expected by the UE.

**Proposed conclusion 6.2.1: For PUCCH carrier switching based on dynamic indication and/or semi-static pattern, a UE does not expect the size/presence of ‘*ChannelAccess-CPext*’ DCI field to vary across PCell / SPCell / PUCCH SCell and PUCCH sSCell.**

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| Support companies | Nokia/NSB, Intel, Ericsson, QC, Lenovo New H3C, DOCOMO, Panasonic, LG, NEC, ETRI, Samsung, Sony, MediaTek |
| Objecting companies | Huawei/Hisi |

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| *Company* | *Comments* |
| Intel | We think that the conclusion from the last meeting on NR-U + PUCCH carrier switching scenarios does not fully cover the spec and UE behaviour expectation from such a combination. Thus the proposal 6.2.1 is important to have. |
| Huawei/Hisi | The application of PUCCH carrier switching on NRU (which is present only on shared spectrum) is not justified. Thus the conclusion could be modified as:  **Proposed conclusion 6.2.1: For PUCCH carrier switching based on dynamic indication and/or semi-static pattern, a UE does not expect the ~~size/~~presence of ‘*ChannelAccess-CPext*’ DCI field ~~to vary across~~ for PCell / SPCell / PUCCH SCell and PUCCH sSCell**  38.212   |  | | --- | | - ChannelAccess-CPext – 2 bits indicating combinations of channel access type and CP extension as defined in Table 7.3.1.1.1-4, or Table 7.3.1.1.1-4A if *ChannelAccessMode-r16* = "*semistatic*" is provided, for operation in a cell with shared spectrum channel access; 0 bit otherwise. | |
| Samsung | OK as a conclusion without specification impact as otherwise it would be a gNB misconfiguration and the UE does not need to care. |
| Moderator | I guess re-iterating this may not really help. Intel / Sergey & Yuan / HW, could you please try to coordinate offline on a potentially agreeable proposal for HW? (to not spam the whole group if the situation continues to be like that)?  I can bring this back later on, when having some ‘acceptable version’ by Sergey Yuan. |

Intel also raises the issue of the 2nd TPC command for scheduled PUCCH for M-TRP operation. Let’s simply check if this is agreeable or not:

**Proposal 6.2.2: For PUCCH carrier switching based on dynamic indication and/or semi-static pattern, apply the same handling for ‘Second TPC command for scheduled PUCCH’ field size determination and zero-bit padding as for PRI and PDSCH-to-HARQ\_feedback.**

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| Support companies | Intel, QC, Panasonic Huawei/Hisi |
| Objecting companies | Samsung |

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| *Company* | *Comments* |
| Intel | In general, we prefer not to artificially limit combinations of features, which can be straightforwardly supported. This is also applicable to m-TRP enhanced PUCCH transmission and PUCCH carrier switching. Thus, our preference is to handle the DCI field size of ‘Second TPC command for scheduled PUCCH’ alignment same way as for PRI and k1 set. Note, in different PUCCH-Config structures for different cells the presence of this field may be separately configured. |
| Samsung | OK as a conclusion without specification impact – gNB can handle. |
| Moderator | There was an objection by Samsung.  @Intel / Sergey could you please try to coordinate offline on a potentially agreeable proposal with Samsung / Aris? (to not spam the whole group if the situation continues to be like that)?  I can bring this back later on, when having some versionby Sergey which is also acceptable to Aris / Samsung? |
| Samsung2 | The problem is that “same handling” is highly likely to lead again to specification text for what was a “conclusion” – “conclusions” are not “provisions” and hence do not have specification impact. In the present case, the gNB could transparently do what current specifications force the UE to implement – having specifications for such cases is not a good thing. |

**PUCCH repetition with dynamic PUCCH cell switching**

Maybe it would be worth agreeing to support this as proposed by Intel & HW/HiSi - as the discussions on the PUCCH repetition only focused on semi-static operation, assuming all the PUCCH repetitions are on the indicated PUCCH cell.

**Proposal 6.2.3: Support joint operation of PUCCH repetition and dynamic PUCCH carrier switching in Rel-17.**

* **The PUCCH cell indication in the DCI scheduling the PUCCH is applicable for all the PUCCH repetitions.**

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| Supporting companies | Nokia/NSB, Intel, Ericsson, QC, Lenovo Huawei/Hisi New H3C, vivo, DOCOMO, Panasonic, CATT, ZTE, LG, NEC, ETRI, MediaTek |
| Objecting companies | Samsung |

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| *Company* | *Comments* |
| Samsung | As it has been repeatedly explained, there is no need and it is actually highly detrimental to have all PUCCH repetitions on the PUCCH-sSCell.  The case of PUCCH repetitions is a primary use case for PUCCH cell switching. |
| Moderator | Not sure what to do with this, except discussing this in GTW session (if having time). Not bringing this to 2nd round again – but directly to GTW. |
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**Further clarifications on dynamic PUCCH cell switching:**

vivo [5] raises the issue, that SR resource configurations and CSI report configurations should not be configured in the PUCCH config(s) for the PUCCH sSCell, as SR and CSI transmission on the PUCCH sSCell is not supported.

**Proposal 6.2.4: A UE configured with dynamic PUCCH cell switching is not expecting to be configured with SR resource configuration(s) and/or CSI report configuration(s) in the PUCCH configuration(s) of the PUCCH sSCell.**

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| Supporting companies | Nokia/NSB, Intel, Ericsson (but see the comment) Huawei/Hisi New H3C, vivo, DOCOMO, Panasonic, CATT, ZTE, LG, NEC, ETRI, [Samsung] |
| Objecting companies | QC |

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| *Company* | *Comments* |
| Ericsson | We are Ok with the intention, but we are not sure if the proposal is really needed.  SR and CSI are not subject to dynamic PUCCH cell switching. Therefore, their configuration is not using the PUCCH sSCell at all.  Then, when dynamic PUCCH cell switching is kicked in for HARQ-ACK, in slots that there is SR and CSI, the dynamic indication should follow the cell (Pcell/PsCell/..) of the SR or CSI. Because we agreed that there will be only one cell with PUCCH at the time. |
| QC | Similar comment as Ericsson, we are not sure if this proposal is needed. It is obvious that CSI or SR does not follow dynamic DCI or the dynamic PUCCH cell switch has nothing to do with CSI and SR.  Given that the RRC might reconfigure this UE to semi-static PUCCH cell switch, it is also a little stringent to prohibit SR or CSI to be “configured” on Scell. |
| ZTE | Share some views as Ericsson. We think the sentence can be a proposal:  When dynamic PUCCH cell switching is kicked in for HARQ-ACK, in slots that there is SR and CSI, the dynamic indication should follow the cell (Pcell/PsCell/..) of the SR or CSI. |
| Samsung | Agree to the proposed statement as a conclusion. It would be a gNB misconfiguration since there are no specified UE procedures for it. |
| Moderator | Seems that some companies think there is no need for such restriction. @vivo (as originating company), companies may have a point that anyhow if you are configured with dynamic PUCCH cell switching, these configurations would anyhow not be used – so why to prevent the related configuration. If combing back to this, there would be a need to say why such restriction is needed.  @all: If having good suggestion on how to proceed on this in a later round (e.g. as a conclusion or which some changed description), please let the moderator to know offline. Do not plan to continue the discussion directly in the 2nd round. |

Intel [15] raises the issue on which PUCCH resource is to be considered in the limitations given by the dynamic PUCCH cell switching. Intel is suggesting to clarify the following:

* Clarify that the valid PUCCH resource on Pcell means PUCCH resources before multiplexing on Pcell
* Clarify that for different priority UCI, any PUCCH resource before multiplexing/prioritization is considered

**Proposed Conclusion 6.2.5: The earlier RAN1 conclusion from RAN1#107-e is further clarified as (with the additions in red):**

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| --- |
| **Conclusion**  For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH ~~PUCCH~~ cell.   * The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the alternative PUCCH cell.   + A valid PUCCH resource on Pcell means PUCCH resources before multiplexing on Pcell * For different priority UCI, any PUCCH resource before multiplexing/prioritization is considered |

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| Supporting companies | Intel Huawei/Hisi, DOCOMO (with further clarification), Panasonic, CATT, LG, NEC |
| Objecting companies | Ericsson (see comment), QC, Lenovo, ZTE, Samsung |

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| --- | --- |
| *Company* | *Comments* |
| Ericsson | Is it really necessary? The feature is about PUCCH cell switching, so what is important to determine the cell for PUCCH. After that is determined, everything else follows as if it was a PCell, and that also include the PUCCH resource, etc. |
| QC | We also do not see the need for this proposal. The UCI dropping on PCell/SPCell/PUCCH SCell follows whatever existing rule in spec. The key of the past agreement is that the dropped UCI is exempted for the condition check in the main text of the conclusion. We don’t see the conclusion has any ambiguity. |
| Lenovo | We think the existing conclusion is sufficient. |
| Huawei/Hisi | Agree with the intention, as it is simple for the UE not to handle/multiplex the potential UCIs on PCell when it receives the DCI indicating PUCCH on SCell. |
| vivo | About the PUCCH resources that can be exempted for dynamic PUCCH carrier switching, there can be two understandings for above conlusion,  Alt.1: the PUCCH resource carrying the UCI after multiplexing on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted, this is more aligned with Rel-16 intra-UE multiplexing rule.  Alt.2: the PUCCH resource carrying the UCI before multiplexing on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted, this option is NOT aligned with Rel-16 intra-UE multiplexing rule, but it maybe simpler.  We slightly prefer Alt.1. |
| DOCOMO | We think the issue is valid, that the PUCCH slot collision checking is for PUCCH resource before or after multiplexing/prioritization. We are fine with current proposal that PUCCH resource on PCell for the collision checking is before UCI multiplexing/prioritization on Pcell. Vivo’s mofication (Alt 1 or Alt 2) is also fine.  Additionally, we think UCI multiplexing on PUSCH should also be clarified, as following examples. |
| CATT | We think the proposal is simpler from implementation perspective. |
| ZTE | The current specification describes the the collision checking is after UCI multiplexing. What's the benefit to revert the behaviour with much cost? |
| LG | We believe the agreement was made to avoid any collision/multiplexing handling between configured UCI transmission and dynamically switched HARQ-ACK transmission. Thus current agreement can be read as Alt. 2 in vivo’s comment. |
| NEC | We think the issue is valid and agree with the intention. |
| Samsung | A main reason for the agreement was to avoid additional complications in determining timelines, expecially for different SCS (as that would likely be the case). The proposed amendment overturns that. |
| Moderator | Let’s try to clarify Alt. 1 or Alt. 2 by vivo in the 2nd round. Clearly, the current agreement seems to be more hinting towards Alt. 1. |

**PUCCH carrier switching based on semi-static pattern**

**SPS PUCCH resource using n1PUCCH-AN (potential RRC impact)**

vivo [5] raises the issue of *n1PUCCH-AN* being configured in SPS-Config and therefore is not separately available for PCell and PUCCH sSCell. Two alternatives on the handling are presented (where Alt. 2 is having RRC impact):

* *Alt. 1: SPS-Config->n1PUCCH-AN corresponds to a configured PUCCH resource on the PCell/PSCell/PUCCH-SCell, as well as a configured PUCCH resource on the PUCCH sSCell, where the two configured PUCCH resources have the same resource ID.*
* *Alt. 2: SPS-Config->n1PUCCH-AN can be extended so that two resource IDs can be configured independently for the PCell/PSCell/PUCCH-SCell and the PUCCH sSCell, respectively.*

Based on moderator understanding, Alt. 1 is basically what the current 38.213 would imply (so Alt. 1 would not require any specification or RRC changes). And if Alt. 1 would be adopted, gNB could still be the appropriate configuration of PUCCH resource ID mapping to PUCCH resources in PCell & PUCCH sSCell have the intended mapping on the two cells. In addition, gNB could also still configure the UE with *SPS-PUCCH-AN-List* to provide the UE with a different PUCCH resources for PUCCH cell and PUCCH sSCell, which solves the problem as this is configured within PUCCH-config of each of the PUCCH cells and is used instead of *n1PUCCH-AN* if configured. In contrast, Alt. 2 would first of all have RRC impact (i.e. we need to define an additional RRC parameter in SPS-Config) and would also require corresponding changes to 38.213.

So let’s see if we could agree the Alt. 1 interpretation as a conclusion below. I bring this conclusion forward (i.e. going for Alt. 1) as this is the current specifications and for a change there (e.g. going for Alt. 1) would require an agreement to the currently specified behavior (which seems to be less likely).

In case you do not support the proposed conclusion below, please indicate if either Alt. 2 or any different interpretation is according to your views applicable.

**Proposed Conclusion 6.2.6: For PUCCH cell switching, *n1PUCCH-AN* in *SPS-Config* corresponds to a configured PUCCH resource on the PCell/PSCell/PUCCH-SCell, as well as a configured PUCCH resource on the PUCCH sSCell, where the two configured PUCCH resources have the same resource ID.**

* ***Note: this seems the operation based on the current version of 38.213***

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| Supporting companies | Nokia/NSB, DOCOMO, LG |
| Objecting companies | Intel, Ericsson, Lenovo Huawei/Hisi New H3C, Panasonic, ZTE, NEC, ETRI, Samsung |

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| --- | --- |
| *Company* | *Comments* |
| Intel | vivo arguments are understood, we would like to see if Alt.2 would be acceptable |
| Ericsson | It seems Alt-2 is a cleaner approach. The same way that the configuration of dedicated PUCCH resource sets are extended to the PUCCH sSCell, it would be cleaner to do the same extension for PUCCh resource for DL SPS.  Also, maybe applying the same configuration for both cells are not suitable, since the configuration involves payload range and PUCCh resource.  **We acknowledge this is high priority since it has RRc impact.** |
| QC | Either Alt-1 or Alt 2 can work. We slightly prefer Alt-2, but we can accept Alt-1 as well. |
| Lenovo | The proposed conclusion overly limits scheduling flexibility. We prefer Alt. 2. |
| Huawei/Hisi | We prefere Alt.2 as a more flexible solution, as the PUCCH resource configurations of the two PUCCH cells may be different. |
| vivo | We prefer Alt.2 for better flexibility. We understand at this stage, the bar for introducing the RRC parameter is high, but it would be good to check whether Alt.2 is acceptable. |
| Panasonic | The possibility of having separate PUCCH resource IDs improves the flexibility. |
| CATT | We also prefer Alt. 2 for better flexibility. |
| LG | We think Alt. 1 is clearly aligned with current framework of PUCCH cell switching. We prefer Alt. 1 for consistency. |
| NEC | Both two alternatives are fine to us. Alt.2 is slightly preferred for flexibility. |
| Huawei/Hisi2 | Note that *CSI-ReportConfig -> PUCCH-CSI-Resource* may also be extended to SCell following the same principle of Alt.2. |
| ETRI | We understand the intention, and the gNB may not allocate an appropriorate index to *n1PUCCH-AN.* |
| Samsung | There are separate *PUCCH-Config*s and no reason for that to not apply to *n1PUCCH-AN* |
| Moderator | Let’s try in the 2nd round to introduce a new RRC parameter. |

**PUCCH repetition and semi-static PUCCH cell switching**

On the PUCCH repetition operation, there are 14 companies suggesting keeping the PUCCH repetition on the cell of the first PUCCH repetition (Alt. 2A, 2B or 2C) whereas 4 companies think there should be PUCCH carrier switching within a PUCCH repetition bundle to be supported (Alt. 1).

12 companies support Options 2A (post-pone a repetition from a PUCCH slot on a different PUCCH cell), 3 companies prefer 2B (drop a repetition from a PUCCH slot on a different PUCCH cell) and one company suggests Alt. 2C (UE does not expect the PUCCH switching pattern to indicate a different cell).

And maybe we could further reduce the number of options to be further discussed in the first round, by focusing on Alt. 1 (with details being FFS) and Alt. 2A (which seems the most popular option from the Alt. 2 ‘camp) for further discussions. I don’t expect that we can resolve (down-select) by email from 4 to 1 option, but having only two options left would be at least one tiny step closer to getting this resolved:

**Proposal 6.2.7: For semi-static PUCCH cell switching with PUCCH repetition, further down-select from the following two alternatives:**

* **Alt. 1: The target cell is determined for each PUCCH repetition individually (i.e., switching within the repetition bundle supported)**
  + **FFS further details and/or restrictions**
* **Alt. 2A: For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported** 
  + **A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions, i.e., the repetition is postponed as in Rel-16.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Ericsson, QC Huawei/Hisi New H3C, vivo, Panasonic, CATT, ZTE, LG, NEC, ETRI, MediaTek |
| Objecting companies | Samsung |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | From the two remaining, we support Alt. 2A. |
| Intel | We think Alt. 2C is also a viable option. But we won’t object limiting the discussion to Alt 1 vs 2A |
| Ericsson | Support 2A. |
| Lenovo | Okay with Alt 2A. |
| Huawei/Hisi | Support 2A. |
| New H3C | Support 2A |
| vivo | Our preference is Alt.2A. Alt.1 requires more discussions and spec efforts. |
| DOCOMO | We think Alt. 2C is the simplest one. But no objection. Prefer Alt 2A to Alt 1. |
| Panasonic | Alt. 1 can achieve a lower latency. |
| CATT | Support Alt. 2A. |
| ZTE | Support 1 |
| LG | Support Alt. 2A |
| NEC | Both two alternatives are fine to us. Alt.2A is slightly preferred for simplicity. |
| ETRI | Support 2A |
| Samsung | We do not support 2A, there is no reason for it as it has been repeatedly explained, and do not agree to a proposal that includes it as a possibility. |
| Moderator | Samsung objected to the down-selection, even though Alt. 1 is included. Need to take this in GTW (seems not possible to proceed here further). |

**SR operation with semi-static PUCCH cell switching**

vivo [5] discusses SR operation. Let’s check if their proposed handling would be agreeable.

**Proposal 6.2.8: When an SR configuration is triggered, PUCCH resource(s) of the associated SR resource configuration(s) on corresponding PUCCH cell(s) will be validated based on the time domain pattern.**

|  |  |
| --- | --- |
| Supporting companies | Vivo, DOCOMO, Panasonic, ZTE |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Intel | We would like to clarify what would the spec impact for this potential agreement? |
| Ericsson | Same comment as Intel. |
| QC | What proposed in the proposal seems obvious. Same comment as above companies that on whether there is any spec impact? If not, then the proposal seems not needed. |
| Huawei/Hisi | It looks the intention has been captured in the spec.   |  | | --- | | A UE can be provided a periodic cell switching pattern for PUCCH transmissions by *pucch-sSCellPattern.* Each bit of the pattern corresponds to a slot for a reference SCS configuration provided by *tdd-UL-DL-ConfigurationCommon* for the PCell with a value of '0' or a value of '1' indicating, respectively, the PCell or the PUCCH-sSCell as the cell for PUCCH transmissions during the slot of the reference SCS configuration. | |
| vivo | In our opinion, the spec impact is we need to define UE behaviour or define the available PUCCH resource for SR PUCCH trasmissions for semi-static PUCCH cell switching  For example, in TS38.331.for a *PUCCH-Config*, in the description for parameter *schedulingRequestResourceToAddModList*, it should be stated that a PUCCH resource configured by the parameter *resource* in a *SchedulingRequestResourceConfig* configured in *schedulingRequestResourceToAddModList* is valid only when the PUCCH cell corresponding to the *PUCCH-Config* is applicable based on the time domain pattern if semi-static PUCCH cell switching is enabled or its validation can be referred to TS 38.213. Furthermore, when an SR configuration is triggered, only if a PUCCH resource of the associated SR resource configuration(s) is valid, corresponding SR PUCCH transmission will be performed by the UE.  Besides, in the clause 9.A of TS38.213, a general description for SR PUCCH resource validation based on the time domain pattern when semi-static PUCCH cell switching is enabled should also be added to clarify UE behaviour in terms of SR PUCCH trasmissions for semi-static PUCCH cell switching. |
| DOCOMO | Agree with the intention, and same principle should be applied for the case of CSI PUCCH reporting configured on multiple PUCCH cells. |
| ZTE | There is only one general agreement on SR and CSI before, so we need this detailed proposal for specification. |
| LG | Based on Huawei’s comment, it would be Ok to leave since UE knows which slot/cell combination is valid for UL transmission. If further clarification is needed, it could be MAC issue to choose which slot for SR transmission. |
| Samsung | No apparent need for the proposal. |
| Moderator | It seems that several companies think there is no need for such agreement, as this is captured in the specifications already.  @vivo (as originating company), if you still think a specs change is needed, could you maybe bring a related TP to the next meeting (or showing some more details where changes will be needed regarding SR)? But based on this situation, continuing the discussions here seems to be not really helping. |

**Order of semi-static PUCCH cell switching and UCI multiplexing:**

CATT [8] discusses, that it would be good to clarify the order of cell switching and UCI multiplexing / prioritization. Clearly, this should not hurt so let’s see if we could have a related conclusion.

**Proposed Conclusion 6.2.9: Semi-static PUCCH cell switching, i.e. the PUCCH cell determination based on the time-domain pattern, should be performed before UCI multiplexing/prioritization.**

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| --- | --- |
| Supporting companies | Nokia/NSB, Intel, Ericsson, QC, Lenovo Huawei/Hisi New H3C, vivo, CATT, ZTE, LG, NEC, Samsung |
| Objecting companies | DOCOMO |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Intel | Should this be discussed together with 6.2.5? |
| Huawei/Hisi | Same understanding with Intel, that the two proposals are clarifying the same issue. |
| DOCOMO | We don’t think Question 6.2.9 and Question 6.2.5 are discussing the same thing. Since Question 6.2.5 is for dynamic cell switching case, and for inter-cell PUCCH collision checking. However, Question 6.2.9 is for semi-static PUCCH cell switching case, and for intra-cell UCI multiplexing or multiplexing of UCI to PUSCH.  We don’t think the conclusion is needed for Question 6.2.9. UE behavior is clear enough.  We had an agreement in RAN1#106bis-e that PRI is interpreatetd based on target PUCCH cell for PUCCH resource determination. In our understanding, the agreement implies that PUCCH resource is determined after PUCCH cell switching, i.e. no PUCCH resource is determined before cell switching. Since UCI multiplexing/prioritization is based on determined PUCCH resource, it’s natural that UCI multiplexing/prioritization is after cell switching.  **Agreement**  For semi-static PUCCH cell switching, the PUCCH resource indicator (PRI) is interpreted based on the PUCCH configuration of determined target PUCCH cell. |
| CATT | For the relationship with proposal 6.2.5, we share the same view as DOCOMO.  For the comment from DOCOMO, we think the agreement is not clear enough. It is also possible that UE determine the PUCCH resources twice based on PCell and target cell respectively. Regardless, if DOCOMO share the same understanding, a conclusion for clarification should not harm. |
| Moderator | @DCM: Based on your reply, it seems clear that you first determine the target PUCCH cell (i.e. the cell switching) and then apply the multiplexing including the related PUCCH resource selection (e.g. based on PRI). The intention here was exactly to clarify that one. Is there something wrong with the proposed conclusion or do you prefer some wording change here?? |

* 1. 1st round of email discussions

**Clarification on dormant UL/DL active BWP**

ETRI raises the issue that it is not fully clear how to handle dormant UL/DL active BWP.

|  |
| --- |
| Agreement  For semi-static PUCCH cell switching, if the alternative PUCCH cell (i.e. PUCCH sCell) is deactivated or the alternative PUCCH Cell is dormant, the UE does not apply time-domain pattern and the UCI is to be transmitted on PCell / SPCell / PUCCH SCell.  **TS38.213-h00**  9.A PUCCH Cell Switching  …  This clause is applicable when a UE is provided a PUCCH-sSCell by *pucch-sSCell* and the PUCCH-sSCell is activated and does not have a dormant UL/DL active BWP.  … |

According to agreement, the activated serving cell with non-dormant BWP can be used for PUCCH transmissions. The specification describes that the PUCCH-sSCell does not have a dormant BWP. In ETRI’s understanding, this serving cell can have a dormant BWP but does not fall into a dormant BWP, otherwise, the PUCCH-sSCell is not configured to have a dormant BWP. ETRI would like to clarify either alternative below.

**Question 6.3.1: For active dormant UL/DL active BWP handling and PUCCH cell switching, PUCCH cell switching is supported, if**

* **Alt 1: … the PUCCH-sSCell is activated and does not switch into a dormant UL/DL active BWP.**
* **Alt 2: … the PUCCH-sSCell is activated and is not configured to have a dormant UL/DL active BWP.**
* **Other:**

|  |  |
| --- | --- |
| Alt. 1 | QC, DOCOMO, ETRI |
| Alt. 2 | vivo, Nokia/NSB |
| Other | vivo, Nokia/NSB, Samsung |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| vivo | We are fine with Alt.2 simialr as PUCCH SCell. Alternatively, we are also fine with that UE can just fallback to PCell to transmit the PUCCH same as Rel-15/16. |
| DOCOMO | We think Alt 1 provides more flexibility for PUCCH Scell configuration. |
| Nokia/NSB | Agree with vivo. The fallback to PCell could be an option as well.  On Alt. 1: especially with semi-static PUCCH cell switching it will be hard to prevent this (if you want to get the power saving of dormancy as well). |
| LG | We would like to check what common understanding of current agreement and specification is. Our understanding is that configuring PUCCH cell switching itself doesn’t affect to UE behavior related to dormant BWP. |
| ETRI | According to the current specification, the PUCCH-SCell, SpCell does not have a dormant DL BWP, and it is about the search space monitoring. Anyway, the previous agreement does not allow dormant BWP in the activated PUCCH-sSCell, though our understanding is that PUCCH could be transmitted for the UL BWP in the PUCCH-sSCell.  We think the intention of the previous agreement is to transmit PUCCH to the PUCCH-sSCell based on the semi-static pattern. In this sense, we think Alt 1 is more flexible but fine to Alt 2 as well. |
| Samsung | No apparent need for a conclusion or restriction. It is a gNB issue. |

**PUCCH carrier switching based on dynamic indication**

**SPS operation with dynamic PUCCH cell switching**

Basically the same options as discussed last time – are again on the table. The input from different companies is summarized below:

|  |
| --- |
| * **Option 1 (8): For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).**   + ***The UE does not expected to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI in a slot overlapping with a PUCCH slot with UCI on PCell / SPCell / PUCCH-SCell slot.***      - **The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the PUCCH sScell.**   + **Support:** HW/HiSi [1], New H3C [4],vivo [5], CATT [8], CAICT [12], Panasonic [13], Intel [15], NEC [17],   + **Further details:**     - HW/HiSi [1]: For dynamic PUCCH cell switching, if the HARQ-ACK for the first SPS PDSCH is indicated on the PUCCH sSCell based on the activation DCI,       * the UE determines for the first SPS PDSCH a k1 value from the PUCCH sSCell’s K1 set according to the K1 indicator field in the activation DCI       * the UE determines for the other SPS PDSCHs without associated DCI a k1 value from PCell’s K1 set according to the K1 indicator field in the activation DCI     - vivo [5]: When HARQ-ACK corresponding to the PDSCH scheduled by an SPS activation DCI is indicated to be reported on the PUCCH sSCell, the K1 value for SPS PDSCH(s) corresponding to the SPS activation DCI is determined based on the K1 indicator field in the SPS activation DCI, as well as the K1 set for the PCell/PSCell/PUCCH-SCell.     - CAICT [12]: When dynamic PUCCH cell switching is configured, if the DCI is for SPS PDSCH activation, the PDSCH-to-HARQ\_feedback timing indicator field value maps to the Pcell’s K1 set. * **Option 2 (5): For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).**    + **The UE does not expected to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI.**   + **Support:** Nokia/NSB [3] (2nd preference), CATT [8], Spreadtrum [10], Intel [15], LG [20] * **Option 3 (3): For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI (including the first SPS PDSCH activated by Activation DCI) is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI**    + ***Note: This changes an earlier agreement in terms of handling for the first SPS PDSCH activated by Activation DCI***   + **Yes:** Nokia/NSB [3] (1st preference), DOCOMO [9], Samsung [18] (2nd preference) * **Option 4 (1): For dynamic PUCCH cell switching, all PUCCH transmissions with HARQ-ACK for SPS PDSCH receptions of a SPS configuration are on the cell indicated by the DCI format activating the SPS PDSCH receptions.**   + **Support:** Samsung [18] |

Clearly, Option 1 has the largest support between the options, but as discussed by HW/HiSi, vivo & CAICT, we still would need to define which K1 set is to be used by the UE for the first SPS PDSCH – namely the one of the indicated PUCCH cell (PCell or PUCCH sSCell, depending on the indication) as proposed by HW/HiSi, or if independently of the PUCCH cell indication always the set the K1 set(s) from PCell/PSCell/PUCCH-SCell are always used as suggested by vivo & CAICT.

The moderator would like to note here, that there are ongoing Rel-15 maintenance discussions in AI 7.1 on how to handle the HARQ-ACK of the first SPS PDSCH. Therefore, the discussions on the understanding there may also influence finally which Option is to be chosen. Therefore, it seems to better to wait still here a bit having slightly more clarity on the intended Rel-15 UE operation here.

Let’s therefore maybe try in the first round (before the having more clarity on the Rel-15 operation) to see, in case we go for Option 1 above, which K1 set to use for the first SPS PDSCH. Please note, that for the Option 2 & Option 3, clearly the K1 set from PCell/PSCell/PUCCH-SCell is to be used for all SPS HARQ and for Option 4, as the HARQ is always carried on the indicated PUCCH cell, the K1 set(s) of the indicated PUCCH cell would apply here.

**Question 6.3.2: If Option 1 for SPS HARQ-ACK handling with dynamic PUCCH cell switching would be supported,**

* **Alt. 1:** 
  + **For the HARQ-ACK first SPS PDSCH, the UE determines a k1 value from K1 set(s) of the indicated PUCCH cell (PCell/PSCell/PUCCH-SCell or PUCCH sSCell’s ) according to the PDSCH-to-HARQ\_feedback timing indicator field in the activation DCI**
  + **For all other SPS PDSCHs except the first SPS PDSCH, the UE determines a k1 value from K1 set(s) of the PCell/PSCell/PUCCH-SCell according to the PDSCH-to-HARQ\_feedback timing indicator field in the activation DCI**
* **Alt. 2: For all SPS PDSCHs including the first SPS PDSCH, the UE determines a k1 value from K1 set(s) of the PCell/PSCell/PUCCH-SCell according to the PDSCH-to-HARQ\_feedback timing indicator field in the activation DCI.**
* **Other:**

|  |  |
| --- | --- |
| Alt. 1 | Intel, QC Huawei/Hisi, vivo, DOCOMO, Panasonic, Nokia/NSB, LG, NEC, ETRI, MediaTek |
| Alt. 2 |  |
| Other |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Huawei/Hisi | If the first activated SPS HARQ-ACK can be indicated on SCell, Alt.2 is problematic since the PCell K1 set may not include k1 values of SCell when constructing the Type 1 CB.  In addition, we agree with Moderator to hold on the decision among the options till the clarification in AI 7.1 and think the preference of the option here should be aligned with the AI 7.1 conclusion. |
| DOCOMO | Though Opt 1 is not our preference, but if adopted, we prefer Alt 1. It is more reasonable that appliable K1 set is consistent with corresponding PUCCH transmission cell. |
| Nokia/NSB | Agree with DCM. |
| ZTE | Option 1 is not our choice, our intention is Option 2 or Option 3 |
| LG | If supported, Alt. 1 is reasonable to keep consistency. |
| Samsung | It would be good to first resolve the main issue. We do not agree to option 1. |
| Moderator | Seems Alt. 1 is the favorite of companies. Let’s use this to clarify the Alt. 1 of the SPS operation. |
| Samsung2 | Do not agree to Alt.1. This question also relates to another pending issue on SPS HARQ-ACK handling for PUCCH cell switching and can be revisited later. |

**PUCCH repetition and semi-static PUCCH cell switching**

On parallel to trying to prune the number of options here from 4 to 2, it would be good to also discuss some needed clarifications for Alt. 1 (if this is to be supported).

**On Alt. 1**, the following operation additions has been provided:

* **(A)** The required number of repetition is derived according to the defined number of repetition associated to the cell initiating the PUCCH repetitions (Panasonic)
* **(B)** If more than one slot on the PUCCH-sSCell overlaps with a slot on the PCell, all slots where the PUCCH can be transmitted on the PUCCH-sSCell are used (Samsung)
  + **(C)** For the other cell, the effective PUCCH transmission is counted towards the required number of repetitions (Panasonic)
* **(D)** PUCCH resources corresponding to PUCCH repetitions other than the first PUCCH repetition are determined from the determined PUCCH cell based on the PRI in the (activated) DCI corresponding to the PUCCH (ZTE)
* On ‘alignment’ of PUCCH resources:
  + **(E)** UE expects that PUCCH resources from PCell/SPCell/PUCCH SCell and PUCCH sScell have the same number of symbols for each PUCCH repetition (ZTE)
  + **(F)** A UE does not expect different number of REs in the PUCCH resources to transmit the repetition (QC)

**Question 6.3.3: If Alt. 1, i.e. the target cell is determined for each PUCCH repetition individually, is supported, which additional clarifications do you think would be needed? Please also check the input below – you can refer here also to (A) to (F) from the company inputs.**

|  |  |
| --- | --- |
| *Company* | *Comments* |
| QC | F is needed otherwise UE has to do recoding for each repetition and gNB cannot combine repetitions with different coding rate with Polar encoding.  B & D also need to be discussed. |
| ZTE | We think A/D/E/F can be considered to simplify the issue of this joint processing. |
| Samsung | Only D is necessary.  B can also be considered to maximize the benefit from switching in case of different SCS. |
|  |  |
|  |  |

**CSI operation with semi-static PUCCH cell switching**

DOCOMO & vivo on how to operate CSI reporting, and have slightly different proposed operation here. So let’s see if companies are more towards the DOCOMO or vivo proposal.

**Question 6.3.4: When CSI reporting on PUCCH is configured on both the PCell/PSCell/PUCCH-SCell and the PUCCH sSCell, which of the following formulations for a potential agreement do you prefer:**

* **Alt. 1 (DCM): the PUCCH cell pattern is applied to determine whether CSI PUCCH will be transmitted or not.**
* **Alt. 2 (vivo): corresponding CSI PUCCH resource(s) on a PUCCH cell will be validated based on the time domain pattern.**

|  |  |
| --- | --- |
| Alt. 1 | Vivo, DOCOMO, ZTE, Samsung |
| Alt. 2 | Vivo, DOCOMO, ZTE, LG |
| Other |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Intel | Would be good to understand first how Alt.2 is going to be captured in specs. |
| Huawei/Hisi | It looks the intention has been captured in the spec.   |  | | --- | | A UE can be provided a periodic cell switching pattern for PUCCH transmissions by *pucch-sSCellPattern.* Each bit of the pattern corresponds to a slot for a reference SCS configuration provided by *tdd-UL-DL-ConfigurationCommon* for the PCell with a value of '0' or a value of '1' indicating, respectively, the PCell or the PUCCH-sSCell as the cell for PUCCH transmissions during the slot of the reference SCS configuration. | |
| vivo | We think our intention is the same as DCM, just wording is different. We would like to clarify that although the CSI reporting on PUCCH is configured on both the PCell/PSCell/PUCCH-SCell and the PUCCH sSCell, based on the PUCCH cell pattern, the CSI PUCCH resources are valid/invalid for CSI transmission.  Similar as for SR, the potential spec impacts are following:  For RRC parameters, e.g. in TS38.331. For example, for the csi-MeasConfig of a PUCCH cell, in the description for parameter csi-ReportConfigToAddModList, it may be stated that a PUCCH resource configured by the parameter pucch-Resource in a CSI-ReportConfig configured in csi-ReportConfigToAddModList is valid only when the PUCCH cell is applicable based on the time domain pattern if semi-static PUCCH cell switching is enabled. Furthermore, only if a CSI PUCCH resource is valid, corresponding CSI PUCCH transmission will be performed by the UE.  Besides, in the clause 9.A of TS38.213, a general description for CSI PUCCH resource validation based on the time domain pattern when semi-static PUCCH cell switching is enabled can also be added to clarify UE behaviour in terms of CSI PUCCH trasmissions for semi-static PUCCH cell switching. |
| DOCOMO | Our understanding of Alt 1 and Alt 2 are similar, that the PUCCH cell pattern determines whether a CSI PUCCH can be transmitted, as in the following example.    If it is common understanding on Huawei’s highlighted part, we are fine with no further clarification. |
| LG | For our understaning, Alt. 1 needs to configure alternative CSI configuration in PUCCH-sSCell. Meanwhile, Alt 2 would require to configure alternative PUCCH resource for CSI configuration in PUCCH-sSCell. We think alt.2 is more aligned with current framework. |
| Moderator | As for the proposal on SR in Sec. 6.2, it seems that several companies think there is no need for such agreement, as this is captured in the specifications already.  @vivo /DoCoMo (as originating company), if you still think a specs change is needed, could you maybe bring a related TP to the next meeting (or showing some more details where changes will be needed regarding SR)? But based on this situation, continuing the discussions here seems to be not really helping. |
| vivo | Thanks a lot moderator’s efforts. Sure, we are fine with your suggestion and consider related TP for next meeting. |

* 1. 2nd round of approvals discussions

**Mod Proposal 6.4.1 (RRC impact): For PUCCH cell switching, introduce a new RRC parameter in *SPS-Config* to allow configuring a separate ‘*n1PUCCH-AN’*  (i.e. PUCCH resource ID) for PUCCH sSCell for SPS HARQ operation.**

|  |  |
| --- | --- |
| Supporting companies | Huawei/Hisi, DOCOMO, vivo, LG (can accept), Panasonic, ZTE, Samsung, Intel, NEC, Spreadtrum, Nokia/NSB (can accept), QC, Ericsson, CATT , New H3C |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Huawei/Hisi | If this proposal is agreed, shall we also consider *CSI-ReportConfig -> pucch-CSI-ResourceList* (single CSI report) to be extended to SCell, following the same principle of *n1PUCCH-AN? PUCCH-CSI-Resource is not included by PUCCH-config.* Note there is RRC impact if considered. |
| LG | We still prefer Alt. 1 but we can live with the proposal. |
|  |  |
|  |  |

Based on input by Huawei above same case for CSI, an additional proposal is brought forward. I will also include a proposal on this to the RRC parameter thread in 8.3:

**New Proposal 6.4.2 (RRC impact): For PUCCH cell switching, introduce a new RRC parameter in *CSI-ReportConfig* to allow configuring a separate ‘*pucch-CSI-ResourceList*’ for PUCCH sSCell.**

|  |  |
| --- | --- |
| Supporting companies | LG (if 6.4.1 is agreed), Panasonic, ZTE, Samsung, Intel, Spreadtrum, Nokia/NSB (can accept), Ericsson, QC, CATT, DOCOMO, New H3C |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| LG | If proposal 6.4.1 is agreed, we prefer to have consistency for the similar issue. However, we still prefer the way of Alt. 1, which have least RRC parameter impact. |
| Intel | OK to support |
| QC | This additional RRC parameter is needed. |
|  |  |

Based on the input in the first round, clarifying the PUCCH repetition for Alt. 1 better based on the input in Question 6.3.3.

**Mod Proposal 6.2.7: For semi-static PUCCH cell switching with PUCCH repetition, further down-select from the following two alternatives:**

* **Alt. 1: The target cell is determined for each PUCCH repetition individually (i.e., switching within the repetition bundle supported)**
  + **If more than one slot on the PUCCH-sSCell overlaps with a slot on the PCell, all slots where the PUCCH can be transmitted on the PUCCH-sSCell are used**
  + **PUCCH resources corresponding to PUCCH repetitions other than the first PUCCH repetition are determined from the determined PUCCH cell based on the PRI in the (activated) DCI corresponding to the PUCCH**
  + **A UE does not expect different number of REs in the PUCCH resources to transmit the repetition**
  + **~~FFS further details and/or restrictions~~**
* **Alt. 2A: For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported** 
  + **A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions, i.e., the repetition is postponed as in Rel-16.**

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| Supporting companies | Huawei/Hisi, DOCOMO, vivo, LG, Panasonic, ZTE, MediaTek, Intel, NEC, Spreadtrum, Nokia/NSB, QC, Ericsson, CATT, New H3C |
| Objecting companies | Samsung |

|  |  |
| --- | --- |
| Alt. 1 | DOCOMO (can accept if more clarification), Panasonic, ZTE(some other restrictions are needed), NEC |
| Alt. 2A | Huawei/Hisi, DOCOMO (1st preference), vivo, LG, MediaTek, Intel, NEC, Spreadtrum, Nokia/NSB, Ericsson (Alt 1 has a conflict w previous agreement), CATT, New H3C |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Huawei/Hisi | It is too restrictive for gNB to configure PUCCHs over the two PUCCH cells associated with the same PRI with the same RE number for ensuring the soft combining.  Moreover, the processing functionalities are per carrier operated for gNB, which means it is highly challenging to perform TTI level combination over carriers, not to say it is not clear how it can work under the cross-site CA mode.  In addition, Alt.1 may suffer reliability/coverage loss if the SCell is with short slot length as shown in below (Alt.1 actually transmits repetitions over 1.5ms, while it is supposed to achieve the coverage goal by transmitting 2ms as Alt.2A). |
| DOCOMO | Two questions for Alt 1:  Q1: For the first sub-bullet under Alt 1, for all PUCCH Scell slots overlapping with one PCell slot, each slot is counted for PUCCH repetition number counting, is that right understanding?  Q2: For the second bullet, we are now wondering whether the rule can be applied to CSI/SR PUCCH repetition? As CSI/SR PUCCH resource is configured with periodicity/offset. There may be no CSI/SR resource in the overlapping slot of the cell. Note that there is no PUCCH resource selection rule based on UCI payload and PRI for CSI/SR (except multiplexing multiple CSI reports when *multi-CSI-PUCCH-ResourceList* is configured)*.* Therefore, our understanding is that current Alt 1 can’t work for CSI/SR PUCCH repetition case. If unified solution is targeted for all UCI types, Alt 1 with separate PUCCH resource determination on two cells is not a good solution.  For sake of progress, we can accept Alt 1 if above two questions are clarified. |
| Panasonic | Alt. 1 ensures both reliability and latency requirements. The repetition ocassions and counting on SCell should be clarified. |
| ZTE | Regarding concern on Alt.1 reliability/coverage loss, that is why the option E in question 6.3.3 should be considered as a restriction for Alt.1.  For DOCOMO question 1: I think your understanding is correct. For question 2: The proposal is not limited to HARQ, can also be applied to SR/CSI. The SR/CSI resource determination doesn’t depend on PRI but follow legacy way, e.g., the configuration on SR/CSI.  For the second sub-bullet of Alt.1, the PUCCH resources should be valid for transmission, e.g., the PUCCH resources colliding with DL can not be regarded as valid PUCCH resources. So we suggest a minor improvement on the wording.   * + **Valid PUCCH resources corresponding to PUCCH repetitions other than the first PUCCH repetition are determined from the determined PUCCH cell based on the PRI in the (activated) DCI corresponding to the PUCCH**   We also propose to add the option E in question 6.3.3 as a sub-bullet for Alt.1 |
| Samsung | What Alt. 2A intends to introduce, on top of Rel-16, is worse than Rel-16 and therefore Alt. 2A is not agreeable for further consideration.  For Alt.1, the condition in the third bullet is unnecessary (not only for UCI payloads less than 12 bits which is typical for repetitions but, from a specification perspective, for any payload). It is a gNB implementation issue and there is no reason for a UE to care.  The second bullet, the (activated) should be removed for now. |
| Intel | We agree with questions / comments from HW/HiSi and DOCOMO |
| NEC | Alt.1 can achieve lower latency, Alt.2A is simple, and we are fine with both two alternatives. |
| QC | Thank FL for the proposal. For Alt 1, with the bullet “A UE does not expect different number of REs in the PUCCH resources to transmit the repetition”, which avoids UE to redo encoding for each repletion, we can live with Alt 1. If this bullet is removed, we don’t support Alt 1.  Of course, we support Alt 2 as well. |
| Ericsson | There is issue with Alt 1. For semistatic PUCCh cell switching, in case of different SCS between PCell and SCell, we agreed to pick up the first slot. Alt 1, 1st sub-bullet contradicts with this approach and suggests differently for case of repetition. If that is the intention of proponents, it is OK but we wanted to make sure it is not overlooked. |
| DOCOMO2 | @ZTE, thanks a lot for sharing your view.  For the first question, we share common understanding. We think it’s better to be clairifed, maybe with following updates.  For the second question, regarding your answer “The SR/CSI resource determination doesn’t depend on PRI but follow legacy way, e.g., the configuration on SR/CSI.”, our question is how can it be ensured that there is SR/CSI resources configured in that overlapping slot? Our understanding is that CSI/SRS resource doesn’t necessarily exist in each slot, but exist in certain slots with the configured periodicity and offset. For example, if the periodicity of CSI/SR on the Scell is 10 slots, and there is no SR/CSI resource in the overlapping slots (marked as 2nd and 3rd repetition), how can UE determine PUCCH resource for the 2nd and 3rd repetition?s |

* 1. 2nd round of email discussions

**Further clarifications on dynamic PUCCH cell switching:**

**Question 6.5.1: For dynamic PUCCH cell switching the following RAN1 conclusion**

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| **Conclusion**  For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell.   * The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the alternative PUCCH cell. |

**is applicable for:**

* **Alt. 1: … the PUCCH resource carrying the UCI after multiplexing on PCell /SPCell / PUCCH Scell…**
* **Alt. 2: … the PUCCH resource carrying the UCI before multiplexing on PCell /SPCell / PUCCH Scell…**

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| Alt. 1 | Huawei/Hisi(2nd), DOCOMO (2nd), vivo, ZTE,NEC |
| Alt. 2 | Huawei/Hisi(1st), DOCOMO (1st), vivo, Samsung, Intel, NEC, Spreadtrum, Nokia/NSB, Ericsson, CATT |
| Other | QC |

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| --- | --- |
| *Company* | *Comments* |
| Huawei/Hisi | Our thinking is the UE does not to handle/multiplex the potential UCIs on PCell when it receives the DCI indicating PUCCH on SCell, by assuming the potential UCIs on PCell must be conflict the DL symbols. But we are also fine with Alt.1 as it is more close to the description of the agreement, i.e., UE has to finish multiplexing before judging the collision with DL symbols as the procedure in R15/16. |
| DOCOMO | Alt 2 is simpler. Also fine with Alt 1 for sake of progress. |
| vivo | We would be fine with either Alt.1 or Alt.2. For Alt.1, the overall Rel-16 intra-UE multiplexing procedure can be reused to find the exmept resource on PCell. For Alt.2, it seems simpler. |
| Samsung | A main objective is to avoid new timeline considerations resulting from different SCS. |
| Intel | As in the original proposal, we think the agreement should be read as Alt.2 which is simpler for a UE implementation and the procedure overall |
| Nokia/NSB | Actually, there seems to be little difference between these two alternatives. But clearly Alt. 2 would simplify the operation.  This is now only for same PHY priority, how about cross-priority operation? Can there actually be a LP PUCCH on PCell overlapping HP PUCCH on Scell? |
| QC | Just to repeat our comment in first round: Current (Rel-16) spec already define the dropping due to semi-static DL, SSB, etc…, is after UCI multiplexing. We think UE behavior is clear. No need to further discuss this issue. The clarification is not needed. |
| Ericsson | Also, prefer Alt 2 for simplicity.  @Nokia: We thought that there will be one cell for PUCCH at a given time, irrepsecitve of the priority. Good to clarify that. Otheriwse would be too complicated. |

**SPS operation with dynamic PUCCH cell switching**

In the first round, it seems that could further clarify based on Question 1, that the K1 set(s) of the indicated PUCCH cell are to be used for the first SPS PDSCH. Which basically leaves us with the current status:

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| * **Option 1 (8): For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH** **without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).**   + ***The UE does not expected to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI in a slot overlapping with a PUCCH slot with UCI on PCell / SPCell / PUCCH-SCell slot.***      - **The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the PUCCH sScell.**   + **For the HARQ-ACK first SPS PDSCH, the UE determines a k1 value from K1 set(s) of the indicated PUCCH cell (PCell/PSCell/PUCCH-SCell or PUCCH sSCell’s ) according to the PDSCH-to-HARQ\_feedback timing indicator field in the activation DCI**   + **For all other SPS PDSCHs except the first SPS PDSCH, the UE determines a k1 value from K1 set(s) of the PCell/PSCell/PUCCH-SCell according to the PDSCH-to-HARQ\_feedback timing indicator field in the activation DCI**   + **Support:** HW/HiSi [1], New H3C [4],vivo [5], CATT [8], CAICT [12], Panasonic [13], Intel [15], NEC [17], * **Option 2 (5): For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).**    + **The UE does not expected to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI.**   + **Support:** Nokia/NSB [3] (2nd preference), CATT [8], Spreadtrum [10], Intel [15], LG [20] * **Option 3 (3): For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI (including the first SPS PDSCH activated by Activation DCI) is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI**    + ***Note: This changes an earlier agreement in terms of handling for the first SPS PDSCH activated by Activation DCI***   + **Yes:** Nokia/NSB [3] (1st preference), DOCOMO [9], Samsung [18] (2nd preference) * **Option 4 (1): For dynamic PUCCH cell switching, all PUCCH transmissions with HARQ-ACK for SPS PDSCH receptions of a SPS configuration are on the cell indicated by the DCI format activating the SPS PDSCH receptions.**   + **Support:** Samsung [18] |

The moderator had hoped that the discussion in *[108-e-NR-CRs-02] Issue#3 SPS PDSCH activation and PUCCH resource selection for the 1st SPS PDSCH* would be progressing a bit more, but currently there seems to be no real convergence there.

Therefore, it is unclear for the moderator on how to proceed here. As this is only a very short round (1day), let’s check first on how to proceed here:

**Question 6.5.2: How do you think we should proceed on the SPS HARQ operation with dynamic PUCCH cell switching:**

* **Alt. 1: Wait for the output or more clarity from the *[108-e-NR-CRs-02]***
* **Alt. 2: Try to take a decision here in 8.3.1 independently of the outcome on *[108-e-NR-CRs-02]***
* **Other**

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| Alt. 1 | Huawei/Hisi, DOCOMO (1st), vivo, Panasonic, ZTE, Intel, NEC(2nd preference), Spreadtrum, Nokia/NSB, Ericsson, CATT |
| Alt. 2 | DOCOMO (2nd), vivo, NEC(1st preference), QC |
|  | Samsung |

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| *Company* | *Comments* |
| Huawei/Hisi | We prefer to clarify firstly at R15 (*[108-e-NR-CRs-02]*), and we follow the same principle in R17. Seems this issue does not have RRC impact, it is no need to rush to a conclusion now.  Make the following changes to avoid duplicate discussions in R15 and R17. Hope it is aligned with other companies choosing Alt.1 if any.  **Alt. 1: Wait for the output or more clarity from the *[108-e-NR-CRs-02]***   * **If “PUCCH corresponding to an SPS-PDSCH (following the RRC *SPS-Config*)” *in [108-e-NR-CRs-02]* is agreed, Option 2/3 is adopted.** * **If “PUCCH corresponding to of a dynamically granted PDSCH (ignoring the RRC *SPS-Config)*” *in [108-e-NR-CRs-02]* is agreed, Option 1 is adopted.** |
| Samsung | Regardless of the conclusion from [108-e-NR-CRs-02], discussion will be needed for the benefit vs. implementation/specification complexity of each option. But a conclusion from [108-e-NR-CRs-02] will be helpful to determine whether certain options are even meaningful. |
| QC | We have existing agreement on the A/N for first SPS PDSCH follow activation DCI to select target cell to transmit PUCCH. [108-e-NR-CRs-02] is discussing A/N resource on Pcell should follow PRI or n1PUCCH-AN. We don’t see the outcome of [108-e-NR-CRs-02] will impact PUCCH cell switch. Therefore we don’t see any need to wait for outcome of [108-e-NR-CRs-02].We should move forward to complete the design of PUCCH cell switch. |
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6.6. 3rd round of email approvals

Let’s continue on the separate RRC parameter for CSI here. Copied from 2nd round:

**New Proposal 6.4.2 (RRC impact): For PUCCH cell switching, introduce a new RRC parameter in *CSI-ReportConfig* to allow configuring a separate ‘*pucch-CSI-ResourceList*’ for PUCCH sSCell.**

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| Supporting companies | LG (if 6.4.1 is agreed), Panasonic, ZTE, Samsung, Intel, Spreadtrum, Nokia/NSB (can accept), Ericsson, QC, ~~CATT, DOCOMO,~~ New H3C, NEC, Lenovo |
| Objecting companies | Vivo |

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| *Company* | *Comments* |
| LG | If proposal 6.4.1 is agreed, we prefer to have consistency for the similar issue. However, we still prefer the way of Alt. 1, which have least RRC parameter impact. |
| Intel | OK to support |
| QC | This additional RRC parameter is needed. |
| Moderator | Start of 3rd round – vivo input copied below. Companies please check if  (a) vivo got a point that you can configure the CSI-reporting on PUCCH for more than on PUCCH cell in a cell group already (so no need for new RRC parameter)  (b) this is not possible – this new RRC parameter in a CSI-report configuration is needed |
| vivo (by email) | Based on 331, see below, it is stated that if the CSI report is sent on PUCCH on the cell, then the *CSI-ReportConfig* should be included in the cell, which is Pcell (without considering PScell and PUCCH Scell) per our understanding.  So from our understanding, no new RRC parameter is needed, just copy/reuse the existing RRC parameters for the PUCCH sScell.  The IE *CSI-ReportConfig* is used to configure a periodic or semi-persistent report sent on PUCCH on the cell in which the *CSI-ReportConfig* is included, or to configure a semi-persistent or aperiodic report sent on PUSCH triggered by DCI received on the cell in which the *CSI-ReportConfig* is included (in this case, the cell on which the report is sent is determined by the received DCI). See TS 38.214 [19], clause 5.2.1.  Now only limited companies share the views. Let’s hear more views from others. |
| HW (by email) | Thanks Lihui for further comments. For the legacy 331, we have the same understanding that, the *CSI-ReportConfig* is only configured on PCell. When adding PUCCH-sSCell in R17, as per your logic, two *CSI-ReportConfigs* should be automatically generated for two PUCCH cells. But two issues come out: Firstly, the description “The IE *CSI-ReportConfig* is used to configure a periodic or semi-persistent report sent on PUCCH on the cell in which the *CSI-ReportConfig* is included” has to be changed somewhat as “on PUCCHs on candidate cells for PUCCH cell switching”.  Secondly, if we donot change anything at 331, then for a specific *CSI-ReportConfig*, how can it be linked with PCell or sSCell? By directly reusing the current 331, we cannot get any hint for PCell/sSCell linkage with the *CSI-ReportConfig/PUCCH-CSI-Resource.* (note a PUCCH resource at PCell and a PUCCH resource at sSCell may share the same *PUCCH-ResourceId*). |
| vivo | For HW (Yuan)’s question on CSI, I would like to provide our response below.  For the 1st question, I do not think we need to change any wording, since the current description mentioned “The IE *CSI-ReportConfig* is used to configure a periodic or semi-persistent report sent on PUCCH on the cell in which the *CSI-ReportConfig* is included”, if a *CSI-ReportConfig* is included in the PUCCH sSCell, the corresponding CSI reporting on PUCCH should be transmitted on the PUCCH sSCell.  For your 2nd question, I am a little bit lost. *CSI-ReportConfig/PUCCH-CSI-Resource* are configured for both PCell and PUCCH sScell respectively and independently, the linkage seems obvious, i.e. a *CSI-ReportConfig*, or a *PUCCH-CSI-Resource* used in the *CSI-ReportConfig*, is only linked to the PUCCH cell where the *CSI-ReportConfig* is included/configured. Besides, the pool of *PUCCH-ResourceIds* is also independent for either of the two PUCCH cells.  According to your proposal that introduce a new RRC parameter in CSI-ReportConfig to allow configuring a separate ‘pucch-CSI-ResourceList’ for PUCCH sSCell, it seems the separate ‘pucch-CSI-ResourceList’ for PUCCH sSCell is under the *CSI-ReportConfig* configured for PCell, the *CSI-MeasConfig/CSI-ReportConfig* cannot be configured for PUCCH sSCell, but the used PUCCH resources in PUCCH-config still needs to be configured for PUCCH sSCell which conflicts the RRC configuration for CSI measure/report framework used in Rel-15/16 Pcell/PScell/PUCCH Scell. |
| LG | For our understanding, we are on (b). UE can be configured with *CSI-ReportConfig* per DL cell, and PUCCH resource ID per report configuration cannot be specified per UL cell currently, unless DCI scheduling CSI report indicates UL cell.  Thus, it would be different from what we agreed for n1PUCCH-AN, which have two different PUCCH ID for PCell and PUCCH-sSCell. In order to have the same level of flexibility, we may configure separated CSI-MeasConfig in PUCCH-sSCell, or configure additional PUCCH resource set for CSI in CSI-ReportConfig in PCell. We prefer latter one, which have less impact (share CSI measurement/report config) and similar to n1PUCCH-AN handling. |
| Nokia/NSB | We still think to have the same flexibility for SPS PUCCH resource & CSI PUCCH resource on PUCCH sSCell, this RRC parameter is needed. |
| Spreadtrum | We understand the concern from vivo. In current 38331, the cell index of a CSI report is configured through the IEs below. So the CSI PUCCH is send on the cell configured with this CSI report config, which is PCell.  ***ServingCellConfig-> CSI-MeasConfig-> CSI-ReportConfig->PUCCH resource***  However, we also believe if a new set of CSI-ReportConfig with all same CSI reference resource and CSI report type, but with a different PUCCH resource linked to PUCCH sSCell is too complex.  Alternatively, a new RRC parameter in CSI-ReportConfig to allow configuring a separate ‘pucch-CSI-ResourceList’ and with proper interpretation can work well, but with less RRC effort.  So we support the proposal. |
| DOCOMO | We now share vivo’s understanding that *CSI-ReportConfig* is respectively configured on the CSI reporting PUCCH cell (i.e. PCell and PUCCH Scell). For *CSI-ReportConfig* is configured on PCell, the associated *PUCCH-CSI-Resource* is a PUCCH resource ID on Pcell. For *CSI-ReportConfig* is configured on PUCCH Scell, the associated *PUCCH-CSI-Resource* is a PUCCH resource ID on PUCCH Scell. Therefore, we now share vivo’s view that the proposal is not necessary. But we also admit adding the new RRC parameter can also work. |
| CATT | Based on the explanation by vivo, we tend to agree with vivo’s understanding that no additional RRC parameter is needed. |
| QC | Following Vivo’s comments, we think that a new RRC parameter is not necessary. Therefore, a modification in our stance: Extending the existing RRC parameter to define both Pcell and Scell and adding a note that CSI can be reported in both Pcell and Scell in the context of semi-static PUCCH carrier switching should be enough. This could be done with an entirely new RRC parameter also, but it is not as smooth. |
| vivo2 | @LG, Nokia: for SPS HARQ-ACK resource n1PUCCH-AN is configured in SPS-config, it is actually per DL cell, so the RRC parameter is needed since it is not PUCCH cell specific; But in Rel-15/16 *CSI-ReportConfig* is configured per PUCCH cell (i.e., PCell/PScell/PUCCH Scell), it is already PUCCH cell specific, existing RRC parameters in *CSI-ReportConfig* can be reused to be configured for PUCCH sScell. As explained, *CSI-ReportConfig/PUCCH-CSI-Resource* are configured for both PCell and PUCCH sScell can be configured independently, full flexibility is provided. Adding new RRC parameters will casue RAN2 to redesign the RRC framework to support CSI report on PUCCH transmitted on PUCCH sSCell. |
| Moderator | Discussed in GTW session. There seems to be no real need indicated there by different companies 🡪 no follow-up in RAN1#108-e |

6.7 3rd round of email discussions

**Semi-static PUCCH cell switching and PUCCH repetition**

Samsung objected in the 2nd round of email approvals to down-select between Alt. 1 and Alt. 2A (because of preference for Alt. 1).

So, the only thing that one can try here now is to get the description of Alt. 1 correctly, and then make the final decision (incl. Alt. 1 or 2A) in the GTW session. There seems to be still some different preferences from the Alt. 1 supporting companies there, e.g. Samsung thinks the 3rd bullet is not needed – whereas e.g. ZTE requests further restrictions to be applied for Alt. 1. Please provide your input on each of these lines 1-4. Moreover, for Alt. 1 supporting companies, please also try to address some of the questions on Alt. 1 raised in the 2nd round of email approvals (e.g. by DOCOMO,

**Question 6.7.1: For semi-static PUCCH cell switching with PUCCH repetition, if Alt. 1 is adopted, the following description is to be used:**

* **The target cell is determined for each PUCCH repetition individually (i.e., switching within the repetition bundle supported)**
  1. **If more than one slot on the PUCCH-sSCell overlaps with a slot on the PCell, all slots where the PUCCH can be transmitted on the PUCCH-sSCell are used**
  2. **PUCCH resources corresponding to PUCCH repetitions other than the first PUCCH repetition are determined from the determined PUCCH cell based on the PRI in the (activated) DCI corresponding to the PUCCH**
  3. **A UE does not expect different number of REs in the PUCCH resources to transmit the repetition**
  4. **UE expects that PUCCH resources from PCell/SPCell/PUCCH SCell and PUCCH sScell have the same number of symbols for each PUCCH repetition**
  + **~~FFS further details and/or restrictions~~**

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| 1 | Support | NEC, Samsung Huawei/Hisi, Intel, Panasonic, New H3C, ZTE, QC |
| Not support |  |
| 2 | Support | NEC, [Samsung] Huawei/Hisi, Intel, New H3C, ZTE, QC |
| Not support |  |
| 3 | Support | Huawei/Hisi, New H3C, ZTE, QC |
| Not support |  |
| 4 | Support | ZTE |
| Not support | QC (need clarification before supporting it) |
| 5 - Other |  | |

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| *Company* | *Comments* |
| NEC | We can live with the proposal for progress.  For DOCOMO Q1: We think your understanding is right that each overlapping slot is counted for PUCCH repetition number counting, then the latency for HARQ-ACK transmission can be reduced.  For DOCOMO Q2: We think if the joint operation rule for PUCCH repetition and PUCCH cell switching is defined, it is up to gNB implementation to ensure that the CSI/SR PUCCH resource is configured in the overlapping slot. |
| Samsung | For the second point, “(activated)” is problematic (and, strictly speaking, ambiguous – e.g. what is “activated DCI”?).  We think the third and fourth points are unnecessary but OK to have them if that is required to have support for the feature. |
| Huawei/Hisi | For 1, we are also fine on the other way like PCell to SCell mapping, i.e., one PCell slot only map to the 1st overlapped SCell slot if they are subject to different PUCCH slot lengths. |
| Intel | One of point 3 and 4 is sufficient in our view |
| New H3C | We are fine with point 1 and point2. Regarding point 3 and pont4, either way is fine and we slightly prefer point 3. |
| DOCOMO | For the first bullet, we prefer to clarify PUCCHrepetition factor perspective.   1. **If more than one slot on the PUCCH-sSCell overlaps with a slot on the PCell, all slots where the PUCCH can be transmitted on the PUCCH-sSCell are used until repetition factor is reached**   For the second bullet, we still think the current description is not applicable to CSI/SR. Thanks @NEC, ZTE for sharing your views to our previous question. We are not sure whether companies have common understanding that resource of CSI/SR repetition on the other cell than the first repetition cell is determined based on CSI/SR configuration on the cell. If consensus can’t be reached, we prefer to determine the resource for repetitions on the other cell similar to Rel-15/16 repetition rule, i.e. same PUCCH length, same starting symbol, same PRB number (with certain RB offset relative to the first repetition), which can be applied to all UCI types.  We think the third bullet and fourth bullet are fine if the second bullet is kept. |
| ZTE | Echo to DOCOMO’s comment, in other parts, we are discussing the resource of CSI/SR on the sScell, which are not touching the CSI/SR repetition. This is a question to be solved. Your suggestion is a possible way, or we can support the joint process at least for HARQ first and further discuss the issue about CSI/SR repetition.  One more thing, if the PUCCH resource is not valid, according to the rule of PUCCH repetition, the invalid resource can be skipped and PUCCH transmission is deferred. |
| QC | Not sure what is the intention to add “4”. We are not saying we will objecting it. But we would like to understand it is the same intention as “3”. Adding “3” is proposal from us. Our intention is to make sure the coding rate are the same across PUCCH repetitions. Therefor, on UE side, UE does not need to redo encoding for each repetitions. On gNB side, repetition combining for Polar code becomes possible.  Maybe I missed, but can Proponents of “4” please clarify the intention of it? |
| ZTE2 | Echo to QC, Alt.4 is intend to keep the same symbol length between the switching, but we also think if the number of RE aligns, the same purpose could be achieved, so let's depriortize Alt.4. |

**Further clarifications on dynamic PUCCH cell switching:**

We had the discussion on the following discussion in the 2nd round already, but clearly if we don’t have understanding on how to interpret the earlier conclusion, this feature cannot be implemented.

Therefore, let’s continue discussion here – but let’s split the questions for same priority and different priorities for the Rel-16 PHY priority. This will be essential, as otherwise agreeing any interaction with Rel-17 Intra-UE prioritization on Sec. 7 will not be possible.

**Question 6.4.1: For dynamic PUCCH cell switching AND A SINGLE PHY PRIORITY the following RAN1 conclusion**

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| **Conclusion**  For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell.   * The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the alternative PUCCH cell. |

**is applicable for:**

* **Alt. 1: … the PUCCH resource carrying the UCI after multiplexing on PCell /SPCell / PUCCH Scell…**
* **Alt. 2: … the PUCCH resource carrying the UCI before multiplexing on PCell /SPCell / PUCCH Scell…**

|  |  |
| --- | --- |
| Alt. 1 | Huawei/Hisi(2nd), DOCOMO ~~(2~~~~nd~~~~)~~, vivo, ZTE,NEC |
| Alt. 2 | Huawei/Hisi(1st)~~, DOCOMO (1~~~~st~~~~)~~, vivo, Samsung, Intel, NEC, Spreadtrum, Nokia/NSB, Ericsson, CATT, LG, Panasonic, New H3C |
| Other | QC |

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| --- | --- |
| *Company* | *Comments* |
| Huawei/Hisi | Our thinking is the UE does not to handle/multiplex the potential UCIs on PCell when it receives the DCI indicating PUCCH on SCell, by assuming the potential UCIs on PCell must be conflict the DL symbols. But we are also fine with Alt.1 as it is more close to the description of the agreement, i.e., UE has to finish multiplexing before judging the collision with DL symbols as the procedure in R15/16. |
| DOCOMO | Alt 2 is simpler. Also fine with Alt 1 for sake of progress. |
| vivo | We would be fine with either Alt.1 or Alt.2. For Alt.1, the overall Rel-16 intra-UE multiplexing procedure can be reused to find the exmept resource on PCell. For Alt.2, it seems simpler. |
| Samsung | A main objective is to avoid new timeline considerations resulting from different SCS. |
| Intel | As in the original proposal, we think the agreement should be read as Alt.2 which is simpler for a UE implementation and the procedure overall |
| Nokia/NSB | Actually, there seems to be little difference between these two alternatives. But clearly Alt. 2 would simplify the operation.  This is now only for same PHY priority, how about cross-priority operation? Can there actually be a LP PUCCH on PCell overlapping HP PUCCH on Scell? |
| QC | Just to repeat our comment in first round: Current (Rel-16) spec already define the dropping due to semi-static DL, SSB, etc…, is after UCI multiplexing. We think UE behavior is clear. No need to further discuss this issue. The clarification is not needed. |
| Ericsson | Also, prefer Alt 2 for simplicity.  @Nokia: We thought that there will be one cell for PUCCH at a given time, irrepsecitve of the priority. Good to clarify that. Otheriwse would be too complicated. |
| Moderator | Continuation in the 3rd round. If we are not able to settle this down here, any joint operation discussions with Rel-17 Intra-UE multiplexing seems then meaningless if now knowing the operation even for the same PHY priority multiplexing restrictions.  Companies please check other companies comments above – maybe you may change your views here. |
| LG | We support Alt. 2 for simplicity. |
| Huawei/Hisi | Still slightly prefer Alt.2 for simplicity, but can accept Alt.1.  In addition, as we think Alt.1 and Alt.2 does not make difference when the slot is DL only slot (may only differ on the D/U slot). So, if we cannot converge to one of the alternatives, can we make a merge of the two alternatives, such as:  **Alt. 1+2: … the PUCCH resource carrying the UCI before/after multiplexing on PCell /SPCell / PUCCH Scell**  Thus whether the UE performs the multiplexing on PCell is UE implementation, and the gNB will ensure that, regardless of the UE multiplex or not, the PCell UCI is invalid. |
| Nokia/NSB | In contrast to HW suggestion above, we prefer a single interpretation (and do not leave this to UE implementation). Othewise this may jeopardize the whole feature, as the dynamic PUCCH cell switching is only really usefully especially for D/U slots. |
| Ericsson | We share same view. We should specify the behaviour and not leave it to the UE. |
| New H3C | We slightly prefer Alt.2 because Alt.2 is simple way. |
| Spreadtrum | We undertand when there is a dynamic PUCCH switching DCI indicating PUCCH sSCell, UE only do UCI multiplexing or dropping on PUCCH sSCell, no other UE behavious related with PUCCH on PCell. Thus, only one PUCCH operation on either PCell or PUCCH sSCell, not both of them. So Alt 2 applies. |
| DOCOMO | We think QC’s comment is valid. We have agreed inter-cell PUCCH slot checking is after dropping due to DL collision. And multiplexing is before dropping due to DL collision. It’s natural that the order is:  multiplexing -> dropping due to semi-static DL/SSB/etc -> inter-cell PUCCH slot collision checking.  Therefore, we think Alt 1 should be supported. Our position is updated. |
| QC2 | We don’t see why Alt 2 could simplify UE behavior. Our view is Alt 2 complicates UE behavior. The following is why.  Assume in slot N, there are two overlapping PUCCHs (A and B). Both PUCCH A and B overlap with semi-static DL before UCI mux. But after multiplex, the resulting PUCCH C does not overlap with DL.  With Alt 2, if gNB schedule a dynamic A/N on Scell on slot N, the PUCCH A & B are dropped before multiplexing. But if gNB does not schedule a dynamic A/N on Scell on slot N. Then PUCCH A&B should be multiplexed and transit using PUCCH C. This means, now depends on Scell has dynamic A/N or not, Pcell either do dropping or intra-UE multiplexing. Isn’t that compicated Pcell intra-UE multiplexing procedure.  Proponents of Alt 2, can you please double check? Am I missing something in the above analysis?  Again, Alt 1 is Rel-16 legacy behavior. We should just follow it. We even think no agreement is needed because that is the default. |

**Proposal 6.8.1: For dynamic PUCCH cell switching WITH TWO PHY PRIORITIES and Rel-16 PHY prioritization:**

* **After UCI multiplexing within a single priority, the UE does not expect a PUCCH for a certain priority on PCell /SPCell / PUCCH SCell to overlap with a PUCCH of the other priority with HARQ-ACK on the dynamically indicated alternative PUCCH sScell.**

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| --- | --- |
| Supporting companies | LG, Intel, Nokia/NSB, Ericsson |
| Objecting companies | Huawei/Hisi, Spreadtrum, CATT, QC |

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| --- | --- |
| *Company* | *Comments* |
| vivo | Before comment on proposal 6.8.1, we would like to provide our understanding. We think the decision for TWO PHY PRIORITIES case may depend on the decision for Question 6.4.1. Unified behvaior for single and two phy priority cases is preferred.  In case “before multiplexing” for single PHY priority is adopted for Question 6.4.1, for the case of two PHY prioritise, we think all PUCCH resources with either HP or LP on Pcell should meet the exempted condition, then HARQ-ACK transmission can be dynamically indicated on the PUCCH sScell.  In case “after multiplexing” for single PHY priority is adopted for Question 6.4.1, for the case of two PHY prioritise, we think afte all Rel-16 multiplexing and prioritization between HP and LP PUCCH procedure, then if the final resultant PUCCH meet meet the exempted condition, then HARQ-ACK transmission can be dynamically indicated on the PUCCH sScell.  The wording of “**After UCI multiplexing within a single priority**” may casue confusion or may imply a different understand with us. |
| LG | Our understanding is that “**After UCI multiplexing within a single priority**” means Step 1. If so, we support the proposal. |
| Samsung | We would prefer to agree to this regardless of “before or after multiplexing” to keep things simple. |
| Huawei/Hisi | We understand the following conclusion applies also to the case of two priorities. So the UE does not expect HP DCI and LP DCI both with carrier indicators will schedule two PUCCHs on PCell and SCell, respectively, at the same PUCCH slot. If the UCI, regardless of priority, is to be transmitted without cell indicator on PCell, then it is expected to be dropped due to TDD collision.   |  | | --- | | **Conclusion**  For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH PUCCH cell.   * The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the alternative PUCCH cell. | |
| Intel | We support the intention of the proposal with LGE’s clarification |
| Lenovo | We agree with Huawei/HiSi’s comment. The previous conclusion covers this case. |
| Ericsson | This proposal simplifes the procedures. |
| New H3C | If previous conclusion as HW mentioned already cover this case, this proposal isn’t needed. |
| Spreadtrum | Agree with HW. |
| DOCOMO | We agree with Huawei that the previous agreement is for PUCCH slot overlapping regardless of priority. |
| ZTE | Share the view with HW |
| CATT | We share the same understanding with Huawei that previous agreement covers single/two PHY priority cases. |
| QC | Agree with Huawei previous agreements already covered this. No new agreement is needed |

6.8 4th round of email approvals

**PUCCH cell switching and PUCCH repetition**

There had been discussions in todays GTW session with the Chairman clearly indicating to not want to come back to discussing PUCCH cell switching & PUCCH repetition in online session GTW.

Therefore, I only see the option to resolve this by email – meaning: if we cannot agree on the support, there will needs to be a conclusion to NOT support the operation. I don’t really see any other way here, and this also applies to the semi-static PUCCH cell switching (where I propose the majority view Alt. 2A, as seeing no chance of having Alt. 1 accepted there either). Let’s see if Samsung is still willing to re-think their position.

**Proposal 6.2.3: Support joint operation of PUCCH repetition and dynamic PUCCH carrier switching in Rel-17.**

* **The PUCCH cell indication in the DCI scheduling the PUCCH is applicable for all the PUCCH repetitions.**

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| Supporting companies | Nokia/NSB, Intel, Ericsson, QC, Lenovo Huawei/Hisi New H3C, vivo, DOCOMO, Panasonic, CATT, ZTE, LG, NEC, ETRI, MediaTek, Spreadtrum |
| Objecting companies | Samsung |

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| --- | --- |
| *Company* | *Comments* |
| Samsung | When is “enough”, “enough”, Mr. moderator? |
| Huawei/Hisi | Both PUCCH carrier switching (for latency) and PUCCH repetitions (for reliability) are valuable features for URLLC. It blends the advantages of PUCCH carrier switching and repetition, and provides more flexibility to gNB to dynamically/adaptively choose either latency gain or reliability gain. For a smart gNB, it would not cause degradation as compared to R16 in any case (indicating all PUCCH with/without repetitions to transmit on PCell is equal to R16).  Moreover, the combination of the two features are natural and there is even NO additional spec impact on top of the current 213 h00.   |  | | --- | | 9 UE procedure for reporting control information ……  For unpaired spectrum operation, if a UE is provided a PUCCH-sSCell as described in clause 9.A, the UE shall apply the procedures described in this clause for both the primary cell and the PUCCH-sSCell.  …… 9.A PUCCH cell switching ……  If a UE is provided *pucch-sSCellDyn* or *pucch-sSCellDynDCI-1-2*, a corresponding DCI format associated with generation of HARQ-ACK information by the UE can include a PUCCH cell indicator field, as described in [5, TS 38.212], that indicates whether the PUCCH transmission with the HARQ-ACK information by the UE is on the Pcell or on the PUCCH-sSCell.  …… 9.2.6 PUCCH repetition procedure A UE can be indicated to transmit a PUCCH over slots using a PUCCH resource, where  - if the PUCCH resource is indicated by a DCI format and includes *PUCCH-nrofSlots*, is provided by *PUCCH-nrofSlots*  - otherwise, is provided by *nrofSlots*  If the UE is provided *subslotLengthForPUCCH*, a slot for a PUCCH transmission with repetitions over slots includes a number of symbols indicated by *subslotLengthForPUCCH*. | |
| DOCOMO | Agree with Huawei’s analysis. |
| Moderator | Moderator tried a last time. As there is still no consensus here (in R17), suggest focusing on how to capture this as conclusion (i.e. no consensus) and maybe an accompanying agreement to clarify what it means to not have this supported. |

**Proposal 6.8.1: Support joint operation of semi-static PUCCH cell switching with PUCCH repetition in Rel-17:**

* **A PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported** 
  + **A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions, i.e., the repetition is postponed as in Rel-16.**

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| Supporting companies | Vivo, QC, Spreadtrum Huawei/Hisi, NEC, LG |
| Objecting companies | Samsung |

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| --- | --- |
| *Company* | *Comments* |
| Samsung | “Enough” for this proposal was at least one meeting ago.  A proposal to enable the system to be worse than doing nothing (Rel-16), and to discard THE main use case for introducing the PUCCH cell switching feature, is bad enough on its own. However, the moderator apparently strongly believes such proposal needs special treatment compared to other non-agreed proposals with ‘large’ support, and should be repeatedly made, round-after-round and meeting-after-meeting, given the plentiful time available, the ease of e-meetings, and the absence of other issues. Will now be a last time or will it come back again in Round 5 or in RAN1#109-e/…? |
| QC | We think “joint operation of semi-static PUCCH cell switching with PUCCH repetition” will be a very useful feature.Maybe even more useful than PUCCH cell switch without repetitions, because it can fully utilize UL slots on both Pcell and Scell. It will be a pity to not support this feature. If this proposal cannot be acceptable to Samsung, can we try the other alternative with the green bullets 1,2,3,[4] added? Whether that is acceptable to all companies? |
| NEC | In RAN1 #106b e-meeting, following agreement was reached for PUCCH repetition factor determineation for PUCCH cell switching. In our understanding, it means that simultaneous configuration of PUCCH cell switching and PUCCH repetition has been supported in Rel-17. Not supporting the joint operation will violates the previous agreement.   |  | | --- | | **Agreement**  For semi-static and dynamic indication of PUCCH cell switching, the PUCCH repetition factor is determined based on the PUCCH format or PUCCH resource on the target PUCCH cell for the first repetition. |   In addition, the feature of simultaneous configuration of PUCCH cell switching and PUCCH repetition is helpful for URLLC performance. PUCCH cell switching is for latency reduction, while PUCCH repetition is for improving reliability or coverage performance. Both latency and reliability are important for URLLC servces, the scheduling flexibility of gNB to configure the joint operation should be allowed.  Therefore, we think the details of the joint operation of PUCCH cell switching and PUCCH repetition need to be determined anyhow. Both Alt.1 and Alt.2A can work. |
| Moderator | Moderator tried a last time. As there is still no consensus here (in R17), suggest focusing on how to capture this as conclusion (i.e. no consensus) and maybe an accompanying agreement to clarify what it means to not have this supported. |

And in case we really don’t get consensus, let’s maybe also check here directly the consequences. Namely how to formulate this in the end to clarify what the UE does not expect to be configured with.

So, the following could be there (please note, this is not up for approval or so, just to be prepared later on and to have the issue fully solved in this meeting still):

**Question 6.8.2: Do you have any comments on the wording (improvements) of the text below, in case we cannot agree on the support of PUCCH cell switching & PUCCH repetition in Rel-17?**

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| --- |
| * ***Proposed Conclusion*: There is no consensus to support the joint operation of *dynamic / semi-static* PUCCH cell switching and PUCCH repetition operation in Rel-17.** * ***Proposed Agreement (similar to SPS deferral)*: A UE is not expecting to be configured with *dynamic / semi-static* PUCCH cell switching and PUCCH repetitions for any PUCCH resource of any PHY priority within a PUCCH cell group.** |

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| *Company* | *Comments* |
| Samsung | The conclusion is unfortunate, the main use case for having PUCCH cell switching is not supported, but at least there won’t be specification support to make PUCCH repetitions worse than Rel-16. I guess that can be considered an achievement. |
| DOCOMO | Prefer to have an agreement. |
| LG | We are fine to have an agreement, similar to SPS deferral. |
| Moderator | Will bring both forward – conclusion and agreement. As for SPS deferral, would be good to have it clearly captured what it means that this is not supported in Rel-17. |

6.9 4th and 5th round of email discussions

**Further clarifications on dynamic PUCCH cell switching:**

Based on the discussion in the 1st to 3rd round, companies are still not sure on how the dynamic PUCCH cell switching would be really working – namely at which point of time (before or after the multiplexing) the following RAN1 conclusion is to be applicable and how this is then interacting with the Rel-16 PHY prioritization:

|  |
| --- |
| **Conclusion**  For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell.   * The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the alternative PUCCH cell. |

So let’s continue to focus first on the SINGLE PHY priority case, as for Rel-16 PHY prioritizion clearly multiplexing is only done within the same priority. Let’ consider the following two cases here – let’s consider HARQ & SR (.. the same would apply for CSI of course as well) :



The following is up for consideration:

* HARQ-ACK handling: Based on the moderator understanding, actually for HARQ-ACK within a slot there is no checking of the PUCCH resource for each of the HARQ-ACK bits individually but only for the total HARQ payload size. So for SPS HARQ-ACK on PCell, independently if we choose Alt. 1 or Alt. 2, the question here is how to define the HARQ-ACK payload size within the slot?
  + Option 1: the HARQ-ACK payload size and the related HARQ PUCCH resource is determined for each slot and each of the two PUCCH cell separately for dynamic PUCCH cell switching
  + Option 2: The UE does not expect any HARQ-ACK on PCell in an overlapping slot 🡪 overturn the
* Let’s assume Option 1 is chosen by companies, then what do the different operations mean here:
  + For. Alt. 1 ‘after multiplexing’, does it mean the UE needs to run the multiplexing procedures several times:
    1. 1st: do the ‘multiplexing on PUCCH’ of UCI (in this case HARQ + SR) on PCell first
    2. 2nd: check if the resulting PUCCH (after multiplexing on PUCCH on PCell is valid – i.e. not colliding with SSB etc. 🡪 otherwise error case (UE can do whatever)
    3. If after 2nd step there is no ‘error case’ identified, determine the PUCCH resource for HARQ on the PUCCH sSCell and perform potential multiplexing on PUSCH.

🡪 this seems to increase the checking need dramatically

* + This Alt. 2:
    1. UE checks if the SPS HARQ PUCCH or SR PUCCH are overlapping with SSB etc..
    2. If no error case, PUCCH resource on PUCCH sSCell is determined and potential multiplexing on PUSCH is performed.

So overall, the overall earlier conclusion at least in terms of HARQ-ACK handling seems to be slightly unclear to the moderator.

So let’s check companies’ views:

**Question 6.9.1: For dynamic PUCCH cell switching, in case there is a PUCCH slot with (SPS) HARQ on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell,**

* **Understanding 1: The HARQ-ACK payload size and the related HARQ-ACK PUCCH resource is separately determined for PUCCH slot on PCell /SPCell / PUCCH SCell and for PUCCH sSCell.   
  🡪 specification impact as based on moderator understanding there isn’t anything like that currently**
* **Understanding 2: Within overlapping PUCCH slots only a single HARQ-ACK payload size and associated HARQ-ACK PUCCH resource is determined. does not expect any HARQ-ACK on PCell in an overlapping slot   
  🡪 change of conclusion in terms of HARQ-ACK handling needed**

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| --- | --- |
| Understanding 1 | Huawei/Hisi, vivo |
| Understanding 2 | Samsung, QC, Spreadtrum, DOCOMO, LG |
| Other | CATT (tend to agree with understanding 2 but not sure if we understand it correctly) |

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| --- | --- |
| *Company* | *Comments* |
| Samsung | There is no need to change the conclusion – it is about slots, not PUCCH resources. |
| QC | Based on the analysis of steps of both Alt 1 and Alt 2. We think both are complicated, although Alt 1 can reuse Rel-16 procedure. Therefore, we suggest to update previous agreement to prohibit A/N, or **even take one step further to prohibit any PUCCH**, on PCell, in the overlapping slot, as the following  **Conclusion**  For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell.  ~~The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the alternative PUCCH cell.~~ |
| CATT | Is the following case allowed according to understanding 2? It is our understanding that it is allowed. For this case, we are not clear why conclusion needs to be updated.    The remaining issue to be clarified is that whether the sub-bullet in previous conclusion applies to UCI before multiplexing or after multiplexing. We are open to hear more views from other companies in that regard. |
| Spreadtrum | SPS HARQ-ACK would be appended or included in dynamic HARQ-ACK if any, so there is no SPS HARQ-ACK on PCell. |
| Huawei/Hisi | No interaction between PCell PUCCH and SCell PUCCH. The spec impact is to clarify the processing of UCI multiplexing on PCell and SCell are handled in parallel without impacting each other. It has been concluded that the SPS HARQ-ACK will not joint the UCI multiplexing of a cross-carrier DG PUCCH, so it is not preferred to revert that understanding.  In addition, removing the subbullet is disastrous for PUCCH carrier switching. For URLLC it is typical that SPS/SR is densely configured, e.g., there is candidate SPS/SR resources configured for each of the slots. If we forbid the gNB to schedule HARQ-ACK on SCell as long as there is SPS/SR occasion on DL slot of PCell (e.g., Slot#2/#3 in the figure), then the SCell will never stand a chance to be scheduled for HARQ-ACK tx. |
| DOCOMO | Considering the situation of collision with DL/SSB symbol may be different for PUCCH resource determined before and after multiplexing, UCI multiplexing on PUCCH/PUSCH is performed before or after applying the conclusion for error case checking.  We admit QC’s suggestion is a possible way to result in a simplest solution. UE behavior can be following (option A). But Huawei’s concern is also valid that it may be too restrictive.  **Option A:** Overturing previous agreement, with removing the sub-bullet.    If no overturning previous conclusion, we may have following possible ways:  **Option B:** Follow Rel-16 rule separately for PCell and PUCCH Scell. Then check PUCCH slot overlapping after applying Rel-16 rules.    **Option C:** Firstly apply Rel-16 UCI multiplexing on PUCCH (no UCI multiplexing on PUSCH) and DL/SSB collision for UCI on PCell. Then check PUCCH slot overlapping. If not error case, then determine PUCCH resource on Scell, and UCI multiplexing on PUSCH if any.    **Option D:** Firstly apply DL/SSB collision for each UCI on PCell. Then check PUCCH slot overlapping. If not error case, then determine PUCCH resource on Scell, and UCI multiplexing on PUSCH if any.    Based on above analysis, option A is the simplest way, while overturing previous agreement is needed. If such overturing is not preferred, we prefer option D due to simplicity. |
| vivo2 | Understanding 1, and Understanding 2 is not aligned with the conclusion we made.  For the example plot by CATT’s figure, we share CATT’s views that it should be allowed.  During the discussion on dynamic PUCCH cell switching, it was conclued that UCI multiplexing cross multiple PUCCH cells is not supported. So, the understanding from Spreadtrum is not correct. Our understanding is if the PUCCH resource carrying SPS HARQ-ACK on Pcell collides with SSB, DL symbols, it will be dropped.  For the case where there is UCI including SPS HARQ-ACK on PCell and the PUCCH sSCell is dynamically indicated, the conclusion was made to relax the restriction for overlapping of UCI from PCell and the PUCCH sSCell. For determining if a UCI, e.g. HARQ-ACK, from PCell can be exempted, the HARQ-ACK payload from PCell in a slot and the related HARQ-ACK PUCCH resource for the slot on PCell are determined in sequence.  We do not prefer to revert the previous conclusion and share with HW’s views that if revert, for the case of SR and SPS config with small periodicity, the dynamic pucch carrier switching actually cannot be used. |
| ZTE | Not to revert the previous conclusion, UE should separately process UCI multiplexing on PCell and Scell, including checking the collision with DL on PCell as ususal way, and then checks whether there is the overlapping between the two valid PUCCH slots. |
| New H3C | Previous conclusion shouldn’t be reverted. We slightly prefer understanding 2. |
| ZTE2 | An additional question to be clarified on previouse conclusion, whether the slot 2 and slot 3 in PCell can be regarded as PUCCH slot?  Interpretation 1: If slot 2 and slot 3 are not regarded as PUCCH slot as SR colliding with SSB/DL Symbol, then there is no issue about before or after multiplexing, and the sub-bullet of conclusion can be removed. Also the Option A in DOCOMO is only the choice. I think it is the simplest way to interpretation to end the discussion.  Interpretation 2: If slot 2 and slot 3 are regarded as PUCCH slot, then the current discussion can continue. |
| Moderator | Thanks for the good discussions above.  @Spreadtrum, we decided to not allow the multiplexing of SPS HARQ from PCell on the PUCCH sSCell  @DCM: thanks for these illustrations, may borrow them for the future discussions (hope this is OK).  @all: For companies supporting Understanding 2, but suggest not to revert the working assumption: If there is no HARQ-ACK PUCCH resource determination on PCell, how can then the UE check if the ‘HARQ-ACK’ is not overlapping with SSB etc., based on the sub-bullet? |
| LG | We have similar view to CATT. We think the intention of the previous agreement is Understanding 2. The agreement is to avoid the case of UL multiplexing between the cells, rather than handling overlapping PUCCH only.  For Moderator’s question on Alt.2, UE checks SPS HARQ-ACK based on PUCCH from n1PUCCH-AN or SPS PUCCH list. So it would be different from current UL multiplexing framework. If some companies have strong concern, we are open to Understanding 1. |

And not really sure on how to proceed here otherwise with the ‘before / after’ multiplexing, as the sub-bullet point of the conclusion on how this is to be done independently of choosing before or after multiplexing is done. Actually, I think it would have been much simpler to agree the Conclusion without the subbullet.. (i.e. no UCI on overlapping slot expected).

**Question 6.9.2: If you have any additional comments or the steps interpretations from the moderator above for Alt. 1 or Alt. 2, or if you think we may need to revisit the condition otherwise (e.g. remove the sub-bullet from the conclusion), please provide your views below.**

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| --- | --- |
| *Company* | *Comments* |
| QC | This issue is surprisely much more complicated than what we originally thought. Please see the following flow chart of Alt 1 and 2. Both Alt 1 and Alt 2 are quite complicated. Between Alt 1 and Alt 2, we prefer Alt 1 because it can reuse at least Rel-16 procedure. The whole procedure of Alt 2 seems new.  But again, both Alternatives are quite complicated. Therefore, we suggest to update previous agreement to prohibit A/N, or **even take one step further to prohibit any PUCCH**, on PCell, in the overlapping slot, as the following  **Conclusion**  For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell.  ~~The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the alternative PUCCH cell.~~ |
| CATT | We are open to Alt. 1 and Alt. 2 but do not think the sub-bullet in previous conclusion should be removed. Otherwise, the dynamic PUCCH carrier switching would be quite limited. |
| Huawei/Hisi | Tend to agree that Alt.1 is a more unified solution. For Alt.1, the UCI processing on PCell and SCell are performed separately; for UCI on PUSCH multiplexing, the PCell UCI and SCell UCI on PUSCH multiplexing can emulate the legacy rules where UCIs are only located on PCell. For Alt.2, on the other hand, the UE has to judge whether to perform UCI multiplexing on PCell depending on the reception of the DCI scheduling HARQ-ACK on SCell and the reception of DCI scheduling an overlapping PUSCH. |
| DOCOMO | We think Alt 1 is similar to “applying Rel-16 rule first, then applying Rel-17 new procedure”, but not totally the same. However, in our understanding, in Rel-16 rule, UCI multiplexing includes UCI multiplexing on PUCCH and PUSCH, while the first step of Alt 1 only includes UCI multiplexing on PUCCH. Therefore, we understand it is not fully the same as Rel-16 rule.  If Rel-16 UCI processing on PCell and SCell are performed separately first, the procedure is more likely to be:    However, one potention issue for such procedure is that the UCI on PCell and dynamic HARQ-ACK on Scell may be multiplexed to the same PUSCH, before applying the conclusion (i.e. checking PUCCH slot overlapping).  Based on comment for above Question 6.9.2, we prefer to remove the sub-bullet in the previous conclusion, and adding aother note.  **Conclusion**  For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell.   * ~~The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the alternative PUCCH cell.~~   Note: The PUCCH slot overlapping is checked without considering any UCI multiplexing on PUCCH/PUSCH, or SSB/DL symbol collision. |
| ZTE | Alt. 1 in QC’s figure is more reasonable. About the note from DOCOMO, I am confused that The PUCCH slot overlapping is checked without considering SSB/DL symbol collision, but in the figure, the UE checks the collision due to SSB/DL before checking PUCCH slot overlapping. |
| LG | In the perspective of UE side, if UE detects DCI scheduling PUCCH on sSCell, the UCI on PCell should be exempted or make an error case. Considering these two possibilities, it seems not necessary for UE to check the collision with semi-static DL for PUCCH cell switching.  In this point of view, We slightly prefer Alt. 2 for simplicity. And we are open to discuss to revise previuous conclusion. |

6.10. 5th round of email approvals

**PUCCH cell switching and PUCCH repetition**

There seems to be no chance to achieve consensus on the support of PUCCH cell switching and PUCCH repetition operation. Therefore, the moderator sees no other option to

1. Have a conclusion that there is no consensus to support this in Rel-17
   * Please note, that there is no consensus is not a question if one does not like the conclusion, but just a statement of the situation that we have at hand**. And please note, if you would ‘object’ let us know what is wrong with this statement, as clearly Samsung is objecting and therefore there is no consensus in RAN1!**
2. Clarification on what this consensus means, i.e. how to interpret this (similarly as we did for SPS HARQ-ACK deferral)

**Proposed Conclusion 6.10.1: There is no consensus to support the joint operation of** **PUCCH repetition and (dynamic or semi-static) PUCCH cell switching in Rel-17.**

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| --- | --- |
| Objecting companies | MediaTek |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| MediaTek | In our view, finalizing the details of the operation of PUCCH repetition and PUCCH cell switching is an essential part of finishing the WI. There is no technical reason to not support such joint operation, and RAN1 should adopt at least one solution to support the joint operation. Otherwise, the performance will be significantly impacted, the network will have to choose between PUCCH cell switching (latency improvement) and PUCCH repetition (reliability enhancement). If RAN1 couldn’t reach consensus, the issue can be discussed in the coming RAN plenary. |
| Samsung | There are 3 options based on the discussions so far:   * + 1. Do nothing – i.e. no support of cell switching and PUCCH repetitions     2. Introduce such support to enable worse operation than in Rel-16     3. Introduce such support to enable better operation than in Rel-16   We would have preferred the third one but it has been objected for rather low-quality reasons (e.g. gNB does not provide proper configurations, if any) or for trivial reasons (e.g. need to define what the resource would be on the switching-to cell) that do not relate to whether or not the functionality can be easily enabled. Given that this topic has been discussed for ~3 meetings, the proposed conclusion/option 1 has now become the default outcome. |
|  |  |
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**Proposal 6.10.2: A UE is not expecting to be configured with *dynamic / semi-static* PUCCH cell switching and PUCCH repetitions for any PUCCH resource of any PHY priority within a PUCCH cell group.**

|  |  |
| --- | --- |
| Supporting companies |  |
| Objecting companies | MediaTek |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | That can be just a conclusion. No need to capture gNB misconfigurations for which there is no PHY support. |
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# Joint operation with Rel-17 Intra-UE multiplexing

In this section, the discussions on joint operation of Rel-17 Intra-UE multiplexing (i.e. configured with (i.e. *UCI-MuxWithDifferentPriority*) and Rel-17 URLLC/IIoT HARQ-ACK feedback enhancements are discussed. ss

7.1 Summary of companies input in their contributions

### 7.1.1 Joint Operation of R17 Intra-UE multiplexing and SPS HARQ deferral

* **Support joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral**
  + Yes: HW/HiSi [1], Ericsson [2], vivo [5], ZTE [6], CATT [8] (?), Sony [11], Intel [15], Apple [16], LG [20] (?)
  + No:
  + FFS: Nokia/NSB [3]
  + Details:
    - Apple [16]: In some cases, the payload size may exceed the capacity of UCI part 1 or UCI part 2, then some dropping rules can be defined to handle those cases. For example, with HP HARQ-ACK mapped to UCI part 1, and LP HARQ-ACK which includes DG HARQ-ACK and SPS HARQ-ACK is mapped to UCI part 2, then SPS HARQ-ACK can be dropped if UCI part 2’s capacity is not sufficient.
    - LG [20]:
      * At least the following conditions are kept for SPS HARQ deferral in case configured with intra-UE multiplexing.
        + SPS HARQ-ACK deferral is enabled in RRC
        + PUCCH given by n1PUCCH or SPS-PUCCH-AN-List-r16 is considered as final PUCCH after intra-UE UL multiplexing
        + PUCCH resource are overlaps in time with semi-static DL symbol, SSB and/or CORESET#0
      * To determine the priority of deferred SPS HARQ-ACK from the PUCCH multiplexed with different priority, HARQ-ACK priority is given by corresponding SPS configuration regardless of deferred PUCCH resource in initial slot.
* **Initial slot handling, i.e. the decision to defer SPS HARQ-ACK is performed after**
  + **Step 1 of Rel-17 Intra-UE multiplexing:** HW/HiSi [1] (?), LG [20](condition after step 1 & cannot be transmitted after step 2)
  + **Step 2 of Rel-17 Intra-UE multiplexing:**, Ericsson [2], Nokia/NSB [3], vivo [5], ZTE [6[, CATT [8], Intel [15]
  + **Other:**
  + **Details:** 
    - HW/HiSi [1]: If after the inter-priority multiplexing operation, and if the UE would be transmitting the SPS HARQ-ACK of hybrid priorities on SPS PUCCH, and the SPS PUCCH is not valid in the initial/next PUCCH slot, both HP SPS HARQ-ACK and LP SPS HARQ-ACK are dropped without further deferral.
    - Spreadtrum [10]: If a LP SPS HARQ-ACK PUCCH is dropped according to Rel-17 intra-UE multiplexing, the LP SPS HARQ-ACK is not deferred.
    - Intel [15]: If the resultant UL channel is a PUCCH resource for SPS PUCCH for priority i, then, defer the SPS HARQ-ACK for priority i. That means, if LP SPS HARQ-ACK is multiplexed with HP SPS HARQ-ACK, and the resultant channel is HP SPS PUCCH resource which is invalid, only deferral of HP SPS HARQ-ACK is allowed, and LP SPS HARQ-ACK is dropped.
* **Target / earliest second slot handling, i.e. the decision on a PUCCH slot being the earliest second PUCCH slot is performed after:** 
  + **Step 1 of Rel-17 Intra-UE multiplexing:** HW/HiSi [1] (?), Ericsson [2] (?), Nokia/NSB [3]
  + **Step 2 of Rel-17 Intra-UE multiplexing:** vivo [5], ZTE [6],CATT [8] (?), Intel [15], LG [20],
  + **Other:**
  + **Details:** 
    - HW/HiSi [1]: Some handling is needed if having parallel deferral of HP & LP SPS HARQ with different PUCCH lengths / time units.
      * The target slot/sub-slot for the LP SPS HARQ-ACK and HP SPS HARQ-ACK are separately determined based on separate LP/HP time units without considering the existence of the other priority, if they are both subject to deferral.
      * If after the inter-priority multiplexing operation, and if the UE would be transmitting the SPS HARQ-ACK of hybrid priorities on SPS PUCCH, and the SPS PUCCH is not valid in the initial/next PUCCH slot, both HP SPS HARQ-ACK and LP SPS HARQ-ACK are dropped without further deferral.
    - Ericsson [2]: SPS HARQ-ACK of different PHY priorities can be separately deferred with the target PUCCHs separately determined according to their respective PHY priorities. Then depending on where the target slot(s) is/are located, Rel-17 intra UE multiplexing can be applied when applicable.
    - Nokia/NSB [3]: After step 2 would lead to iterative / recursive step 1 and step 2 operation. Too high UE & gNB complexity
    - vivo [5]: Note when deferred SPS HARQ-ACK of two PHY priorities are involved in the above case (i) or case (ii), the target PUCCH slot for deferred SPS HARQ-ACK of each PHY priority is determined respectively at the same time. It can also be understood that PUCCH slots for different PHY priorities may has different length.
    - CATT [8]: SPS HARQ-ACK of different PHY priorities are separately deferred with target PUCCH slots separately determined according to their respective PHY priorities
    - Spreadtrum [10]: SPS HARQ for deferral of different PHY priorities can be separately deferred with the target PUCCHs separately be determinated according to their respective PHY priorities. If a LP SPS HARQ-ACK PUCCH is dropped according to Rel-17 intra-UE multiplexing, the LP SPS HARQ-ACK is not deferred.
    - Sony [11]: When Rel-17 intra-UE UCI multiplexing is enabled and if the deferred SPS HARQ-ACKs contain HP HARQ-ACKs, the resource for the target PUCCH is selected from the 2nd PUCCH Config, regardless of the L1 priority of the originally scheduled target PUCCH.
      * *Moderator comment:* It is moderator’s understanding that for a deferred HP SPS HARQ due to step 2.1 always a PUCCH resource from the 2nd PUCCH config is selected. This is not different to the case of HP SPS HARQ in the initial slot.
    - Intel [15]: If the resultant UL channel is a PUCCH resource for SPS PUCCH for priority i, then, defer the SPS HARQ-ACK for priority i. That means, if LP SPS HARQ-ACK is multiplexed with HP SPS HARQ-ACK, and the resultant channel is HP SPS PUCCH resource which is invalid, only deferral of HP SPS HARQ-ACK is allowed, and LP SPS HARQ-ACK is dropped.

### 7.1.2 Joint Operation of R17 Intra-UE multiplexing and One-shot HARQ re-transmission

* **Support joint operation of Rel-17 Intra-UE multiplexing and one-shot HARQ re-tx**
  + Yes: HW/HiSi [1], Nokia/NSB [3], vivo [5], CATT [8] (?), Intel [15], Apple [16], LG [20]
  + No:
  + FFS:
  + Details:
    - HW/HiSi [1]:
      * UE does not expect the overlapping between LP HARQ-ACK subject to one-shot retransmission and HP HARQ-ACK (… due to ambiguity issue of LP DCI missing)
        + *Moderator comment*: the ambiguity issue is mainly for the gNB, so couldn’t the gNB by implementation just prevent any HP HARQ-ACK to collide / overlap with a re-tx of a LP HARQ-ACK re-transmission? i.e. do we need to handle this by specification, or could this not be a gNB implementation / operation choice?
    - Nokia/NSB [3]:
      * A single DCI triggering the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB can trigger the re-transmission of HARQ-ACK information of only a single HARQ-ACK CB of a single PHY priority.
      * The UE does not expect more than one triggering DCI for Rel-17 one-shot feedback indicating the same PUCCH slot of a certain PHY priority in step 1 for the re-transmission of HARQ-ACK CBs of different PUCCH slots to be re-transmitted.
        + *Note: In step 2, there could be still multiplexing of LP and HP HARQ-ACK CBs to be retransmitted on PUCCH or PUSCH.*
      * The ‘backward HARQ-ACK slot-offset’ is interpreted with the granularity of a PUCCH slot of the respective PHY priority of step 1 of PCell /PSCell / PUCCH SCell
    - Vivo [5]:
      * In our opinion, even if a HP HARQ-ACK codebook and a LP HARQ-ACK codebook are multiplexed into a PUCCH or PUSCH based on the rules of Rel-17 intra-UE multiplexing, when a re-transmission of either of the two HARQ-ACK codebooks is required, gNB can simply issue a triggering DCI indicating the PHY priority of the HARQ-ACK codebook required to be re-transmitted, and indicating the original PUCCH conveying the HARQ-ACK codebook by HARQ\_retx\_offset. If both of the two HARQ-ACK codebooks are required to be re-transmitted, gNB can simply issue two separate triggering DCIs, from which one is used for each HARQ-ACK codebook, respectively.
    - CATT [8]:
      * only HARQ-ACK with same priority as the triggering DCI indication can be triggered for one-shot HARQ-ACK re-transmission
    - Intel [15]:
      * For one-shot triggering of a PUCCH which is a mix of LP and HP HARQ-ACK according to R17 multiplexing, the one-shot trigger only instructs to retransmit HARQ-ACK of priority j which is indicated in the triggering DCI
    - Apple [16]:
      * One-short HARQ retransmission can be handled per physical layer priority follows existing agreements, the payload at LP or HP with retransmitted one-shot HARQ-ACK can be handled by the intra-UE MUX framework
      * In some cases, the payload size may exceed the capacity of UCI part 1 or UCI part 2, then some dropping rules can be defined to handle those cases. For example, with HP HARQ-ACK mapped to UCI part 1, and LP HARQ-ACK which includes initial DG HARQ-ACK and retransmitted one-shot HARQ-ACK is mapped to UCI part 2, then one-shot HARQ retransmission can be dropped if UCI part 2’s capacity is not sufficient.
    - LG [20]
      * For One-shot HARQ-ACK retransmission of the PUCCH multiplexed with different priority, only the HARQ-ACK codebook having indicated priority index is to be retransmitted.
        + HARQ offset of triggering DCI is determined based on slot length of the indicated priority in the triggering DCI.

### 7.1.3 Joint Operation of R17 Intra-UE multiplexing and Type 3 / Enh. Type 3 CB

* **Support joint operation of Rel-17 Intra-UE multiplexing and enh. Type 3 CB**
  + Yes: HW/HiSi [1], [Nokia/NSB [3], vivo [5], CATT [8], Intel [15]
  + No:
  + FFS:
  + Details:
    - HW/HiSi [1]:
      * The UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB with the same priority index as the enhanced Type 3 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB.
      * UE does not expect the overlapping between LP HARQ-ACK subject to Type 3 CB/enhanced Type 3 CB and HP HARQ-ACK.
    - Nokia/NSB [3]:
      * The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size.
      * The A/N of HARQ processes is mapped to the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size irrespective of the PHY priority of the ‘A/N’ of the HARQ processes.
      * The enhanced Type 3 HARQ-ACK has the same structure, size and content (in terms of HARQ-IDs, CCs) irrespective of the PHY priority.
      * The UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook in neither step 1 nor step 2 of the Rel-17 Intra-UE multiplexing framework.
    - Intel [15]: For phy prioritization between LP/HP PUCCH carrying (e)Type3 CB and HP/LP PUCCH carrying HARQ-ACK using Release 17 multiplexing, follow the agreed behavior
    - LG [20]
      * Alternative 1: UE does not expect that type-3 or enhanced type-3 triggering DCI indicates lower priority transmission
      * Alternative 2: UE assumes that type-3 or enhanced type-3 triggering DCI corresponds to higher priority transmission (regardless of the value of priority indication field)

### 7.1.4 Joint Operation of R17 Intra-UE multiplexing and semi-static PUCCH cell switching

* **Support joint Operation of R17 Intra-UE multiplexing and semi-static PUCCH cell switching**
  + **Yes:** HW/HiSi [1], Ericsson [2], Nokia/NSB [3]. vivo [5], CATT [8]
  + **No:**
  + **FFS:**
  + **Details:**
    - HW/HiSi [1]: can be straightforwardly supported with negligible spec impact
    - Ericsson [2]:
      * When dynamic or semi-static PUCCH cell switching is enabled for a PUCCH group, at any given time the PUCCH resources would be allocated to a same cell (either PCell /PSCell / PUCCH SCell or PUCCH sScell).
      * Once a target cell is determined based on a dynamic indication or time-domain pattern due to dynamic or semi-static PUCCH cell switching, respectively, the intra-UE multiplexing procedures can be applied to resolve collision in case of overlapping PUCCH resources on the target cell.
    - Nokia/NSB [3]: The Rel-17 Intra-UE multiplexing operation including step 1 and step 2 are performed on the applicable target PUCCH cell.

### 7.1.5 Joint Operation of R17 Intra-UE multiplexing and dynamic PUCCH cell switching

* **Support joint Operation of R17 Intra-UE multiplexing and dynamic PUCCH cell switching**
  + **Yes:** HW/HiSi [1], Ericsson [2], vivo [5],CATT [8], Intel [15]
  + **No:** Nokia/NSB [3],
  + **FFS:**
  + **Details:**
    - HW/HiSi [1]: can be straightforwardly supported with negligible spec impact
    - Ericsson [2]:
      * When dynamic or semi-static PUCCH cell switching is enabled for a PUCCH group, at any given time the PUCCH resources would be allocated to a same cell (either PCell /PSCell / PUCCH SCell or PUCCH sScell).
      * Once a target cell is determined based on a dynamic indication or time-domain pattern due to dynamic or semi-static PUCCH cell switching, respectively, the intra-UE multiplexing procedures can be applied to resolve collision in case of overlapping PUCCH resources on the target cell.
    - Nokia/NSB [3]: Further clarifications would be needed (still not available) 🡪 do not support in Rel-17.
    - CATT [8]: LP HARQ-ACK would not be multiplexed with HP UCI if they are on different PUCCH cells
    - Intel [15]: For the conclusion that “For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell”,
      * Clarify that the valid PUCCH resource on Pcell means PUCCH resources before multiplexing on Pcell
      * Clarify that for different priority UCI, any PUCCH resource before multiplexing/prioritization is considered

### 7.1.6 Joint Operation of simultaneous PUCCH/PUSCH and Rel-17 HARQ-ACK enhancements

* **Support joint Operation of R17 simultaneous PUSCH/PUCCH and any of the HARQ-ACK enhancements**
  + **Yes:** vivo [5] (any of the Rel-17 HARQ enhancements), QC [19] (for PUCCH cell switching)
  + **No:**
  + **FFS:**
  + **Details:**

7.2 1st round of email approvals

Joint Operation of R17 Intra-UE multiplexing and One-shot HARQ re-transmission

Several companies also provided input on the support of this joint operation. And based on the input, it seems that all input receiving is hinting, that for the indicated priority in one-shot HARQ re-transmission triggering DCI only the HARQ-ACK CB of that priority should be triggered.

So let’s try to see if we are able to find a complete solution proposal to support this feature combination in Rel-17.

**Mod Proposal 7.2.1: Support joint operation of Rel-17 Intra-UE multiplexing and one-shot HARQ re-tx in Rel-17**

* **One-shot HARQ retransmission is be handled per physical layer priority following the existing agreements in step 1, i.e.** 
  + **Only the HARQ-ACK CB of the indicated PHY priority in one-shot HARQ-ACK triggering DCI is triggered for one-shot HARQ-ACK CB re-transmission**
  + **The ‘backward HARQ-ACK slot-offset’ is interpreted with the granularity of a PUCCH slot of the respective PHY priority of step 1 of PCell /PSCell / PUCCH SCell**
  + **The UE does not expect more than one triggering DCI for Rel-17 one-shot feedback indicating the same PUCCH slot of a certain PHY priority in step 1 for the re-transmission of HARQ-ACK CBs of different PUCCH slots to be re-transmitted.**
* **After the one-shot HARQ-ACK re-transmission operation in step1, the UE continues in step 2 of the Rel-17 Intra-UE multiplexing framework** 
  + **There are no further restrictions imposed, e.g. multiplexing of one or a combination of LP HARQ-ACK CBs, including LP Type1 CB/Type2 CB /one-shot ~~triggered for~~ re-transmission CB, with one or a combination of HP HARQ-ACK CBs, including LP Type1 CB/Type2 CB /one-shot ~~triggered for~~ re-transmission CB~~, and a HP Type 1 or HP Type 2 HARQ-ACK CB~~ in step 2 is not precluded.**

|  |  |
| --- | --- |
| Supporting companies | Ericsson Huawei/Hisi (see comments), vivo, DOCOMO, CATT, Nokia/NSB, ZTE, Intel, LG, ETRI, Samsung |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| QC | The statement  “**The UE does not expect more than one triggering DCI for Rel-17 one-shot feedback indicating the same PUCCH slot of a certain PHY priority in step 1 for the re-transmission of HARQ-ACK CBs of different PUCCH slots to be re-transmitted.**”  Is not needed since it is already the agreement from #106e  **Agreement**  For Rel-17 one-shot triggering for HARQ-ACK re-transmission, the UE does not expect more than one triggering DCI for Rel-17 one-shot feedback indicating the same PUCCH slot for the re-transmission of HARQ-ACK CBs of different PUCCH slots to be re-transmitted  Note: i.e. only a single HARQ-ACK codebook / PUCCH occasion can be re-transmitted in a PUCCH slot |
| Huawei/Hisi | One clarification question for the last subbullet: why the multiplexing of “HP HARQ-ACK CB triggered for re-transmission, and a HP Type 1 or HP Type 2 HARQ-ACK CB in step 2”should appear in Step 2? Does it mean the following?  **There are no further restrictions imposed, e.g. multiplexing of one or a combination of LP HARQ-ACK CBs, including LP Type1 CB/Type2 CB /one-shot ~~triggered for~~ re-transmission CB, with one or a combination of HP HARQ-ACK CBs, including LP Type1 CB/Type2 CB /one-shot ~~triggered for~~ re-transmission CB~~, and a HP Type 1 or HP Type 2 HARQ-ACK CB~~ in step 2 is not precluded**  Basically we donot support the multiplexing of LP one shot CB with HP PUCCH since the LP T-DAI in HP DCI, even if introduced, cannot indicate the CB size of one shot retransmission. But we can live with the subbullet for progress. |
| Moderator | @QC: The earlier agreement to moderator understanding was not to concatenate more than one HARQ-ACK re-tx codebook to be appended within a single PHY priority which is important for the multiplexing and PUCCH resource selection procedure. For R16 PHY prioritization, there is still the PHY prioritization operation that follows after that. Now here, having the same restrictions in step 1, what do we do or allow in step 2.  @HW: yes – what you describe above was the moderator’s intention . Thanks for the related edits, change that in **Mod Proposal 7.2.1**.  On the ambiguity: I guess this can be prevented by gNB implementation (i.e. gNB just preventing any other HARQ to be multiplexed). |
| ZTE | I think no more open issue for this joint processing. The subbullets in the proposal are all agreement and common sense in the individual function. |
| vivo2 | There seems typo on the modified proposal? **LP** should be changed to HP?  **There are no further restrictions imposed, e.g. multiplexing of one or a combination of LP HARQ-ACK CBs, including LP Type1 CB/Type2 CB /one-shot ~~triggered for~~ re-transmission CB, with one or a combination of HP HARQ-ACK CBs, including LP Type1 CB/Type2 CB /one-shot ~~triggered for~~ re-transmission CB~~, and a HP Type 1 or HP Type 2 HARQ-ACK CB~~ in step 2 is not precluded** |
| LG | We also think **LP** should be changed to HP in the comment from vivo2. |
| Samsung | With the LP 🡪 HP update mentioned above. |
| Sony | Isn’t the 1st bullet already agreed that the 1-shot ReTx retransmit HP or LP and the granularity of the offset based on the indicated L1 priority in the triggering DCI? |

Joint Operation of R17 Intra-UE multiplexing and semi-static PUCCH cell switching

There seems to also good interest in trying to support this combination.

The moderator tries to formulate a complete proposal based on the details from the companies’ inputs here. Let’s start from checking this proposal:

**Proposal 7.2.2: Support joint Operation of R17 Intra-UE multiplexing and semi-static PUCCH cell switching**

* **The Rel-17 Intra-UE multiplexing operation of step 1 and step 2 are performed using the determined target PUCCH cell based on the semi-static time domain pattern,** 
  + **i.e., once a target cell is determined based on the time-domain pattern due, the intra-UE multiplexing procedures can be applied to resolve collision in case of overlapping PUCCH resources on the target PUCCH cell.**

|  |  |
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| Supporting companies | Ericsson Huawei/Hisi, vivo, DOCOMO,OPPO, CATT, Nokia/NSB, ZTE, Intel, LG, ETRI, Sony |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| QC | OK to support this joint feature. But a new UE capability signaling for this joint operation is needed. A UE can support R17 Intra-UE multiplexing and semi-static PUCCH cell switching does not automatically can support this joint feature. |
| Samsung | It is not clear how to handle the case where a PUSCH overlaps with multiple PUCCHs on different PUCCH cells |
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|  |  |

7.3 1st and 2nd round of email discussions

Joint Operation of R17 Intra-UE multiplexing and SPS HARQ deferral

There had been rather good input in TDocs on this feature combination. As for other agreed supported features, it will be needed to not just agree to support something in general, but at the same time also agree the intended baseline operation of the feature combination.

Therefore, the following three discussions are planned here:

* Get an input on the overall support from companies for this feature combination – to check if detailed discussions may pay off or not in the end.
* Have some general procedures clarified (e.g. based on the input by LG [20])
* Trying to get an idea on the ‘initial slot’ SPS deferral handling/operation with the Rel-17 Intra-UE multiplexing framework
* Trying to get an idea on the ‘target slot / earliest second slot’ determination with the Rel-17 Intra-UE multiplexing framework

So let’s first check the general intention of companies to have the joint operation supported (as in case there is strong resistance, it may not be worth the effort to discuss the potential details as well).

**Proposal 7.3.1: Support joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral in Rel-17**

* **FFS detailed operation including ‘initial slot’ handling and ‘earliest second slot’ determination**

|  |  |
| --- | --- |
| Supporting companies | Intel [Huawei/Hisi], Samsung, Sony, Samsung |
| Objecting companies | QC |
| FFS | Vivo, CATT, Nokia/NSB ,ZTE, LG, NEC, New H3C |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| QC | In general, the whole feaure gets too complicated with this joint configuration. UE need to check if a target slot is valid for deferred LP SPS A/N with intra-UE mux, and check if a target slot is valid for deferred HP SPS A/N with intra-UE mux, then check if a target slot is valid for deferred HP and LP A/N jointly. The interation between valid slot checking and the two step intra-UE mux procedure is super complicated. But at the end, the benefit is not expected to be that impressive, given there are tools to retransmit SPS A/N already.  With the above, we don’t support this proposal, which creates too many new open issue at late stage of Rel-17. |
| vivo | Whether to support the joint operation highly depends on the decision for the initial and target slot handling. |
| Nokia/NSB | Agree with vivo |
| Intel | We support the general intention and do not see big issues in finalization of this joint operation. |
| LG | We have similar view to vivo. |
| Huawei/Hisi | To address the concern too complicated procedure for handling two deferring SPS HARQ-ACKs with different priorities, can we make some restrictions to allow only one SPS deferral subject to deferral (either HP SPS deferral or LP SPS deferral but not both)? Thus the deferring SPS HARQ-ACK can take multiplexing in Step 1 and Step 2 only with DG PUCCH/PUSCH if any. The SPS deferral is mainly targeted for IIoT with periodic services, so it is reasonable and typical that SPS deferral is only configured for HP. The expense is some RRC impact to enable SPS deferral for a specific priority. Changes could be:  **Proposal 7.3.1: Support joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral in Rel-17, with the limitation that UE expects the SPS HARQ-ACK subject to most one priority is configured with SPS HARQ-ACK deferral when intra-UE multiplexing is configured.** |
| QC2 | Huawei’ modified proposal deserves to be discussed. |

Moreover, it would be good to have some things in general clarified on the operation. Based on companies inputs the following baseline principles could be applied:

**Proposal 7.3.2: If joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral is supported in Rel-17**

* **The decision of deferral in the initial slot or the determination of the target slot is still based on:**
  + **PUCCH given by n1PUCCH or SPS-PUCCH-AN-List-r16 which is regarded as invalid**
  + **The determination of valid symbols in the initial and target PUCCH slot/sub-slot a collision with semi-static DL symbols, SSB and symbols indicated by *pdcch-ConfigSIB1* in *MIB* for a CORESET for Type0-PDCCH CSS set is regarded as ‘invalid’ or ‘no symbols for UL transmission’.**
* **To determine the priority of deferred SPS HARQ-ACK from the PUCCH multiplexed with different priority, HARQ-ACK priority is given by the corresponding SPS configuration regardless of deferred PUCCH resource in initial slot.**

|  |  |
| --- | --- |
| Supporting companies | Vivo, DOCOMO, Nokia/NSB, ZTE, Intel, LG, Sony, Spreadtrum, CATT, |
| Objecting companies | QC [Huawei/Hisi], Samsung, New H3C |

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| --- | --- |
| *Company* | *Comments* |
| QC | Firstly, it would be better to separate the discussion for initial and target slot.  Secondly, a question for clarification: is the decision of deferral made separately for HP SPS A/N and LP SPS A/N? Is the decision made before step1, after step 1 but before step 2, or after step 2? All the details need to be discussed before agreeing on this proposal |
| ZTE | My understanding is to reuse the 2 step procedure for this joint processing. |
| Huawei/Hisi | We are fine with the first bullet.  For the 2nd bullet, what is the purpose of defining the priority for SPS HARQ-ACK within a hybrid priority PUCCH/PUSCH? If it is used for one shot retransmission, we do not agree with this bullet, since in our understanding, the one shot retx triggering DCI can indicate the retx of the single priority PUCCH before the multiplexing of Step 2. |
| Samsung | First, the order of UCI multiplexing of different priorities and the decision of deferral should be clarified. We understand that UCI multiplexing of different priorities is performed before the decision of deferral. Then, the decision of deferral in the initial slot or the determination of the target slot should be separately discussed.  For the decision of deferral, another issue is whether a PUCCH resource given by *n1PUCCH* or *SPS-PUCCH-AN-List-r16* of a different priority can be used for the decision.  For the determination of the target slot, both PUCCH and PUSCH should be considered. For example, SPS HARQ-ACK in an invalid PUCCH can be multiplexed in a PUSCH and PUCCH slot is considered as the target slot.  The second sub-bullet is not clear. The priority issue can be decoupled from SPS HARQ-ACK deferral. |
| NEC | We are fine with the 1st bullet.  For the 2nd bullet, we are not clear of the intention of defining the priority for deferred SPS HARQ-ACK, it is used for Rel-17 intra-UE multiplexing operation? E.g., apply separate coding when multiplex deferred SPS HARQ-ACK of different priorities on HP PUCCH/PUSCH. |
| New H3C | We are fine with the 1st bullet. For 2nd sublet, how eo determine priority of SPS HARQ-ACK isn’t clear to us. |

Next, let’s discuss how to handle the initial slot handling, i.e. how to determine if some SPS HARQ-ACK bits configured with SPS deferral in the initial slot are determined to be deferred. For this operation, we have the following related behavior defined:

|  |
| --- |
| **Conclusion**  For SPS HARQ-ACK deferral, the operation in the ‘initial’ slot is further clarified as:   * The UE performs first the (Rel-16) UCI multiplexing operation. If after the UCI multiplexing operation into a PUCCH or PUSCH if any, and if the UE would be transmitting SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN which is not valid, the SPS HARQ-ACK configured for deferral is deferred.   **Conclusion**  For SPS HARQ-ACK deferral, if a UE is not configured with Rel-17 intra-UE multiplexing but configured with Rel-16 PHY prioritization, the UE first performs Rel-16 UCI multiplexing and PHY prioritization in both initial slot and target slot and if a LP SPS HARQ-ACK PUCCH is deprioritized, the LP SPS HARQ-ACK is not deferred.   * Note: If the SPS HARQ-ACK is deprioritized in any slot, no further deferral. |

In principle two options can be considered here: that the decision is done after the UCI multiplexing operation already after step 1 (within the same PHY priority) or after the overall step 2 procedure.

* Taking the decision to defer already after step 1 would be aligned with the Rel-16 PHY prioritization operation (from implementation point of view) but as pointed out by some companies could lead to the case that the SPS HARQ is determined to be deferred but would still be transmitted due to the Rel-17 Intra-UE multiplexing operation of different priorities in step 2.
* Taking the decision to defer after step 2 prevents this ‘double SPS HARQ-ACK transmission’ but could lead to more cases that LP SPS HARQ-ACK is not actually transmitted as e.g. the LP SPS HARQ-ACK in step 2 is to be dropped (e.g. in case of overlap with positive HP PUCCH with SR only, or overlapping with HP PUSCH with HP HARQ-ACK and 2 part HP CSI).

Please provide your views below, also in the comments table if you think some additional handling or conditions would needed.

**Mod Question 7.3.3: If joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral is supported in Rel-17, the determination if SPS HARQ-ACK is to be deferred in the initial slot is performed:**

* **Alt. 1: After the step 1 of the Rel-17 Intra-UE multiplexing operation within the same PHY priority only, i.e.,** 
  1. ***If after the step 1 of Rel-17 UCI multiplexing operation into a PUCCH or PUSCH if any, and if the UE would be transmitting LP SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN which is not valid, the LP SPS HARQ-ACK configured for deferral is deferred.***
  2. ***If after the step 1 of Rel-17 UCI multiplexing operation into a PUCCH or PUSCH if any, and if the UE would be transmitting HP SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN which is not valid, the HP SPS HARQ-ACK configured for deferral is deferred.***
  3. ***Independent of the deferral decision of LP SPS HARQ-ACK and HP SPS HARQ-ACK after step 1 of the Rel-17 UCI multiplexing operation into a PUCCH or PUSCH if any, the UE performs step 2 of the Rel-17 Intra-UE multiplexing framework.***
* **Alt. 2: After step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation ~~within the same PHY priority only~~, i.e.,**
  1. ***If after the Rel-17 UCI multiplexing operation (including step 1 and step 2) into a PUCCH or PUSCH if any, and if the UE would be transmitting LP SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from*** 
     + ***Alt. 2A (Intel): the first PUCCH configuration***
     + ***Alt. 2B (Nokia): the first or second PUCCH configuration***

***which is not valid, the LP SPS* HARQ*-ACK configured for deferral is deferred.***

* 1. ***If after the Rel-17 UCI multiplexing operation (including step 1 and step 2) into a PUCCH or PUSCH if any, and if the UE would be transmitting HP SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the second PUCCH configuration which is not valid, the HP SPS HARQ-ACK configured for deferral is deferred.***
  2. ***LP SPS HARQ-ACK that cannot be mapped to a HP PUCCH or HP PUSCH based on the Rel-17 Intra-UE multiplexing framework and is therefore dropped in step 2.1 or step 2.2, is not subject to deferral.***

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| --- | --- |
| Alt. 1 | vivo (2nd prefernce), DOCOMO, Nokia/NSB (2nd) |
| Alt. 2A | Intel (1st pref) |
| Alt. 2B | vivo (1st prefernce), Nokia/NSB, ZTE, Intel (2nd pref), LG(except for step.3) Huawei/Hisi (if supported), Samsung, Sony, NEC, CATT |
| Other |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| QC | The formulation of proposal just for initial slot is already a show of the complication level of supporting this feature. Like we commented already, due to the high complexity and marginal benefit, it is not worthwhile to spend effort on this.  With the above, we don’t support this proposal |
| vivo | For Alt.2, we suggest following update for the main bullet to avoid the confusion.  **Alt. 2: After step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation ~~within the same PHY priority only~~.**  In addition, we prefer unified handling for initial slot and target slot. |
| DOCOMO | Alt 1 is the simplest.  Moreover, we think Question 7.3.3 and Question 7.3.4 should be discussed together since aligned behavior in initial slot and target slot is desidered. |
| Intel | Alt.1 may introduce redundant SPS HARQ-ACK transmission, thus we prefer Alt. 2A or Alt. 2B, wherein 2A looks simpler but 2B may have lower LP dropping probability. |
| LG | We think Alt. 2B could be baseline since it could rescue LP SPS HARQ-ACK by intra-UE multiplexing. However, step 3 could be reconsidered since it brings side effect to drop SPS HARQ-ACK which can be transmitted if there is no intra-UE multiplexing. For dropped LP HARQ-ACK, It could fallback in to Alt. 1-1. |
| Huawei/Hisi | Alt. 2 is preferred, while Alt.1 should not be considered since the UE may receive DCI scheduling DG PUCCH/PUSCH on the slot, so it is not reasonable that the SPS deferral HARQ-ACK makes the deferral decision immediately after Step 1 and do not perform the multiplexing at Step 2 taking into account the deferred SPS HARQ-ACK.  For Alt.2, a key question is, if two sliding SPS HARQ-ACK deferral are supported, whether/how they will consider the existence of each other when doing the multiplexing at Step 2.1.  E.g., as both HP/LP SPS HARQ-ACKs are sliding, for a HP SPS HARQ-ACK at subslot#3, whether it will consider the existence of another LP SPS HARQ-ACK at Slot#2? If not, then if the HP SPS HARQ-ACK determines an invalid slot for PUCCH transmission at subslot#4 while the LP SPS HARQ-ACK determines a valid slot for PUCCH transmission at Slot#2, should the HP SPS HARQ-ACK redo the multiplexing?    If it will consider the existence of another LP SPS HARQ-ACK at each slot, then it is unavoidable to multiplex them into a hybrid SPS PUCCH for each slot, thus Alt.2A seems not work well, since UE has to drop the LP SPS HARQ-ACK as early as Slot#1. |
| Samsung | “or PUSCH” should be removed. If the resulting channel is a PUSCH, there is no further deferral. The initial slot should focus on PUCCH only while the target slot should consider both PUCCH and PUSCH. |
| Moderator | @LG: the third bullet is there, as there could be SPS HARQ-ACK dropping with R17 intra-UE multiplexing also, in case the slot is ‘all UL’ (i.e. not TDD specific dropping) that the LP SPS HARQ-ACK is to be dropped. Preventing such dropping would be somehow against the idea of the deferral in the first place.  @HW: this is the initial slot (i.e. slot determined by n+k1), there should no be any issue there with HP & LP SPS HARQ-ACK. The problem seems to just come in the the determination of the target slot in slots n+k1+1…  @Samsung: the ‘PUCCH or PUSCH if any’ is from the earlier conclusion, please check above.  Let’s continue discussing here in the 2nd round… |
| Huawei/Hisi | @Moderator: yes, the cases we presented above is applied to a candidate target slot. But we think the unified rule should be considered for both initial slot and candidate target slot, considering the case where a slot m could be an initial slot (m=n\_HP+k1) for HP SPS, but not necessarily an initial slot for LP SPS (m=n\_LP+k1+X), when, e.g., the initial slot of n\_LP+k1 is earlier than n\_HP+k1. |
| Sony | If after Step 2, the HP & LP SPS HARQ-ACKs are to be deferred, how do we define the initial PUCCH:   1. As two separate initial PUCCHs. Treat the HP & LP SPS HARQ-ACK as separate even thought they had undergone the UCI multiplexing process and the resultant PUCCH is dropped. That is the HP & LP SPS HARQ-ACK each independently find their target PUCCH. 2. As a single intital PUCCH. Treat the HP & LP SPS HARQ-ACKs as one initial PUCCH since the resultant PUCCH containing these HARQ-ACKs of different L1 priorities is invalid.   That is can we have an initial PUCCH contains HP & LP SPS HARQ-ACKs or initial PUCCH can only contain SPS HARQ-ACK of a single L1 priority? |
| Samsung | Thanks to the moderator for the clarification - we are fine with “or PUSCH”. |
| NEC | Alt.2B is preferred, we share same view with Intel that Alt.1 may lead to redundant SPS HARQ-ACK transmission. |
| QC ***2*** | Alt 2 provides better system performance and Alt 2B is the more efficient of the two options. |

Similarly, for the target slot determination either after step 1 or step 2 can be considered. The following issues have been raised by different companies:

* Again, when having the determination of the target slot after step 1 already would align the operation with PHY prioritization. Based on moderator assessment this would lead to the simpler specification & implementation as the target slot determination is already done before starting step 2 of the Intra-UE multiplexing operation (i.e. there are not several hypothesis on deferred SPS HARQ-ACK presence needed in step 2). On the other hand, this may lead to longer latency as potentially the SPS HARQ-ACK could still be transmitted in a slot based on the step 2 multiplexing decisions.
* For different PUCCH slot/sub-slot configurations, there could be different time units for HP PUCCH and LP PUCCH. Therefore, having the determination after step 2 will require specific handling of such cases. For companies supporting to make the deferral decision after step 2, please explain how to handle such operation.
* But even for the same time unit, when performing the determination of the target slot for HP and LP SPS HARQ-ACK which are pending for deferral after step 2, we would need to define the operation there:
  + Is there some joint determination for that case (i.e. joint decision if HP and LP SPS HARQ for deferral)? This would simplify as the UE would only need to perform step 2 with two hypothesis (namely having both LP & HP deferred SPS HARQ present or not) but again may lead to higher HP SPS HARQ-ACK latency as potentially only having the deferred SPS HARQ-ACK mapped could lead to successful transmission there.
  + Or is the determination done in a certain order (e.g. first check for HP SPS HARQ-ACK target slot condition and then check for LP SPS HARQ-ACK target slot condition)? This could lead to higher probability of mapping HP SPS HARQ-ACK subject to deferral but would lead to running step 2 with more than two hypothesis.
  + For companies supporting to make the deferral decision after step 2, please explain how to handle this here, assuming there is both pending LP and HP SPS HARQ-ACK pending for deferral.

**Mod Question 7.3.4: If joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral is supported in Rel-17, the determination of the ‘target’ or ‘earliest second slot’ for the SPS HARQ-ACK deferral procedure is performed:**

* **Alt. 1: After the step 1 of the Rel-17 Intra-UE multiplexing operation within the same PHY priority only, i.e.,** 
  + ***The target PUCCH slot of a certain PHY priority is defined as the next PUCCH slot, where after performing step 1 of the Rel-17 UCI multiplexing operation into a PUCCH or PUSCH of that PHY priority if any, the UE would be either (i) transmitting HARQ-ACK using a PUCCH/PUSCH other than the PUCCH determined from PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN of that PHY priority or (ii) would be transmitting HARQ-ACK using a PUCCH resource configured in PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN for that PHY priority being regarded as valid.***
  + ***If after the target slot determination for LP SPS HARQ and/or HP SPS HARQ subject to deferral followed by step 2 of the Rel-17 Intra-UE multiplexing operation, the deferred LP and/or HP SPS HARQ-ACK cannot be transmitted, the LP and/or HP SPS HARQ-ACK is dropped without further deferral.***
* **Alt. 2: After step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation ~~within the same PHY priority only~~, i.e.,**
  + ***The target PUCCH slot  for a certain PHY priority is defined as the next PUCCH slot of that priority, where after performing step 1 and step 2 of the Rel-17 UCI multiplexing operation into a PUCCH or PUSCH if any, the UE would be either (i) transmitting HARQ-ACK using a PUCCH/PUSCH other than the PUCCH determined from PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration or (ii) would be transmitting HARQ-ACK using a PUCCH resource configured in PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration being regarded as valid.***
  + ***FFS further details e.g. handling of different time unit handling, joint versus separate deferral (and related order of deferral processing)***

|  |  |
| --- | --- |
| Alt. 1 | vivo (2nd prefernce), DOCOMO, Nokia/NSB, LG, NEC |
| Alt. 2 | vivo (1st prefernce) , ZTE, Intel Huawei/Hisi (in principle), CATT |
| Other | Samsung, Sony |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| QC | The formulation of proposal just for initial slot is already a show of the complication level of supporting this feature. Like we commented already, due to the high complexity and marginal benefit, it is not worthwhile to spend effort on this.  With the above, we don’t support this proposal |
| vivo | For Alt.2, we suggest following update for the main bullet to avoid the confusion.  **Alt. 2: After step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation ~~within the same PHY priority only~~.**  In addition, we prefer unified handling for initial slot and target slot. |
| DOCOMO | Prefer Alt 1 due to simplicity.  Moreover, we think Question 7.3.3 and Question 7.3.4 should be discussed together since aligned behavior in initial slot and target slot is desidered. |
| Intel | It doesn’t matter whether the same or different time unit for LP and HP PUCCH is configured. The unified procedure (Alt 2 under question 7.3.3) is applied.  For each priority, UE finds next time unit with PUCCH resource for this priority (it does not mean UE checks validity). The time unit can be a slot or a sub-slot, depending on HARQ-ACK PUCCH configuration for each priority.  If the PUCCH resource for different priorities overlaps, then UE performs Rel-17 intra-UE multiplexing accordingly. Under intra-UE AI, RAN1 is defining how to associate a LP PUCCH into a HP time unit, which handles the case of different time unit of LP and HP.  If we go with joint determination, it seems more feasible to always treat deferred LP and HP as one UCI, e.g., as HP UCI.  Or, target slot is separaetey determined for each priority, but not necessarily in certain order.  Figures below provide examples for separate determination. |
| LG | We prefer Alt. 1 to support parallel deferral operation per priority. |
| Huawei/Hisi | If the joint operation between cross-priority SPS HARQ-ACK deferral is supported, we tend to go with the direction of Alt.2, while as captured by Moderator, there are still a couple of FFS issues.  Otherwise, we can make some restrictions to allow only one SPS deferral subject to deferral as we mentioned in Proposal 7.3.1. |
| Samsung | If the resulting UL channel is a PUSCH, or a PUCCH using a resource other than a resource provided by *PUCCH SPS-PUCCH-AN-List-r16* or *n1PUCCH-AN*, there is no further deferral. |
| Moderator | @Samsung: Please not, this is just using the formulations of existing agreements – i.e. there is no change there in the above (except priority & first / 2nd PUCCH config, step 1 and/or step2)!? |
| Moderator for 2nd round | Companies supporting Alt. 2, could you please provide further details on the handling if both LP & HP SPS are subject to deferral? If restricting this to single PHY priority only (as suggested by Huawei) seems to somehow defeat the purpose? Or could we limit this to HP SPS HARQ-ACK only?? Please provide your further input below. |
| Huawei/Hisi | **Two sliding SPS HARQ-ACKs of different priorities under Alt.2:**  ***handling of different time unit:*** HP SPS follows HP time unit (subslot); LP SPS follows LP time unit (slot). As we agreed the time unit of handling overlapping is per HP time unit, i.e. subslot here, for each HP time unit, the UE performs the intra-UE multiplexing by always assuming the LP SPS HARQ-ACK is present at the slot.  ***joint versus separate deferral:*** For each candidate subslot of HP, after Step 2.2, if the eventual channel carrying the HP HARQ-ACK is PUCCH/PUSCH other than SPS PUCCH or a valid SPS PUCCH, the current subslot is the target slot for HP. If the eventual channel carrying the HP HARQ-ACK is an invalid SPS PUCCH, defer HP SPS HARQ-ACK to the next subslot.  For the slot of LP, if the LP SPS HARQ-ACK is multiplexed in the slot or any subslot of the slot, and after Step 2.2, the eventual channel of the subslot/slot carrying LP SPS HARQ-ACK is PUCCH/PUSCH other than SPS PUCCH or a valid HP/LP SPS PUCCH, the current subslot/slot is the target slot for LP. If the eventual channel carrying the LP HARQ-ACK is an invalid HP SPS PUCCH, LP SPS HARQ-ACK is kept still in the slot; if the eventual channel carrying the LP HARQ-ACK is an invalid LP SPS PUCCH, defer LP SPS HARQ-ACK to the next slot.    **Two sliding SPS HARQ-ACKs of different priorities under Alt.2:**  **One sliding SPS HARQ-ACKs of a single priority:**  The intention of limiting the SPS deferral to single priority is due to the concern that the complicated design for handling two “sliding” SPS deferrals cannot be quickly converged, as a result of which, the joint configuration of both features cannot be supported. With such limitation, we may at least warrant the two features can be simultaneously configured with a simple way out. We are also fine with configuring only HP with SPS deferral.  **Proposal 7.3.1: Support joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral in Rel-17, with the limitation that UE expects the SPS HARQ-ACK subject to [Alt.1: at most one priority; Alt.2: HP] is configured with SPS HARQ-ACK deferral when intra-UE multiplexing is configured.** |
| Sony | I share similar view with vivo that the sentence in Alt. 2 is rather confusing:   * **Alt. 2: After step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation within the same PHY priority only, i.e.,**   Why would there still be two L1 priorities after Step 2? Shouldn’t there be one resultant PUCCH containing both HP & LP HARQ-ACKs?  I also share similar view with Intel, which is also related to my previous question regarding initial PUCCH. Can the initial PUCCH contain HP & LP HARQ-ACK? If yes then it should be treated as a single set of UCIs. |
| Samsung | For LP SPS HARQ-ACK, if it is dropped by HP UL channel (SR for example, there should be no further deferral. The follow text is captured in Alt 2 of Q 7.3.3.  ***LP SPS HARQ-ACK that cannot be mapped to a HP PUCCH or HP PUSCH based on the Rel-17 Intra-UE multiplexing framework and is therefore dropped in step 2.1 or step 2.2, is not subject to deferral.***  Decision of deferral should be determined separately for HP and LP.  We suggest the following update for Alt 2   * **Alt. 2: After step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation ~~within the same PHY priority only~~, i.e.,**   + ***The target PUCCH slot  for a certain PHY priority is defined as the next PUCCH slot of that priority, where after performing step 1 and step 2 of the Rel-17 UCI multiplexing operation into a PUCCH or PUSCH if any, the UE would be either (i) transmitting HARQ-ACK using a PUCCH/PUSCH other than the PUCCH determined from PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration or (ii) would be transmitting HARQ-ACK using a PUCCH resource configured in PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration being regarded as valid or (iii) dropped due to the collision of HP UL channel.***   + ***FFS further details e.g. handling of different time unit handling, joint versus separate deferral (and related order of deferral processing)*** |
| Intel2 | Regarding the deferral for both HP and LP HARQ-ACK, if we assume HP SPS follows HP time unit (subslot); LP SPS follows LP time unit (slot).  If a LP PUCCH resource in a slot overlaps with one or more HP PUCCHs, the LP PUCCH resource is added in **only one** sub-slot according to rules under intra-UE AI. In the one sub-slot, if the resultant channel is valid, then there is no deferral for both LP and HP. If the resultant channel is invalid, then there is deferral for both LP SPS AN and HP SPS AN to next slot and sub-slot respectively.  If a LP PUCCH resource in a slot does not overlap with HP PUCCH, then it is the same as the case of no intra-UE multiplexing.        Further, under intra-UE AI, it is very clear, if a LP PUCCH is associated with a time unit, e.g., LP PUCCH in slot #1 is associated with sub-slot #1, and it is multiplexed with the HP PUCCH in the time unit (LP PUCCH is multiplexed with HP PUCCH in sub-slot #1), then this LP PUCCH is done. No matter it is not transmitted or transmitted, once it is multiplexed, it can not be futher added in the next sub-slot. Such behaviour applies to all LP PUCCHs, including LP PUCCH for SPS, or LP PUCCH for dynamic PDSCH, or LP PUCCH for SR/CSI.  Now, with SPS deferral, we should not change the intra-UE multiplexing procedure. Therefore, if LP SPS PUCCH is multiplexed with HP SPS PUCCH in sub-slot #1 and resultant PUCCH is invalid, LP SPS PUCCH should be deferred to the next LP time unit, i.e., slot #2. |
| NEC | Alt.1 is preferred for simplicity. |
| Sony | Both Alt. 1 and Alt. 2 seems to suggest that the initial PUCCH cannot contain both LP & HP HARQ-ACKs. Is this already agreed?  That is if the initial slot contains LP & HP PUCCHs and the resultant PUCCH after UCI multiplexing is dropped what is the behaviour:   1. The resultant PUCCH containing LP & HP HARQ-ACK is deferred that is the LP & HP HARQ-ACK are both deferred assuming they belong to a single initial PUCCH. 2. The LP & HP HARQ-ACK in the resultant PUCCH is demultiplexed and individually seek a target PUCCH   The sentence “***for a certain PHY priority***” in both Alt. 1 and Alt. 2 suggest that the target can take only SPS HARQ-ACK with one type of PHY priority. Does this mean that:   1. A HP SPS HARQ-ACK cannot be multiplexed into a LP PUCCH even if this LP PUCCH is the earliest second PUCCH? 2. A LP SPS HARQ-ACK cannot be multiplexed into a HP PUCCH even if this HP PUCCH is the earliest second PUCCH?   If this is the intention then which part of Alt.1 and Alt. 2 is joint operation of intra-UE mux and SPS HARQ-ACK deferral? |

Joint Operation of R17 Intra-UE multiplexing and enhanced Type 3 CB

Several companies also suggest supporting the combination of R17 Intra-UE multiplexing and enhanced Type 3 CB operation.

Looking at the input received, there are several different options discussed by companies on how to handle the enhanced Type 3 CB restrictions, that the UE does not expect HARQ-ACK to be mapped in a Type 1 or Type 2 CB.

* HW proposes,
  + that restriction is only applicable to the same PHY priority as the indicated PUCCH priority for the enh. Type 3 transmission (i.e. restriction applied only in step 1)
  + UE does not expect a ‘LP’ Type 3 / enh. Type 3 CB in step 2 to be overlapping with HP HARQ-ACK in step 2
* Nokia proposes that the restriction is applicable to step 1 and step 2 (i.e. within the same and across priorities).
* Intel proposes, to follow the agreed behavior for PHY prioritization between LP/HP PUCCH carrying (e)Type3 CB and HP/LP PUCCH carrying HARQ-ACK using Release 17 multiplexing.
* LG proposes two solutions:
  + Alternative 1: UE does not expect that type-3 or enhanced type-3 triggering DCI indicates lower priority transmission
  + Alternative 2: UE assumes that type-3 or enhanced type-3 triggering DCI corresponds to higher priority transmission (regardless of the value of priority indication field)

Let’s check companies’ views in case the combination is supported on how to handle the two PHY priorities here. **In case you have a good suggestion on how a complete proposal on the operation could be formulated, please provide your suggestion in the comments table as well.**

For the 2nd round, as for Type 3 CB without R17 mux, let’s try to prune the options here and align with the discussions there. Please note, that the modification to Alt. 1 seems to cover also the earlier Alt. 3.

**Mod Question 7.3.5: If joint Operation of R17 Intra-UE multiplexing and enhanced Type 3 HARQ-ACK CB is supported in Rel-17, which of the following alternatives do you prefer:**

* **Alt. 1 (HW):** 
  + **The UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB with the same priority index (i.e. in step 1) as the enhanced Type 3 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB. The UE performs Rel-17 Intra-UE multiplexing step 2 as defined.**
  + **For Rel-16 Type 3 CB, the UE creates the Rel-16 Type 3 CB with a PUCCH based on the indicated priority in step 1, and performs step 2 of the Rel-17 Intra-UE multiplexing of potential HARQ-ACK of different priority afterwards.**
  + **~~UE does not expect the overlapping between LP HARQ-ACK subject to Type 3 CB/enhanced Type 3 CB and HP HARQ-ACK.~~**
* **Alt. 2 (Nokia):** 
  + **The UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook in neither step 1 (i.e., of the same PHY priority) nor step 2 (i.e., of a different priority) of the Rel-17 Intra-UE multiplexing framework.** 
    - ***i.e. only Rel-16 Type 3 or Rel-17 enhanced Type 3 HARQ-ACK CB of the indicated priority is to be multiplexed in step 2***
* **~~Alt. 3 (Intel):~~** 
  + **~~For PHY prioritization between LP/HP PUCCH carrying (e)Type3 CB and HP/LP PUCCH carrying HARQ-ACK using Release 17 multiplexing, follow the agreed behavior~~**
* **~~Alt. 4 (LG):~~** 
  + **~~The UE does not expect that type-3 or enhanced type-3 triggering DCI indicates a lower PHY priority.~~**
* **~~Alt. 5 (LG):~~** 
  + **~~The UE assumes that type-3 or enhanced type-3 triggering DCI corresponds to higher priority transmission (regardless of the value of priority indication field~~**

|  |  |
| --- | --- |
| Alt. 1 | DOCOMO (accpetable) Huawei/Hisi (move 2nd bullet to FFS), QC |
| Alt. 2 | DOCOMO (1st preference), Nokia/NSB, Intel (2nd), LG(2nd), Samsung, Sony, CATT |
| ~~Alt. 3~~ | ~~Vivo, Intel (1~~~~st~~~~),~~ |
| ~~Alt. 4~~ | ~~LG~~ |
| ~~Alt. 5~~ | ~~LG~~ |
| Other |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| QC | Isn’t it logical to agree first on Proposal 7.3.6? |
| Moderator | @QC: as for other agreements during the WI phase, the moderator prefers to have a single agreement with the details included. To prevent later discussions on what we agreed to be supported… |
| LG | Our proposal is to handle type-3 codebook freely from prioritization with some level of flexibility. We are also fine with Alt. 2. |
| Huawei/Hisi | As clarified in Question 3.3.1, in R16, the HP/LP prioritization is performed without considering the HARQ-ACK CB type. Same principle should be adopted in R17, where the UE multiplex HP/LP HARQ-ACKs regardless of the HARQ CB type. Consider a case where a HP Type 1 HARQ-ACK CB collides with LP enh. Type 3 in the same slot, it is not reasonable for UE to drop the HP HARQ-ACK with high reliable PUCCH and give priority to the LP PUCCH of Type 3 CB with low reliability; that will result in reliability loss and cripple the performance of URLLC.  We can set the second bullet as FFS, as whether/how to schedule the collision may also be up to gNB implementation.   * **Alt. 1 (HW):**    + **The UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB with the same priority index as the enhanced Type 3 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB.**   + **FFS: UE does not expect the overlapping between LP HARQ-ACK subject to Type 3 CB/enhanced Type 3 CB and HP HARQ-ACK.** |
| Moderator  (start of 2nd round) | Tried to clarify Alt. 1 and Alt. 2 based on the comments and the discussion in Sec. 3.2 also. Let’s see if we can somehow converge here. |
| Huawei/Hisi | We think the same principle of Proposal 3.3.1 should be applied in this proposal, i.e., the HP/LP intra-UE multiplexing is applied regardless of the CB type, so the rule of type 3/enh. type 3 CB overriding type 1/2 CB applies only to the same priority.  For the reliability/latency warrant of HP, it is not reasonable to allow a LP channel to drop a HP channel, even if the LP channel contains all information of the HP channel, since that will lower the bottom line of the URLLC performance. |
| Sony | Unclear why there are restriction about which L1 priority HARQ-Ack can or cannot be mux into e-Type 3 CB. Hence Intel proposal seems sensible just treat the PUCCH carrying e-Type 3 CB as any other PUCCH that needs to be multiplexed. |
| Nokia/NSB | Maybe still on Question on companies in favor of Alt. 1 here.  Let’s assume the gNB triggers a R16 Type 3 CB (containing all HARQ information) with HP PUCCH, and I have an overlapping LP PUCCH (let’s assume with Type 1 CB), based on Alt. 1, would then the UE multiplex the ‘HP’ Type 3 CB and the LP Type 1 CB on the same PUCCH? Isn’t this then a bit counter-intuitive?  We do agree that Alt. seems simpler to implement, but multiplexing e.g. a R16 Type 3 CB and a Type 1 / Type 2 CB of the other priority on a LP PUSCH, HP PUCCH or PUSCH seems to be not really the intention here.  Please note, that for R16 PHY prioritization, gNB will be able to indicate the Type 3 CB on HP PUCCH, so there is not such issue of unnecessary double transmission (as the LP PUCCH would be dropped).  @Sony: to my reading, the Alt. 1 now describes in more words exactly the original Intel behavior (but better for Intel to comment here) |

So let’s also check the general intention of companies to have the joint operation supported (as in case there is strong resistance, it may not be worth the effort to discuss the potential details as well).

**Proposal 7.3.6: Support joint operation of Rel-17 Intra-UE multiplexing and enhanced Type 3 CB in Rel-17.**

* **FFS details**

|  |  |
| --- | --- |
| Supporting companies | QC, vivo, DOCOMO, ZTE, Intel, LG, Sony ~~Huawei/Hisi~~, CATT |
| Objecting companies |  |
| FFS | Nokia/NSB, Samsung Huawei/Hisi, NEC, New H3C |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | Depends on the details. |
| Samsung | Agree with Nokia. 99% of the functionality from the features has been achieved and further enhancements, if any, should have an analogous specification/complexity impact. |
| Huawei/Hisi | If no consensus, we prefer not to support the joint operation. |
| New H3C | This feature has complexity impact on implementiton. |

Joint Operation of R17 Intra-UE multiplexing and dynamic PUCCH cell switching

There was also good input on the joint operation of R17 intra-UE mux and dynamic PUCCH cell switching. Clearly more clarifications will be needed for dynamic PUCCH cell switching compare to semi-static PUCCH cell switching (as there the cell is defined by the time-domain pattern for both LP and HP PUCCH), as there could be potentially UCI of different priorities on different PUCCH cells we would need to clarify the related handing here.

So let’s see what companies think how the operation could be enabled. I hereby just list the input provided here and based on the feedback we would maybe in a better position in another round to have a clear proposal on the overall operation of this joint operation. **In case you have a good suggestion on how a complete proposal on the operation could be formulated, please provide your suggestion in the comments table as well.**

**Question 7.3.7: If joint Operation of R17 Intra-UE multiplexing and dynamic PUCCH cell switching is supported in Rel-17, which of the following alternatives do you prefer:**

* **Alt. 1 (Ericsson):** 
  + **When dynamic PUCCH cell switching is enabled for a PUCCH group, at any given time the PUCCH resources would be allocated to a same cell (either PCell /SPCell / PUCCH SCell or PUCCH sSCell).**
  + **Once a PUCCH target cell is determined based on a dynamic indication, the Rel-17 intra-UE multiplexing procedures can be applied to resolve collision in case of overlapping PUCCH resources on the target cell.**
* **Alt. 2 (CATT):** 
  + **LP HARQ-ACK would not be multiplexed with HP UCI if they are on different PUCCH cells**
* **Alt. 3 (Intel):** 
  + **For the conclusion that “*For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell*”,**
    - **Clarify that the valid PUCCH resource on Pcell means PUCCH resources before multiplexing on Pcell**
    - **Clarify that for different priority UCI, any PUCCH resource before multiplexing/prioritization is considered**
* **Other**

|  |  |  |
| --- | --- | --- |
| Alt. 1 | Support | DOCOMO, ZTE, Intel (2nd), LG(1st) |
| Not support |  |
| Alt. 2 | Support |  |
| Not support |  |
| Alt. 3 | Support | DOCOMO, Intel (1st) Huawei/Hisi |
| Not support |  |
| Other | QC | See comments below |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| QC | With the restriction that “For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell”, it seems the Rel-17 intra-UE mux procedure can be simplified: if a slot has HARQ-ACK transmission on Scell (follow dynamic switch indication), then the slot does not have PUCCH transmit on Pcell. Based on this observation, Ericsson’s proposal seems reasonable, if RAN1 support this joint feature. But we think this discussion can be deprioritized as we view this a low priority issue. |
| DOCOMO | We support both Alt 1 and Alt 3.  Alt 1 is discussing about intra-UE multiplexing/prioritization on the target cell. Alt 3 is discussing about inter-cell UCI overlapping.  As discussed for **Proposed Conclusion 6.2.5**, we think the point of Alt 3 is valid that multiplexing/priorization should be clarified for inter-cell PUCCH collision checking. And we think UCI multiplexing on PUSCH also needs to clarified. |
| LG | For Alt. 3, we think it is necessary to conclude first for the same priority case. |
| Huawei/Hisi | As discussed in 6.2.5, the UE only performs the intra-UE multiplexing at the dynamically indicated sSCell, while all the UCIs/PUCCHs without dynamic cell indication on PCell would be regarded as conflict with TDD DL (and there is no need to perform multiplexing among them on PCell); otherwise it is considered as an error case. |
| CATT | Our proposal would like to clarify that for the following case, LP SPS HARQ-ACK is not multiplexed with HP HARQ-ACK. It seems to us that it is the common understanding for all the three alternatives? |

So let’s also check the general intention of companies to have the joint operation supported (as in case there is strong resistance, it may not be worth the effort to discuss the potential details as well).

**Proposal 7.3.8: Support joint operation of Rel-17 Intra-UE multiplexing and dynamic PUCCH cell switching in Rel-17.**

* **FFS details**

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| --- | --- |
| Supporting companies | DOCOMO, ZTE, Intel Huawei/Hisi,NEC, CATT, Panasonic |
| Objecting companies | Nokia/NSB, Samsung |
| FFS | QC, vivo, LG |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| QC | This can be deprioritized, given Rel-17 intra-UE mux is still under discussion. Designing how it works with cell switch seems a secondary issue to us. |
| Samsung | Minor/no benefit with substantial specification/implementation impact. |
|  |  |
|  |  |

7.4 3rd and 4th round of email discussions

Joint Operation of R17 Intra-UE multiplexing and SPS HARQ deferral

There had been further good by companies in the 1st and 2nd round on the handing in the 1st and 2nd round.

Based on the input to Question 7.3.3, a strong majority of companies seem to prefer to adopt Alt. 2B, i.e. to perform the initial slot handing after the 2nd step of intra-UE prioritiziation and for LP HARQ, the LP SPS HARQ condition to apply for the 1st and 2nd PUCCH configuration (LP or HP SPS PUCCH).

On Question 7.3.4 in the target slot, the opinions are still more split between performing the target slot determination after step 1 (simpler, no issues with parallel deferral and no issues with different PUCCH slot length for HP and LP HARQ) and after step 2 (being able to potentially having higher chance of not loosing the deferred LP SPS HARQ-ACK).

Well, let’s try to put all this together in a single proposal, so that it is more clear about what we would be talking here.

**Proposal 7.4.1: Support joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral in Rel-17**

* **The determination if SPS HARQ-ACK is to be deferred in the initial PUCCH slot (i.e. PUCCH slot determined by n+k1) is performed after step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation** 
  + ***If after the Rel-17 UCI multiplexing operation (including step 1 and step 2) into a PUCCH or PUSCH if any, and if the UE would be transmitting LP SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration***

***which is not valid, the LP SPS* HARQ*-ACK configured for deferral is deferred.***

* + ***If after the Rel-17 UCI multiplexing operation (including step 1 and step 2) into a PUCCH or PUSCH if any, and if the UE would be transmitting HP SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the second PUCCH configuration which is not valid, the HP SPS HARQ-ACK configured for deferral is deferred.***
  + ***LP SPS HARQ-ACK that cannot be mapped to a HP PUCCH or HP PUSCH based on the Rel-17 Intra-UE multiplexing framework and is therefore dropped in step 2.1 or step 2.2, is not subject to deferral.***
* **The determination of the ‘target’ or ‘earliest second’ PUCCH slot (i.e. starting in PUCCH slot n+k1+1) for the SPS HARQ-ACK deferral procedure is performed**
  + **Alt. 1: After the step 1 of the Rel-17 Intra-UE multiplexing operation within the same PHY priority only, i.e.,** 
    - ***The target PUCCH slot of a certain PHY priority is defined as the next PUCCH slot, where after performing step 1 of the Rel-17 UCI multiplexing operation into a PUCCH or PUSCH of that PHY priority if any, the UE would be either (i) transmitting HARQ-ACK using a PUCCH/PUSCH other than the PUCCH determined from PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN of that PHY priority or (ii) would be transmitting HARQ-ACK using a PUCCH resource configured in PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN for that PHY priority being regarded as valid.***
    - ***If after the target slot determination for LP SPS HARQ and/or HP SPS HARQ subject to deferral followed by step 2 of the Rel-17 Intra-UE multiplexing operation, the deferred LP and/or HP SPS HARQ-ACK cannot be transmitted, the LP and/or HP SPS HARQ-ACK is dropped without further deferral.***
  + **Alt. 2: After step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation, i.e.,**
    - ***The target PUCCH slot  for a certain PHY priority is defined as the next PUCCH slot of that priority, where after performing step 1 and step 2 of the Rel-17 UCI multiplexing operation into a PUCCH or PUSCH if any, the UE would be either (i) transmitting HARQ-ACK using a PUCCH/PUSCH other than the PUCCH determined from PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration or (ii) would be transmitting HARQ-ACK using a PUCCH resource configured in PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration being regarded as valid.***
    - ***FFS further details e.g. handling of different time unit handling, joint versus separate deferral (and related order of deferral processing)***
  + **NEW Alt. 2A (Samsung): After step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation, i.e.,**
    - ***The target PUCCH slot  for a certain PHY priority is defined as the next PUCCH slot of that priority, where after performing step 1 and step 2 of the Rel-17 UCI multiplexing operation into a PUCCH or PUSCH if any, the UE would be either (i) transmitting HARQ-ACK using a PUCCH/PUSCH other than the PUCCH determined from PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration or (ii) would be transmitting HARQ-ACK using a PUCCH resource configured in PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration being regarded as valid or (iii) dropped due to the collision of HP UL channel.***
    - ***FFS further details e.g. handling of different time unit handling, joint versus separate deferral (and related order of deferral processing)***

|  |  |  |
| --- | --- | --- |
| **Support joint operation using Alt. 1** | Support | LG |
| Object | Samsung, Sony (needs clarification), QC |
| **Support joint operation using Alt. 2** | Support | Intel, Panasonic, ZTE, vivo |
| Object | Samsung, Sony (needs clarification), QC, Nokia/NSB |
| **Support joint operation using Alt. 2A** | Support | Samsung, Panasonic Huawei/Hisi, ZTE, CATT |
| Object | Sony (needs clarification), QC, Nokia/NSB, LG (need clarification) |
| **Support the joint operation (FFS on Alt. 1, Alt. 2, Alt. 2A)** |  | |
| **Object the joint operation (independently of Alt. 1, Alt. 2 or Alt. 2A)** | Sony (needs clarification), QC | |
| **Other** |  | |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | For joint operation with Rel-16 intra-UE prioritization, we made the following conclusion.  **Conclusion**  For SPS HARQ-ACK deferral, if a UE is not configured with Rel-17 intra-UE multiplexing but configured with Rel-16 PHY prioritization, the UE first performs Rel-16 UCI multiplexing and PHY prioritization in both initial slot and target slot and if a LP SPS HARQ-ACK PUCCH is deprioritized, the LP SPS HARQ-ACK is not deferred.   * Note: If the SPS HARQ-ACK is deprioritized in any slot, no further deferral.   Same rule should apply in Rel-17 intra-UE multiplexing if LP SPS HARQ-ACK is dropped.  Therefore, resolving the collision with semi-static DL is performed after intra UE multiplexing, if a LP SPS HARQ-ACK PUCCH collides with HP SR, the LP SPS HARQ-ACK is dropped before checking the collision with semi-static DL  **Agreement**  For Rel-17 intra-UE multiplexing, PUCCH and PUSCH cancellation due to dynamic SFI, semi-static DL symbols and SSB symbols are performed after step 2 of Rel-17 intra-UE multiplexing. |
| Intel | Support Alt.2 as we explained in 1st round. For the issue of different time units for LP and HP, the complexity (if any) could be limited by restricting the joint operation to the same time unit for LP and HP. |
| Sony | Didn’t mean to object to everything but would appreciate if my previous questions are addressed as the proposal isn’t very clear. Would appreciate if someone can address the following:   1. For Alt. 2, if the initial PUCCH is LP, then the ONLY way the LP SPS HARQ-ACK can be deferred into the target slot is that the after Step 2, the resultant channel is a LP PUSCH? That is if the resultant is a HP PUCCH then it is game over for LP SPS HARQ-ACK deferral? 2. Is it possible that both LP SPS HARQ-ACK and HP SPS HARQ-ACK have the same target PUCCH? That is say for example in the drawing below:  * SPS LP HARQ-ACK#1 and SPS HP HARQ-ACK#2 are both deferred and then we have a HP HARQ-ACK#3 that is a target PUCCH, can the LP HARQ-ACK#1 and HP HARQ-ACK#2 be multiplexed into **HP** HARQ-ACK#3: * SPS LP HARQ-ACK#1 and SPS HP HARQ-ACK#2 are both deferred and then we have a LP HARQ-ACK#3 that is a target PUCCH, can the LP HARQ-ACK#1 and HP HARQ-ACK#2 be multiplexed into **LP** HARQ-ACK#3 |
| Huawei/Hisi | Agree with Samsung that the dropping of LP deferred SPS due to HP/LP collision should not be deferred any longer. |
| QC | Complicated new feature with very little benefit should not be introduced in late stage of Rel-17. We have seriously concern that Rel-17 URLLC cannot be completed because of introducing this feature at late stage. |
| vivo | We support Alt.2 and share Intel’s views that the complexity (if any) could be limited by restricting the joint operation to the same time unit for LP and HP. |
| Nokia/NSB | We don’t see how we could complete this feature in Rel-17, if Alt. 2 is selected, as many additional details need to be decided. Restricting the operation for same time unit or a single PHY priority only etc, has more impact on application flexibility than going for Alt. 1 and being less optimal  But overall looking at the current situation, we may have some sympathy with the position by QC on this issue. |
| DOCOMO | We still think unified principle should be applied for initial slot and target slot. There may be deferred SPS HARQ-ACK and initial SPS HARQ-ACK in the candidate slot, if different principle is applied, which rule should be applied for the candidate slot?  We think deferring after step 2 has large complexity, we don’t like to support deferring determination after step 2 for initial slot or for target slot. For such situation, we will not support joint operation. |
| LG | We prefer Alt. 1 since Alt. 1 perform deferral per priority, so it works as single priority case in the perspective of each priority.  We can also accept Alt. 2A, however, there is something need to be clarified. Firstly, it should be clarified whether LP HARQ-ACK deferred from HP PUCCH is considered LP or HP. And, if target PUCCH and slot is determined after step 2, it seems unclear what deferred HARQ-ACK does in step1 and step 2. Does UE consider payload of deferred HARQ-ACK of certain priority in step 1? Or UE suddenly can multiplex deferred HARQ-ACK on PUCCH determined after step 2? |
| Sony | We are starting to agree with QC here that it isn’t even clear what we are trying to agree here since no one can answer my questions. Hence, we think we shouldn’t support this complicated joint feature. |
| NEC | We share same view with QC/Sony, the joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral can be not supported now due to the high complexity. |
| Moderator | Looking at the options provided, there is not a single Alt having more supporting than objecting companies. Moreover, there are several companies thinking that the joint operation cannot be supported.  Let’s try if we could agree based on Alt. 2A (which had most supporting companies here) as a last push to have the joint operation supported in Rel-17. |

HW raises the issue if for joint operation, the SPS HARQ-ACK deferral should be limited to a single PHY priority only. Let’s see if such potential restriction could be acceptable to companies to simplify the target slot operation.

**Proposal 7.4.2: For joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral in Rel-17,**

* **If Alt. 1 target slot handing is selected, that UE expects the SPS HARQ-ACK of at most one priority is configured with SPS HARQ-ACK deferral when intra-UE multiplexing is configured.**
* **If Alt. 2 (2 / 2A) target slot handling is selected, the UE expects only HP SPS HARQ-ACK is configured with SPS HARQ-ACK deferral when intra-UE multiplexing is configured.**

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| Supporting companies | Huawei/Hisi |
| Objecting companies | Samsung, Intel, Sony, ZTE, CATT, QC, Nokia/NSB, LG |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | SPS HARQ-ACK deferral determination should be performed separately per priority. This will minimize spec impact - no optimization is needed here. No additional restriction is necessary. |
| Huawei/Hisi | Support this proposal for simplicity. Either alternative is OK for us. Note that Alt.1 has RRC impact. |
| Intel | This is a bigger restriction than necessary. We think the previous proposal 7.4.1 needs to be resolved first. |
| Sony | If only ever one L1 priority is selected for deferral, why do we even call this feature intra-UE UCI multiplexing of **DIFFERENT** L1 priority? |
| New H3C | We are fine this proposal for to simplify the target slot operation/scheme. |
| Huawei/Hisi2 | @Sony The intra-UE UCI interaction/multiplexing of different priorities between the deferral SPS HARQ-ACK and the **DG PUCCH/PUSCH** of another priority still exist. Only the interaction of the two ‘sliding’ SPS deferrals are not supported, which is a limited restriction. |
| ZTE | Not sure the benefit from so much restriction. |
| QC | Complicated new feature with very little benefit should not be introduced in late stage of Rel-17. We have seriously concern that Rel-17 URLLC cannot be completed because of introducing this feature at late stage. |
| LG | We also think same benefit can be achieved with less restriction than proposed. |
| Sony | **@Huawei**: Can you please clarify what is meant by “sliding” SPS deferrals? Are you referring to accumulation of SPS HARQ-ACKs from multiple dropped PUCCHs? |
| Huawei/Hisi3 | **@Sony:** Let us consider there are only two SPS deferrals with HP and LP, respectively. HP is 7OS subslot and LP is slot. A question is: For the deferral of HP SPS HARQ, whether will it consider the existence of the LP SPS, which is also subject to deferral? Different from the DG PUCCH, the position of the deferring SPS HARQ-ACK is uncertain. The interaction between HP SPS and LP SPS will decide the resultant PUCCH and thereby the validity of the current slot, while the validity of a candidate target slot will in turn impact whether they will meet each other and multiplex in the next slot – chicken egg problem.  E.g., HP SPS defers per subslot, and LP SPS defers per slot. If for the initial subslot of HP and for the initial slot of LP, they do not overlap, and both of the subslot/slot are invalid, then whether the LP SPS should 1) defer to the next slot (and HP/LP will never collide with each other for later slots), or 2) stay still at slot#1 until HP SPS finish the deferral over all subslots within the slot? Note that the two ways will lead to different results, since whether to assume the existence of another SPS HARQ-ACK with a different priority would impact the intra-UE multiplexing result, and impact whether validity of the slot.    In our understanding, in either way it will lead to open issues and non-trivial spec impact. So, the simple and realistic way is to restrict there is only one priority subject to SPS HARQ-ACK deferral. **The FFS issues on handling of different time unit handling and joint versus separate deferral will not exist then.**  **Proposal 7.4.1: Support joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral in Rel-17 with the restriction that the SPS HARQ-ACK of a *designated priority (FFS Alt.1 or Alt.2) is subject to deferral***   * **The determination if SPS HARQ-ACK is to be deferred in the initial PUCCH slot (i.e. PUCCH slot determined by n+k1) is performed after step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation**    + ***If after the Rel-17 UCI multiplexing operation (including step 1 and step 2) into a PUCCH or PUSCH if any, and if the UE would be transmitting ~~LP~~ SPS HARQ-ACK of the designated priority using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration which is not valid, the ~~LP~~ SPS HARQ-ACK of the designated priority configured for deferral is deferred.***   + ***~~If after the Rel-17 UCI multiplexing operation (including step 1 and step 2) into a PUCCH or PUSCH if any, and if the UE would be transmitting HP SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the second PUCCH configuration which is not valid, the HP SPS HARQ-ACK configured for deferral is deferred.~~***   + ***LP SPS HARQ-ACK that cannot be mapped to a HP PUCCH or HP PUSCH based on the Rel-17 Intra-UE multiplexing framework and is therefore dropped in step 2.1 or step 2.2, is not subject to deferral.*** * **The determination of the ‘target’ or ‘earliest second’ PUCCH slot (i.e. starting in PUCCH slot n+k1+1) for the SPS HARQ-ACK deferral procedure is performed**   + **(NEW Alt. 2A) After step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation, *the target PUCCH slot  for ~~a certain~~ the designated PHY priority is defined as the next PUCCH slot of that priority, where after performing step 1 and step 2 of the Rel-17 UCI multiplexing operation into a PUCCH or PUSCH if any, the UE would be either (i) transmitting HARQ-ACK using a PUCCH/PUSCH other than the PUCCH determined from PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration or (ii) would be transmitting HARQ-ACK using a PUCCH resource configured in PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration being regarded as valid or (iii) dropped due to the collision of HP UL channel.***     - ***~~FFS further details e.g. handling of different time unit handling, joint versus separate deferral (and related order of deferral processing)~~*** |
| LG | Thanks to Huawei’s clarification, we understands Huawei’s concern on chiken eggs problem in the case that UE is configured with SPS deferral in both priority. However, we think it would be an issue since the deferral should be determined and performed after UL multiplexing. The deferral condtion includes the result of UL multiplexing, so each deferral determination would be along with the result of UL multiplexing. Thus, the case 2 should be common understanding. The timing of the determination should be up to the discussion in AI 8.3.3. |
| Moderator | Based on these discussions here and seeing the company inputs, there seems to be no consensus to reduce the SPS HARQ-ACK deferral operation in terms of HP and/or LP SPS HARQ, if joint operation is to be supported.  🡪 such restriction will not be considered further |

Joint Operation of R17 Intra-UE multiplexing and enhanced Type 3 CB

In contrast to the discussions on the PHY prioritity handling with Rel-16 PHY prioritization, where a clear majority supports to have the Type 3 CB handling per PHY priority and then apply the Rel-16 PHY prioritization (see discussions there and related proposal for approval in Sec. 3.5), for the Rel-17 Intra-UE multiplexing it seems that it is the other way around here and companies prefer to have the handling jointly for step 1 & step 2 there. Moreover, there had still be questions on how Alt. 2 would be working here on the one side and the argument against Alt. 1 that even for R16 Type 3 CB, there would be duplicated bits in the PUCCH transmission (i.e. full R16 Type 3 HARQ-ACK CB + HP/LP Type 1 or Type 2 CB).

If having a chance to support this in Rel-17, we should agree the support still in this meeting. Alt. 2 is tried to be further clarified by the moderator.

So, let’s check this here:

**Proposal 7.4.3: Support joint operation of R17 Intra-UE multiplexing and enhanced Type 3 HARQ-ACK CB in Rel-17, based on the following operational details:**

* **Alt. 1:** 
  + **The UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB with the same priority index (i.e. in step 1) as the enhanced Type 3 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB. The UE performs Rel-17 Intra-UE multiplexing in step 2 as defined.**
  + **For Rel-16 Type 3 CB, the UE creates the Rel-16 Type 3 CB with a PUCCH based on the indicated priority in step 1, and performs step 2 of the Rel-17 Intra-UE multiplexing of potential HARQ-ACK of different priority afterwards.**
* **Alt. 2:** 
  + **The UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB to be transmitted that cannot be mapped to the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook in neither step 1 (i.e., of the same PHY priority) nor step 2 (i.e., of a different priority) of the Rel-17 Intra-UE multiplexing framework.**
  + **For Rel-16 Type 3 HARQ-ACK CB in step 2.1 or step 2.2, only the Rel-16 Type 3 HARQ CB is multiplexed on the HP PUCCH or HP PUSCH based on the indicated PHY priority in the triggering DCI and any Type 1 or Type 2 HARQ-CK of either priority is not multiplexed in the final HP PUCCH / PUSCH transmission.** 
    - ***~~i.e. only Rel-16 Type 3 or Rel-17 enhanced Type 3 HARQ-ACK CB of the indicated priority is to be multiplexed in step 2~~***

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| **Support joint operation using Alt. 1** | Support | Huawei/Hisi, Intel, CATT, QC, vivo, Nokia/NSB, DOCOMO, Sony, NEC, ZTE, New H3C, LG |
| Object | Samsung |
| **Support joint operation using Alt. 2** | Support | Samsung, DOCOMO, LG |
| Object | Huawei/Hisi |
| **Support the joint operation (FFS on Alt. 1 or Alt. 2)** |  | |
| **Object the joint operation (independently of Alt. 1 or Alt. 2)** |  | |
| **Other** | Samsung | |

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| *Company* | *Comments* |
| Samsung | For all combined features, we prefer to support them with minimum specification impact as optimizations actually result to the opposite if the features are to be ever deployed.  Also, no reason for not concluding now (nothing to FFS) - also OK to not support. |
| Huawei/Hisi | As explained in the last round, it is harmful for URLLC reliability/latency to allow LP channel (w/ Type 3/enh. Type 3 CB) to overrid HP channel, which would cause the reliability to decline from 99.999% to 99%. Thus Case2 and Case4 should at least follow Alt.1. For Case3, it is possible that HP enh. Type 3 CB may not include all HARQ IDs of LP Type 1/2 CB when the HP enh. Type 3 CB is configured as a compact manner to optimize the UL reliability (while Type 1/2 CB is targeting for carrying heavy loaded eMBB with substancial HARQ-ACKs). It looks only Case1 is a valid case that HP Type 3 CB should overrid LP Type 1/2 CB, but from the reliability perspective, it is not likely that the gNB will configure such a big size of HARQ-ACK CB for URLLC. Due to the desire of unified principle, we think Alt.1 should be adopted.  Case1: HP Type 3 CB vs LP Type 1/2 CB  Case2: LP Type 3 CB vs HP Type 1/2 CB  Case3: HP enh. Type 3 CB vs LP Type 1/2 CB  Case4: LP enh. Type 3 CB vs HP Type 1/2 CB |
| Intel | To align with (e)Type3 + R16 intra-UE discussion in section 3. |
| Sony | **@Huawei:** The whole point of being able to configure multiple e-Type 3 CB and the gNB is able to point to one of these multiple e-Type 3 CB where one of them would match the HARQ-ACKs in a Type 1 or 2 CB to be retransmitted. That was the understanding. We debated this long and hard, where some companies (including Sony) think it was not an efficient way of doing things as the e-Type 3 CB size is semi-statically configured whilst the combinations of HARQ-ACKs change dynamically. However, companies insisted on supporting e-Type 3 CB and so it is gNB’s responsibility to configure and ensure the HARQ-ACKs are retransmitted in the triggered e-Type 3 CB.  It is therefore strange that we are now back to concerns about HP HARQ-ACK or LP HARQ-ACK not being included in an e-Type 3 CB and start introducing PHY priroities restrictions.  Also why would a gNB “overwrite” the reliability of HP HARQ-ACK with LP HARQ-ACK’s reliability? If there are HP HARQ-ACK to be retransmitted why would the gNB trigger a LP PUCCH to carry the e-Type 3 CB? |
| Huawei/Hisi2 | @Sony Historically we are also one of the companies which do not hold a positive view of e-Type 3. We can accept it due to the reason it reduces the payload size of the retx CB to some extent which is beneficial for reliability. But it does not mean the gNB should be responsible to schedule all cross-priority HARQ IDs in the e-Type3 for the HP/LP co-existence case, especially considering some compact HARQ ID set can be configured for HP e-Type3, which cannot fully cover massive HARQ IDs of heavy loaded LP services.  For the second concern, the gNB schedules LP e-Type 3 CB in advance, at which time it is not aware of the upcoming HP traffic. The scheduling of HP HARQ-ACK should not be limited by the possible collision & HARQ ID set of the LP e-Type 3, which would harm URLLC performance. |
| CATT | Alt. 1 seems sufficient from our perspective. For Alt. 2, our understanding is that in step 2 the LP and HP HARQ-ACKs are still separately encoded and the benefit is not clear to us. |
| QC | We actually share the same view with Samsung that Rel-17 intra-UE mux is already complicated and behind the schedule. RAN1 should be very careful to introduce any new functionality to intra-UE mux. But this could be an exception, because Alt 1 seems having very small additional spec impact. |
| Nokia | We earlier preferred Alt. 2, but looking at the discussion here and the needed specification & clarifiations, it seems that Alt. 1 could be the only chance to have this in Rel-17. Otherwise, we prefer not to support the interaction in Rel-17. |
| DOCOMO | Either is fine for us. |
| LG | Alt. 1 actually means that UE fallback to Rel-16 UL multiplexing if type-3 codebook is involved.  Meanwhile, Alt. 2 is not to make such case so that UE can rely on type-3 codebook once scheduled.  We slightly prefer Alt. 2. |
| Sony | **@Huawei:** Thanks for the clarification. Is this proposal linked with Propsosal 3.5.1? Here we say that the mapping is only applicable for HARQ-ACKs that share the same L1 priority of the trigger PUCCH carrying the e-Type 3 CB. If we agree to this, then do we still need Alt. 1? |
| Moderator | We the handling a bit aligned to Alt. 1 for R16 PHY prioritization in the Fri. GTW session. Companies to please take this into account here in providing or changing your earlier input / preferences in the 4th round |
| Sony | Since we made the following agreement regarind Rel-16 PHY prioritization in Proposal 3.5.1:  **Agreement**  **The Rel-16 PHY prioritization operation and Rel-16 Type 3 with PHY priority operation & Rel-17 enhanced Type 3 HARQ-ACK CB with PHY priority operation is further clarified as:**   * **For Rel-17 enhanced Type 3 HARQ-ACK CB operation, the restriction on the Type 1 / Type 2 HARQ-ACK CB mapping from the earlier agreement below is only applicable to the same PHY priority of the Type 1 / Type 2 CB as the PUCCH for the enhanced Type 3 CB re-transmission. A LP PUCCH (or PUSCH) carrying the R17 enh. Type 3 CB is dropped according to the Rel-16 PHY prioritization procedures in case of an overlapping HP channel.**  |  | | --- | | **Agreement**  For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook. |  * **For Rel-16 Type HARQ-ACK 3 HARQ-ACK CB operation, the UE creates the Rel-16 Type 3 HARQ-ACK CB for transmission on a PUCCH of the indicated priority. A LP PUCCH (or PUSCH) carrying the R16 Type 3 HARQ-ACK CB is dropped according to the Rel-16 PHY prioritization procedures in case of an overlapping HP channel.**   We decided to change to Alt. 1 to be consistent. |
| ZTE | Based on the agreement in GTW on Rel-16 PHY prioritization, we prefer Alt.1 now to keep consistent. |
| Moderator | Alt. 1 has many more supporting companies – let’s check if 5th round if agreeable with Alt. 1. |

Joint Operation of R17 Intra-UE multiplexing and dynamic PUCCH cell switching

Based on the first & second round input, on the details Alt. 1 (from Ericsson) and Alt. 3 (from Intel) seems to have most support. Please also note, that Alt. 3 is still relying on the fact that the restriction is before or after multiplexing for single PHY priority is still continuing (unclear).

Anyhow, let’s as for the this joint operation see where companies stand here overall:

**Proposal 7.4.4: Support joint operation of Rel-17 Intra-UE multiplexing and dynamic PUCCH cell switching in Rel-17, based on the following operational details:**

* **Alt. 1:** 
  + **When dynamic PUCCH cell switching is enabled for a PUCCH group, at any given time the PUCCH resources would be allocated to a same cell (either PCell /SPCell / PUCCH SCell or PUCCH sSCell).**
  + **Once a PUCCH target cell is determined based on a dynamic indication, the Rel-17 intra-UE multiplexing procedures can be applied to resolve collision in case of overlapping PUCCH resources on the target cell.**
* **Alt. 3:** 
  + **For the conclusion that “*For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell*”,**
    - **Clarify that the valid PUCCH resource on Pcell means PUCCH resources before multiplexing on Pcell**
    - **Clarify that for different priority UCI, any PUCCH resource before multiplexing/prioritization is considered**

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| **Support joint operation using Alt. 1** | **Support** | Huawei/Hisi(2nd), Intel (2nd), QC, DOCOMO, LG, ZTE |
| **Object** |  |
| **Support joint operation using Alt. 3** | **Support** | Huawei/Hisi(1st), Intel (1st), DOCOMO (with clarification) |
| **Object** |  |
| **Support the joint operation (FFS on Alt. 1 or Alt. 3)** |  | |
| **Object the joint operation (independently of Alt. 1 or Alt. 3)** | Samsung, Nokia/NSB | |
| **Other** |  | |

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| *Company* | *Comments* |
| Samsung | Additional specification complexity to a feature (intra-UE) that is already complex without any meaningful benefit. |
| Huawei/Hisi | We can also accept Alt.1 as a simple design though it has more restrictions on gNB scheduling.  Can we understand Alt.1 is a defult solution if we cannot converge on Alt.2? It seems neat no additional design is needed.  As a clarification question, for the two subbullets of Alt.3 they seem to address the similar meaning (the first subbullet applies to single priority, while the second subbullet applies to cross priority)? |
| Intel | Prefer a resolution one way or another |
| QC | We actually share the same view with Samsung that Rel-17 intra-UE mux is already complicated and behind the schedule. RAN1 should be very careful to introduce any new functionality to intra-UE mux. But this could be an exception, because Alt 1 seems having no additional spec impact.  Alt 3 seems complicate intra-UE multiplexing, based on the below analysis. So we don’t support Alt 3  Assume in slot N, there are two overlapping PUCCHs (A and B). Both PUCCH A and B overlap with semi-static DL before UCI mux. But after multiplex, the resulting PUCCH C does not overlap with DL.  With Alt 2, if gNB schedule a dynamic A/N on Scell on slot N, the PUCCH A & B are dropped before multiplexing. But if gNB does not schedule a dynamic A/N on Scell on slot N. Then PUCCH A&B should be multiplexed and transit using PUCCH C. This means, now depends on Scell has dynamic A/N or not, Pcell either do dropping or intra-UE multiplexing. Isn’t that compicated Pcell intra-UE multiplexing procedure. |
| vivo | We can accept Alt.3, but better wait for outcome of related discussion |
| Nokia/NSB | Share the same view as Samsung & QC. |
| DOCOMO | We are fine with either option, but we think Alt 2 needs modification based on result of Question 6.4.1 and Proposal 6.8.1. |
| LG | We support Alt. 1 for simplicity. We are also open to discuss Alt.3 for details. |
| NEC | We can accept either option. |
| ZTE | Alt. 1 is simple and we think if we have no consensus on this issue, Alt.1 is the default way. |
| Moderator | Alt. 1 has many more supporting companies – let’s check if 5th round if agreeable with Alt. 1. |

7.5. 5th round of email approvals

Joint Operation of R17 Intra-UE multiplexing and SPS HARQ deferral

Looking at the input provided in the 3rd and 4th round, the following can be noted:

* If joint operation is supported, there seems to be no consensus to restrict the SPS HARQ-ACK deferral to either HP SPS HARQ-ACK only or only to having a single priority SPS HARQ up for deferral (based on Proposal 7.4.2)
* Looking at the input given to Proposal 7.4.1
  + Looking at the options provided, there is not a single Alt having more supporting than objecting companies.
  + Moreover, there are several companies thinking that the joint operation cannot be supported.

As the time of Rel-17 end getting very close (only 3 days left, only a single GTW session left with very minor time possible), the moderator makes a last try to see if we can support this – based on the alternative that is supported by most companies here – which seems to be Alt. 2A. If we cannot converge on this one, I guess the only reasonable outcome would be to have no consensus on the joint operation in Rel-17.

That said, let’s hope for companies being willing to compromise here.

**Mod Proposal 7.4.1 (based on Alt. 2A): Support joint operation of Rel-17 Intra-UE multiplexing and SPS HARQ deferral in Rel-17**

* **The determination if SPS HARQ-ACK is to be deferred in the initial PUCCH slot (i.e. PUCCH slot determined by n+k1) is performed after step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation** 
  + ***If after the Rel-17 UCI multiplexing operation (including step 1 and step 2) into a PUCCH or PUSCH if any, and if the UE would be transmitting LP SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration***

***which is not valid, the LP SPS* HARQ*-ACK configured for deferral is deferred.***

* + ***If after the Rel-17 UCI multiplexing operation (including step 1 and step 2) into a PUCCH or PUSCH if any, and if the UE would be transmitting HP SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the second PUCCH configuration which is not valid, the HP SPS HARQ-ACK configured for deferral is deferred.***
  + ***LP SPS HARQ-ACK that cannot be mapped to a HP PUCCH or HP PUSCH based on the Rel-17 Intra-UE multiplexing framework and is therefore dropped in step 2.1 or step 2.2, is not subject to deferral.***
* **The determination of the ‘target’ or ‘earliest second’ PUCCH slot (i.e. starting in PUCCH slot n+k1+1) for the SPS HARQ-ACK deferral procedure is performed**
  + **After step 2 (in case of overlap) of the Rel-17 Intra-UE multiplexing operation, i.e.,**
    - ***The target PUCCH slot  for a certain PHY priority is defined as the next PUCCH slot of that priority, where after performing step 1 and step 2 of the Rel-17 UCI multiplexing operation into a PUCCH or PUSCH if any, the UE would be either (i) transmitting HARQ-ACK using a PUCCH/PUSCH other than the PUCCH determined from PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration or (ii) would be transmitting HARQ-ACK using a PUCCH resource configured in PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration being regarded as valid or (iii) dropped due to the collision of HP UL channel.***
    - ***FFS further details e.g. handling of different time unit handling, joint versus separate deferral (and related order of deferral processing)***

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| Supporting companies | Sony (proposal unclear), Samsung |
| Objecting companies |  |

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| *Company* | *Comments* |
| Sony | Still do not understand the proposal:  **For the Initial PUCCH**:   1. It isn’t clear if the resultant PUCCH contains both LP SPS HARQ-ACK and HP SPS HARQ-ACK or not. For example in figure below SPS#1 has LP HARQ-ACK and SPS#2 has HP HARQ-ACK and both goes to a single PUCCH. And the resultant PUCCH cannot be transmitted. Is this the scenario being described? 2. Do we then demux the SPS HARQ-ACKs so that they are grouped into separate PHY priorities (if there are more than 2 SPS) and then each group proceed to find a target PUCCH?     **For the Target PUCCH**:  What does this sentence mean:  ***The target PUCCH slot  for a certain PHY priority is defined as the next PUCCH slot of that priority, …***  What does “*for a certain PHY priority*” means? Since the target PUCCH is the resultant PUCCH or resultant PUSCH after multiplexing, is this “*for a certain PHY priority*” refers to the PHY priority of resultant PUCCH/PUSCH?  Does this proposal allow:   1. Deferred LP SPS HARQ-ACK to be multiplexed into a target HP PUCCH/PUSCH? 2. Deferred HP SPS HARQ-ACK to be multiplexed into a target LP PUCCH/PUSCH? 3. Deferred LP SPS HARQ-ACK + HP SPS HARQ-ACK to be multiplexed into a target HP PUCCH/PUSCH? 4. Deferred LP SPS HARQ-ACK + HP SPS HARQ-ACK to be multiplexed into a target LP PUCCH/PUSCH?   The description in the proposal addresses none of these scenarios which should be the fundamental reason for intra-UE mux & SPS HARQ-ACK deferral. It isn’t even clear which scenarios the proposal is actually targeting or which combination of LP/HP initial PUCCH and LP/HP target PUCCH/PUSCH it is referring to. |
| Samsung | HP and LP determination should be separate – same as for joint operation with PHY prioritization.  For different PUCCH time units, as in Huawei’s case, only the first HP SPS HARQ-ACK would be multiplexed with LP SPS HARQ-ACK – the other HP SPS HARQ-ACK would not.  For the demultiplexing issue raised by Sony, it exists for the same priority. SR can be multiplexed in the SPS HARQ-ACK PUCCH - when a UE determines to defer SPS HARQ-ACK, the UE needs to demultiplex from the SR. So, there is no issue for multiplexing of different priorities.  For the details related to the FFS, we don’t think there is any issue. |
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Joint Operation of R17 Intra-UE multiplexing and enhanced Type 3 CB

Looking at the input on Proposal 7.4.3, there is a strong majority of companies thinking of supporting Alt. 1 aligned with the operation for PHY prioritization.

Similar as discussed above, if we cannot agree on this, it seems the joint operation would no be supported. But let’s try to give it a last push in Rel-17 here:

**Mod Proposal 7.4.3 (based on Alt. 1): Support joint operation of R17 Intra-UE multiplexing and enhanced Type 3 HARQ-ACK CB in Rel-17, based on the following operational details of Alt. 1:**

* **The UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB with the same priority index (i.e. in step 1) as the enhanced Type 3 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB. The UE performs Rel-17 Intra-UE multiplexing in step 2 as defined.**
* **For Rel-16 Type 3 CB, the UE creates the Rel-16 Type 3 CB with a PUCCH based on the indicated priority in step 1, and performs step 2 of the Rel-17 Intra-UE multiplexing of potential HARQ-ACK of different priority afterwards.**

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| Supporting companies | Sony, Samsung |
| Objecting companies |  |

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| *Company* | *Comments* |
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Joint Operation of R17 Intra-UE multiplexing and dynamic PUCCH cell switching

Similary, there is a majority of companies (that support the combination) suggesting Alt. 1, let’s try to see if we can support the joint operation based on Alt. 1 in R17.

**Mod Proposal 7.4.4 (based on Alt. 1): Support joint operation of Rel-17 Intra-UE multiplexing and dynamic PUCCH cell switching in Rel-17, based on the following operational details of Alt. 1:**

* **When dynamic PUCCH cell switching is enabled for a PUCCH group, at any given time the PUCCH resources would be allocated to a same cell (either PCell /SPCell / PUCCH SCell or PUCCH sSCell).**
* **Once a PUCCH target cell is determined based on a dynamic indication, the Rel-17 intra-UE multiplexing procedures can be applied to resolve collision in case of overlapping PUCCH resources on the target cell.**

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| Supporting companies |  |
| Objecting companies | Samsung |

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| *Company* | *Comments* |
| Samsung | No need and no benefit from further complicating intra-UE multiplexing/timelines by supporting dynamic PUCCH cell switching, particularly for different SCS of PCell and PUCCH-sSCell. |
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1. Input to GTW sessions

8.1 Fri. Feb. 25th 20222

**Mod Proposal 3.5.1 : The Rel-16 PHY prioritization operation and Rel-16 Type 3 with PHY priority operation & Rel-17 enhanced Type 3 HARQ-ACK CB with PHY priority operation is further clarified as:**

* **For Rel-17 enhanced Type 3 HARQ-ACK CB operation, the restriction on the Type 1 / Type 2 HARQ-ACK CB mapping from the earlier agreement below is only applicable to the same PHY priority of the Type 1 / Type 2 CB as the PUCCH for the enhanced Type 3 CB re-transmission. A LP PUCCH (or PUSCH) carrying the R17 enh. Type 3 CB is dropped according to the Rel-16 PHY prioritization procedures in case of an overlapping HP channel.**

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| **Agreement**  For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook. |

* **For Rel-16 Type HARQ-ACK 3 HARQ-ACK CB operation, the UE creates the Rel-16 Type 3 HARQ-ACK CB for transmission on a PUCCH of the indicated priority. A LP PUCCH (or PUSCH) carrying the R16 Type 3 HARQ-ACK CB is dropped according to the Rel-16 PHY prioritization procedures in case of an overlapping HP channel.**

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| Supporting companies | Vivo, NEC, Samsung Huawei/Hisi, Intel, Nokia/NSB, Ericsson, New H3C, Spreadtrum, DOCOMO, CATT, Sony |
| Objecting companies | OPPO |

**Proposal 6.2.3: Support joint operation of PUCCH repetition and dynamic PUCCH carrier switching in Rel-17.**

* **The PUCCH cell indication in the DCI scheduling the PUCCH is applicable for all the PUCCH repetitions.**

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| Supporting companies | Nokia/NSB, Intel, Ericsson, QC, Lenovo Huawei/Hisi New H3C, vivo, DOCOMO, Panasonic, CATT, ZTE, LG, NEC, ETRI, MediaTek |
| Objecting companies | Samsung |

**New Proposal 6.4.2 (RRC impact): For PUCCH cell switching, introduce a new RRC parameter in *CSI-ReportConfig* to allow configuring a separate ‘*pucch-CSI-ResourceList*’ for PUCCH sSCell.**

|  |  |
| --- | --- |
| Supporting companies | LG (if 6.4.1 is agreed), Panasonic, ZTE, Samsung, Intel, Spreadtrum, Nokia/NSB (can accept), Ericsson, QC, ~~CATT, DOCOMO,~~ New H3C, NEC, Lenovo |
| Objecting companies | Vivo |

We had the following discussion in Round 2:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Mod Proposal 6.2.7: For semi-static PUCCH cell switching with PUCCH repetition, further down-select from the following two alternatives:   * Alt. 1: The target cell is determined for each PUCCH repetition individually (i.e., switching within the repetition bundle supported)   + If more than one slot on the PUCCH-sSCell overlaps with a slot on the PCell, all slots where the PUCCH can be transmitted on the PUCCH-sSCell are used   + PUCCH resources corresponding to PUCCH repetitions other than the first PUCCH repetition are determined from the determined PUCCH cell based on the PRI in the (activated) DCI corresponding to the PUCCH   + A UE does not expect different number of REs in the PUCCH resources to transmit the repetition   + ~~FFS further details and/or restrictions~~ * Alt. 2A: For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported   + A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions, i.e., the repetition is postponed as in Rel-16.  |  |  | | --- | --- | | Supporting companies | Huawei/Hisi, DOCOMO, vivo, LG, Panasonic, ZTE, MediaTek, Intel, NEC, Spreadtrum, Nokia/NSB, QC, Ericsson, CATT, New H3C | | Objecting companies | Samsung |  |  |  | | --- | --- | | Alt. 1 (4 companies) | DOCOMO (can accept if more clarification), Panasonic, ZTE(some other restrictions are needed), NEC | | Alt. 2A (12 companies) | Huawei/Hisi, DOCOMO (1st preference), vivo, LG, MediaTek, Intel, NEC, Spreadtrum, Nokia/NSB, Ericsson (Alt 1 has a conflict w previous agreement), CATT, New H3C | |

With further clarifications in the 3rd round on the needed conditions. So the following updated proposal is brought forward, but hopefully even conclude to one of the options

**Mod2 Proposal 6.2.7: For semi-static PUCCH cell switching with PUCCH repetition, further down-select from the following two alternatives:**

* **Alt. 1: The target cell is determined for each PUCCH repetition individually (i.e., switching within the repetition bundle supported)**
  + **If more than one slot on the PUCCH-sSCell overlaps with a slot on the PCell, all slots where the PUCCH can be transmitted on the PUCCH-sSCell are used**
  + **PUCCH resources corresponding to PUCCH repetitions other than the first PUCCH repetition are determined from the determined PUCCH cell based on the PRI in the ~~(activated)~~ DCI corresponding to the PUCCH**
  + **A UE does not expect different number of REs in the PUCCH resources to transmit the repetition**
  + **FFS: UE expects that PUCCH resources from PCell/SPCell/PUCCH SCell and PUCCH sScell have the same number of symbols for each PUCCH repetition**
  + **~~FFS further details and/or restrictions~~**
* **Alt. 2A: For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported** 
  + **A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions, i.e., the repetition is postponed as in Rel-16.**

**Mod Proposal 2.2.2: For SPS HARQ-ACK deferral, further clarify the timeline behavior on top of the earlier RAN1#105-e agreement with the following additions in green:**

|  |
| --- |
| Agreement: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:   * In case the UE is expected to receive PDSCH of a certain HARQ Process ID according to TS 38.214 Sec. 5.1, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped at the PUCCH/PUSCH that would carry the HARQ-ACK associated with the PDSCH expected to be received.   + Note: there is no further discussion on specific handling for the case of DG PDSCH with the same HARQ process ID |

|  |  |
| --- | --- |
| Supporting companies | Huawei/Hisi, vivo, Samsung, Nokia/NSB, Sony, Ericsson, CATT, New H3C, NEC, Panasonic |
| Objecting companies | QC |

# References

1. R1-2200959 UE feedback enhancements for HARQ-ACK Huawei, HiSilicon
2. R1-2201002 HARQ-ACK Enhancements for IIoT/URLLC Ericsson
3. R1-2201017 HARQ-ACK Feedback Enhancements for URLLC/IIoT Nokia, Nokia Shanghai Bell
4. R1-2201021 Remaining issues for HARQ-ACK feedback enhancements New H3C Technologies Co., Ltd.
5. R1-2201090 Remaining issues on HARQ-ACK enhancements for Rel-17 URLLC vivo
6. R1-2201161 Discussion on HARQ-ACK enhancements for eURLLC ZTE
7. R1-2201295 HARQ-ACK enhancements for Rel-17 URLLC/IIoT OPPO
8. R1-2201356 UE feedback enhancements for HARQ-ACK CATT
9. R1-2201475 Discussion on HARQ-ACK feedback enhancements for Rel.17 URLLC NTT DOCOMO, INC.
10. R1-2201544 Discussion on HARQ-ACK feedback enhancements for Rel-17 URLLC Spreadtrum Communications
11. R1-2201579 Remaining issues on HARQ-ACK enhancements for URLLC Sony
12. R1-2201599 UE feedback enhancements for HARQ-ACK CAICT
13. R1-2201608 Discussion on remaining issues on PUCCH carrier switching Panasonic
14. R1-2201611 UE feedback enhancements for HARQ-ACK ETRI
15. R1-2201693 Open issues on UE HARQ feedback enhancements Intel Corporation
16. R1-2201769 Remaining issues in UE feedback enhancements for HARQ-ACK Apple
17. R1-2201903 UE feedback enhancements for HARQ-ACK NEC
18. R1-2202009 Maintenance on HARQ-ACK feedback enhancements Samsung
19. R1-2202134 HARQ-ACK enhancement for IOT and URLLC Qualcomm Incorporated
20. R1-2202341 Discussion on UE feedback enhancement for HARQ-ACK LG Electronics

# Appendix A: RAN1 agreements on HARQ-ACK feedback enhancements for NR Rel-17 URLLC/IIoT

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

Agreements:

Support Rel-17 enhancements to avoid SPS HARQ-ACK dropping for TDD due to PUCCH collision with at least one DL or flexible symbol.

* This topic is to be considered as high priority
* FFS detailed solution(s)

Agreements:

* Simultaneous PUSCH / PUCCH within a cell group (of Sec. 6.13 of R1-2007216) and enhanced (sub-slot) HARQ-ACK multiplexing on PUSCH (of Sec. 4.3 of R1-2007216) can be further discussed as part of AI 8.3.3 in this WI (but not as part of AI 8.3.1.1).

Agreements:

Study further at least the following schemes:

* SPS HARQ skipping for ‘skipped’ SPS PDSCH
* PUCCH repetition enhancements (at least for HARQ-ACK), e.g., sub-slot based, etc.
* Retransmission of cancelled HARQ
* SPS HARQ payload size reduction and / or skipping for ‘non-skipped’SPS PDSCH
* Type 1 HARQ codebook based on sub-slot PUCCH config
* PUCCH carrier switching for HARQ feedback

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

Agreements: To address the issue of SPS HARQ-ACK dropping for TDD systems, focus on the following two options:

* Option 1: Deferring HARQ-ACK until a next (e.g., first) available PUCCH
  + FFS: Details including the definition of a next (e.g, first) available PUCCH, CB construction / multiplexing
* Option 2: Dynamic triggering of a one-shot / Type-3 CB type of re-transmission
  + FFS: Details on triggering and/or CB construction (incl. potential Type-3 CB optimizations) / multiplexing

**Agreements: In the studies on PUCCH carrier switching for HARQ-ACK, PUCCH carrier switching for different cells operated is considered only for cells that are part of the active UL CA configuration.**

**Agreements: For the studies on SPS HARQ skipping for skipped SPS PDSCH, the further discussions should focus on the following reduced sets methods:**

* **‘NACK skipping’ for (skipped) SPS PDSCH (Alt. 1)**
  + **FFS: details including at least when to skip the HARQ-ACK as well as NACK skipping configuration details (per SPS or group of SPS configurations etc.)**
  + Note: this alternative assumes inherently no identification of a skipped SPS PDSCH by the UE
* **Dynamic indication of skipped SPS PDSCH occasions (Alt. 3)**
  + **FFS: details including dynamic indication methods such as e.g. DCI, MAC CE, specific DM-RS instead of SPS DM-RS, …**

**Agreements:** For the studies on SPS HARQ payload size reduction (of non-skipped SPS PDSCH), the further discussions should focus on the following reduced sets of methods:

1. ACK skipping (NACK-only) (Alt. 1)
   1. FFS: Details
2. NACK skipping (ACK-only) (Alt. 2)
   1. FFS: Details
3. HARQ bundling / compression (Alt. 3)
   1. FFS: Details including HARQ bundling / compression window, bundling / compression technique
4. HARQ-ACK disabling /skipping for certain SPS configurations (Alt. 4)
   1. The skipping / disabling is higher-layer configured per SPS configuration
   2. FFS: HARQ-ACK skipping behaviour for Type 1 CB

**RAN#89 (Dec. 2020) – see agreed conclusion from** [RP-202872](http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Docs/RP-202872.zip)

**RAN conclusion on IIoT scope:**

* For handling of the PUCCH repetitions it is proposed to proceed as follows:

1. RAN1 to continue discussion on PUCCH repetition, whether to specify or not, in the IIoT/URLLC WI for single TRP.
   1. The following items are not within scope of the continued discussions in the IIoT/URLLC WI:
      1. DMRS-less PUCCH with UCI payload up to 11 bits
      2. PUSCH-repetition-Type-B like PUCCH repetition
      3. DMRS bundling across PUCCH repetitions
2. PUCCH repetition issues with multi-TRP to be handled in Fe-MIMO WI.

* For the UE CSI/HARQ-ACK feedback enhancements in the IIoT/URLLC WI, RAN1 work to continue the discussions. Status to be checked in March if any RAN level guidance needed.
  + RAN1 to continue discussion on A-CSI on PUCCH, whether to specify or not.

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

Agreements:

* Support deferring SPS HARQ-ACK dropped due to TDD specific collisions until a next available PUCCH in Rel-17 based on semi-static configuration of slot format
  + FFS: Details (including possible conditions for such a deferring, whether or not to consider semi-statically configured flexible symbols for PUCCH availability, etc.)
  + Aim for minimal standardization efforts and UE complexity in implementation

Agreements:

Further down-select between the following two options for SPS HARQ-ACK deferral:

* Option 1: Joint RRC configuration of the SPS HARQ-ACK deferral per PUCCH cell group
  + *Note: any SPS HARQ-ACK within a PUCCH cell group in principle is subject to deferral*
* Option 2: The SPS HARQ-ACK deferral is configured per SPS configuration
  + *Note: part of sps-config, only HARQ-ACK of SPS PDSCH configurations configured for deferral is in principle subject to deferral*

Agreements: Support sub-slot based PUCCH repetition for HARQ-ACK based on the Rel-16 PUCCH procedure for slot-based PUCCH applied to sub-slot based PUCCH

* Note: the intention is to take the Rel-16 slot-based PUCCH by replacing with “sub-slot” appropriately, without further optimization unless necessary
* FFS whether or not there is any restriction for the applicability of sub-slot based PUCCH repetition for HARQ-ACK
* Dynamic repetition indication is supported also for sub-slot based PUCCH in Rel-17
  + FFS: if the method to be specified in Cov. Enh WI for slot-based PUCCH repetition can be directly applied to sub-slot PUCCH or if changes are needed

Agreements: Support PUCCH repetition for PUCCH formats 0 and 2 at least for sub-slot based PUCCH repetition.

* FFS: Support for slot-based PUCCH repetition

Agreements: Rel-16 UCI multiplexing  / PUCCH overriding rules are reused for deferred SPS HARQ-ACK in the target slot, if applicable.

Agreements: For SPS HARQ-ACK, the deferral from the initial slot/sub-slot determined by *k1* in the activation DCI to the target slot/sub-slot determined by *k1*+ *k1def*, the UE will check the validity of a target slot/sub-slot evaluating from one slot/sub-slot to the next sub/sub-slot (i.e. in principle *k1def* granularity is 1 slot/sub-slot)

* FFS: if there is a limit on the minimum deferral considered the required UE processing (*k1def* ≥0)
* FFS: if there is a limit on the maximum deferral

Agreements: For SPS HARQ-ACK deferral, for the determination of valid symbols in the initial slot/sub-slot a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’ or ‘no symbols for UL transmission’.

Agreements: **For further study on** **whether and how to support** **PUCCH carrier switching** **in a PUCCH group, focus on the following three alternatives:**

* **Alt. 1: PUCCH carrier switching is based dynamic indication in DCI**
* **Alt. 2B: PUCCH carrier switching is based on certain (semi-static) rules**
* **Alt. 2C: PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
* Note: In above alternatives, it is assumed that HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group, can be sent on a PUCCH onan Scellalso instead ofonly onPcell/PScell/PUCCH-SCellin the same PUCCH group, as opposed to Rel-16 where HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group can only be sent on Pcell/PScell/PUCCH-SCell in the same PUCCH group.
* ***Note: Realistic deployment scenarios including TDD configurations should be considered for the study***

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

Agreements: For SPS HARQ-ACK deferral, for the determination of valid symbols in the target slot/sub-slot a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’ or ‘no symbols for UL transmission’.

Agreements: For SPS HARQ-ACK deferral, support a limit on the maximum deferral of SPS HARQ in terms of *k1def* or *k1*+ *k1def*

* + FFS: limitation given by a maximum value of *k1def* or a maximum of *k1eff* =*k1*+ *k1def*
  + FFS how the limitation is determined (e.g. by K1 set(s) or RRC configured limit)

Agreements: For SPS HARQ-ACK deferral, there is no lower limit defined for *k1def*

**Conclusion:**

No support for dynamic indication of skipped SPS PDSCH occasions in Rel-17 as part of this WI.

Agreement: Restrict the further discussions on the initial slot handling for SPS HARQ-ACK deferral to the identified alternatives Alt. 1, Alt. 1A and 2.

Agreement: For SPS HARQ-ACK deferral, the limit on the maximum deferral of SPS HARQ is defined in terms of *k1eff =k1*+ *k1def.*

Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:

* In case the UE receives PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.

Agreement: For SPS HARQ-ACK deferral, the initial HARQ-ACK transmission occasion is considered to determine the out-of-order HARQ condition

Agreement: Support Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17.

* The properties of the Type-1 HARQ-ACK codebook for sub-slot PUCCH at least includes that a PDSCH TDRA is associated with a UL /PUCCH sub-slot if the end of the PDSCH overlaps with the associated sub-slot determined by a k1 in the set of sub-slot timing values K1.
* FFS: whether the PDSCH TDRA grouping is performed per DL slot or sub-slot
  + Decide between PDSCH TDRA grouping per DL slot and sub-slot during RAN1#105-e

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

Working Assumption: For at least HARQ-ACK re-transmission:

* Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16) in Rel-17
  + *Definition of enhanced Type 3 CB:* 
    - *The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration*
    - *The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)*
* Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17
  + *Details are FFS*
* Enhanced Type 3 HARQ-ACK CB and/or one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB are subject to separate UE capabilities

Agreement: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration

* Details are FFS (including applicability of dynamic and/or semi-static means)
* Aim for minimum specification impact
* Dynamic indication and/or semi-static configuration are subject to separate UE capabilities
* The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and supports PUCCH carrier switching across cells with different numerologies.
  + FFS whether additional rules are needed to support PUCCH carrier switching across cells with different numerologies
* FFS the maximum number of PUCCH cells
* FFS whether and how to support joint operation of dynamic and semi-static carrier switching for a UE
* FFS whether and how to support joint operation of PUCCH carrier switching and SPS HARQ-ACK deferral

Agreement: For PUCCH carrier switching, the PUCCH resource configuration is per UL BWP (i.e. per candidate cell and UL BWP of that specific candidate cell).

Agreement: For PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1), the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology of the dynamically indicated target PUCCH cell.

**RAN#92-e (June 2021) – *see section 3.2 of*** [***RP-211569***](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_92e/Docs/RP-211569.zip)

During the GTW session the following recommendations with further revisions were endorsed.

* **……**
* **Revised Recommendation2**: Provide the following RAN guidance on *HARQ-ACK enhancement [RAN1]*
  + No further discussions on SPS HARQ-ACK skipping and size reduction~~bundling/compression~~.

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

**Agreement**

The SPS HARQ-ACK deferral is enabled per SPS configuration

* Note: part of sps-config, only HARQ-ACK of SPS PDSCH configurations enabled for deferral is in principle subject to deferral

**Agreement**

Definition of when to defer from the initial slot:

* Alt1: Deferral only, if the SPS HARQ-ACK in the initial slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using the PUCCH by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN is not valid

**Agreement**

Update the following RAN1#105-e agreement as (RED):

* RAN1#105-e Agreement: For PUCCH carrier switching, the PUCCH ~~resource~~ configuration (i.e. *pucch-Config / PUCCH-ConfigurationList*) is per UL BWP (i.e. per candidate cell and UL BWP of that specific candidate cell).
  + FFS: CSI and SR

**Agreement**

For SPS HARQ-ACK deferral, the maximum deferral value in terms of k1+k1def is RRC configured per SPS configuration.

**Agreement**

For SPS HARQ-ACK deferral, only SPS HARQ bits subject to deferral from HARQ-ACK codebook from an initial PUCCH slot are deferred to the target PUCCH slot

**Agreement**

For SPS HARQ-ACK deferral, deferred SPS HARQ bits from more than one ‘initial PUCCH slot’ can be jointly deferred to a target PUCCH slot

**Agreement**

Confirm the following RAN1#105-e working assumption:

For at least HARQ-ACK re-transmission:

* Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16) in Rel-17
  + Definition of enhanced Type 3 CB:
    - The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration
    - The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)
* Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17
  + Details are FFS
* Enhanced Type 3 HARQ-ACK CB and/or one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB are subject to separate UE capabilities

**Agreement**

Support PHY priority handling for a PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size.

* The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size.
* The A/N of HARQ processes is mapped to the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size irrespective of the PHY priority of the ‘A/N’ of the HARQ processes.
* FFS: If the HARQ-ACK codebook size or structure is dependent on the PHY priority (e.g. separate configuration of CBG/NDI usage, separate configuration of HARQ IDs / CCs per priority, SPS HARQ-ACK process IDs of specific priority only for a SPS HARQ-ACK only codebook, …).

**Agreement**

Support PHY priority handling for a PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB in Rel-17.

* The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB.
* The A/N of HARQ processes is mapped to the Rel-16 Type 3 HARQ-ACK CB irrespective of the PHY priority of the ‘A/N’ of the HARQ processes.
* The support is subject to a Rel-17 UE capability and a UE supporting this capability can be configured in Rel-17 with Rel-16 Type 3 HARQ-ACK CB and PHY prioritization.

**Agreement**

For the PHY priority handling of the enhanced Type 3 CB(s) of smaller size, the enhanced Type 3 HARQ-ACK has the same structure, size and content (in terms of HARQ-IDs, CCs) irrespective of the PHY priority.

**Agreement**

Support Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size triggering using DCI format 1\_2 for a UE supporting DCI format 1\_2.

* The triggering support for DCI format 1\_2 is independently (from triggering using DCI format 1\_1) RRC configured to the UE.

**Agreement**

Support Rel-16 Type 3 HARQ-ACK CB triggering using DCI format 1\_2 in Rel-17 for a UE supporting DCI format 1\_2.

* The support is subject to a Rel-17 UE capability and a UE supporting this capability can be configured with DCI format 1\_2 triggering of the Rel-16 Type 3 HARQ-ACK CB.

**Agreement**

For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook.

**Agreement**

The DCI triggering (by a DL assignment) the one-shot HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB dynamically indicates the HARQ-ACK codebook(s) / PUCCH occasions to be re-transmitted.

* FFS details

**Agreement**

A single DCI triggering the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB can trigger the re-transmission of HARQ-ACK information of only a single HARQ-ACK CB.

**Agreement**

The Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB is done through an explicit triggering indication in the DCI through a DCI field.

**Agreement**

Support PHY priority handling for the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB.

* The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the re-transmitted HARQ-ACK information.
* The indicated PHY priority in the triggering DCI is used to determine the HARQ-ACK information to be re-transmitted corresponding to the indicated PHY priority.

**Conclusion**

The dynamic repetition indication solution for slot-based PUCCH repetition from the RAN1#105-e working assumption from Cov. Enh. WI can be directly applied for dynamic repetition indication for sub-slot based PUCCH repetition.

**Agreement**

For sub-slot based PUCCH repetition for HARQ-ACK, semi-static configured PUCCH repetition (i.e. using *nrofSlots*) and dynamic repetition factor based operation is supported.

* Sub-slot based PUCCH repetition based on semi-static configuration (i.e. using *nrofSlots*) and based on dynamic indication is subject to separate UE capabilities

**Agreement**

For SPS HARQ-ACK deferral, the target PUCCH slot is defined as the next PUCCH slot where *sps-PUCCH-AN-List-r16* or*n1PUCCH-AN* PUCCH resource is regarded as valid*,*or a PUCCH resource*(from PUCCH-ResourceSet, i.e. DG PDSCH HARQ multiplexed*) is dynamically indicated

* The target PUCCH slot determination is based on the total HARQ-ACK payload size including deferred SPS HARQ-ACK information and non-deferred HARQ-ACK information (if any) of a candidate target PUCCH slot
* The final PUCCH resource selection in the target PUCCH slot in terms of PUCCH resource set and PUCCH resource ID follows the Rel-16 procedures.

**Agreement**

For SPS HARQ-ACK deferral, if after the target PUCCH slot determination the deferred SPS HARQ-ACK cannot be transmitted, the deferred SPS HARQ-ACK bits are not further deferred and are dropped.

**Agreement**

For SPS HARQ-ACK deferral, in the target PUCCH slot the deferred SPS HARQ-ACK bits are appended to the initial HARQ bits / Type 1 or Type 2 codebook.

**R1-2108546** Moderator summary #3 on HARQ-ACK feedback enhancements for NR Rel-17 URLLC/IIoT Moderator (Nokia)

**Agreement**

For SPS HARQ-ACK deferral, confirm the RAN1#104b-e working assumption with the following updates in RED:

(working assumption) To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:

* In case the UE is expected to receive~~s~~ PDSCH of a certain HARQ Process ID according to TS 38.214 Sec. 5.1, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.
  + Note: there is no further discussion on specific handling for the case of DG PDSCH with the same HARQ process ID

**Agreement**

For enh. Type 3 HARQ-ACK CB(s), support dynamic selection based on indication in the triggering DCI of one of at least one enh. Type 3 HARQ-ACK CB(s).

* Each of the at least one enh. Type 3 HARQ-ACK CBs is at least defined by RRC configuration This includes the option to configure all DL HARQ processs of all configured CCs as one enh. Type 3 HARQ-ACK CB (resulting in same structure and size as the Rel-16 Type 3 HARQ-ACK CB)
* This includes UE capability signaling (value range {1…X}) on the maximum number of supported simultaneously configured enh. Type 3 HARQ-ACK CBs that can be dynamically indicated
* Details including the value of X are FFS

**Agreement**

The following enhanced Type 3 CB types of smaller size are supported, the CB to contain either:

* the HARQ processes of a subset of configured CCs, or
* a subset of configured HARQ processes (specific to CCs)

FFS: additional enh. Type 3 CB types

**Agreement**

For Rel-17 one-shot triggering for HARQ-ACK re-transmission, the UE does not expect more than one triggering DCI for Rel-17 one-shot feedback indicating the same PUCCH slot for the re-transmission of HARQ-ACK CBs of different PUCCH slots to be re-transmitted

* Note: i.e. only a single HARQ-ACK codebook / PUCCH occasion can be re-transmitted in a PUCCH slot

**Agreement**

Support slot-based PUCCH repetition for PUCCH Format 0 and Format 2 also for single TRP operation.

* The support is subject to independent UE capability indication

**Agreement**

In addition to HARQ-Ack of PDSCH dynamically scheduled by a DCI indicating a PUCCH carrier, the dynamic target carrier indication also applies to:

* HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI based on the indication in the activation DCI
* HARQ-ACK corresponding to the SPS Release DCI based on the indication in the release DCI
* triggered PUCCH for Rel-16 Type 3 CB, Rel-17 enh. Type 3 CB of smaller size and Rel-17 one-shot triggering for HARQ-Ack retransmission based on the indication in the triggering DCI
* FFS: Additional cases

**Agreement**

Semi-static PUCCH carrier switching is applicable to all UCI types incl. HARQ-ACK, SR and CSI.

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

**Agreement**

For PUCCH carrier switching, support PUCCH carrier switching only among different TDD cells with PUCCH configured on the NUL carrier in Rel-17

**Agreement**

For semi-static PUCCH cell switching, PCell / PSCell / PUCCH-SCell is reference cell:

* The time domain pattern configurations are based on the numerology of the reference cell.
* The PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology and PUCCH configuration of a reference cell to be able to apply the time-domain PUCCH cell switching pattern.
* Note: There may not be a need to define a ‘reference cell’ in the specification. This terminology is used for further clarifications of the procedure.

**Agreement**

For PUCCH cell switching, support independent TPC per PUCCH cell including

* Separate P0 / TPC configuration per PUCCH cell
  + Note: This flexibility is already provided as PUCCH-config is per UL BWP of a PUCCH cell
* Accumulating closed loop power control commands only within the same PUCCH target cell by reusing Rel-15 procedure, i.e.
  + For dynamic PUCCH cell indication, the TPC command in the DCI scheduling the PUCCH only applies for the dynamically indicated PUCCH target cell
  + For semi-static / time-domain pattern, the TPC command in the DCI scheduling the PUCCH only applies for the determined PUCCH target (using the time-domain pattern)
* Separate TPC command indication using DCI format 2\_2 for the individual PUCCH cells
  + Note: this requires configuration of individual TPC command starting points for each PUCCH cell within DCI format 2\_2

**Agreement**

UE does not expect overlapping PUCCH slots with dynamic PUCCH cell indication on more than one cell, i.e., gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot.

**Agreement**

For semi-static PUCCH cell switching, the time-domain pattern configuration is based on the following properties:

* A single time-domain pattern is configured per PUCCH cell group
* The granularity of the time-domain pattern is one slot of the PCell / PSCell / PUCCH-SCell ~~reference cell~~
* The time-domain pattern is applied periodically
  + FFS on period / pattern length (e.g., 10ms, RRC configured, …).
* The pattern defines for each slot of the PCell / PSCell / PUCCH-SCell ~~reference cell~~ at least the applicable target PUCCH cell

**Agreement**

For semi-static PUCCH cell switching, the PUCCH resource indicator (PRI) is interpreted based on the PUCCH configuration of determined target PUCCH cell.

**Conclusion**

For SPS HARQ-ACK deferral, only SPS HARQ-ACK bits subject to deferral from one or more initial slots which have not reached the maximum deferral value are jointly deferred to the next available PUCCH (other SPS HARQ-ACK is dropped).

**Agreement**

For SPS HARQ-ACK deferral, the bit ordering of deferred SPS HARQ-ACK information from one or more initial slots in the target PUCCH slot is based on the Rel.16 SPS HARQ-ACK bit order principle as in clause 9.1.2 of TS38.213 is applied, i.e., based on serving cell index, SPS configuration index, SPS PDSCH slot index.

**Conclusion**

No additional enhanced Type 3 CB ‘types’ (such as activated CCs, of specific SPS configurations, etc.) in terms of RRC configuration are supported.

**Agreement**

For one enhanced Type 3 HARQ-ACK CB, the same CBG and NDI configuration applies to both PHY priorities following the RAN1#106-e agreement.

**Agreement**

The same set of enhanced Type 3 CBs (incl. CBG and NDI configuration) is applied for triggering using DCI format 1\_1 and 1\_2.

**Agreement**

Reuse the legacy 1-bit ‘*one-shot HARQ-ACK request*’ for triggering indication of the enhanced Type 3 HARQ-ACK CB of smaller size.

* At least if only a single enhanced Type 3 HARQ-ACK CB is configured, the triggering DCI with the triggering bit set to ‘1’ is also able to schedule PDSCH.

**Agreement**

Support triggering of one-shot HARQ re-transmission on PUCCH using DCI format 1\_2.

**Agreement**

To align with Rel-16 slot-based PUCCH repetition operation, support sub-slot based PUCCH repetition configured with / using *nrofSlots* (i.e., not using dynamic indication) of all UCI types (incl. HARQ, SR & CSI).

**Agreement**

For sub-slot based PUCCH repetition, the following agreement from Cov. Enh. WI for slot-based PUCCH repetition is adopted also for sub-slot based PUCCH repetition:

|  |
| --- |
| *Agreement*   * *for a PUCCH resource, if both a new repetition parameter corresponding to Rel-17 dynamic PUCCH repetition factor indication and the Rel-15/16 nrofSlots are configured, the new repetition parameter overrides nrofSlots.* |

**Agreement**

For sub-slot based PUCCH repetition, the following agreement from Cov. Enh. WI for slot-based PUCCH repetition is adopted also for sub-slot based PUCCH repetition:

|  |
| --- |
| *Agreement: Dynamic PUCCH repetition factor indication for SR or P/SP-CSI on PUCCH is not supported in Rel-17.* |

**Agreement**

For PUCCH cell switching based on dynamic indication in the DCI,  introduce a new, dedicated DCI field for the DCI scheduling PDSCH to indicate the target PUCCH cell.

**Agreement**

In addition, the dynamic target PUCCH cell indication also applies to HARQ-ACK corresponding to SCell dormancy indication without scheduling PDSCH.

**Agreement**

The periodicity / length of the time-domain pattern for semi-static PUCCH cell switching is directly determined by the RRC configuraton of the time domain pattern *pucchCellPattern*

* Note: *pucchCellPattern* has a variable length of (1… *maxNrofSlots*)

**Agreement**

For semi-static and dynamic indication of PUCCH cell switching, the PUCCH repetition factor is determined based on the PUCCH format or PUCCH resource on the target PUCCH cell for the first repetition.

**Agreement**

The CBG and NDI usage can be independently configured for different enhanced Type 3 HARQ-ACK CBs.

**Agreement**

For Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17, the TDRA pruning/grouping is performed per DL slot after TDRA determination per sub-slot.

* Strive to minimize the impact on relevant pseudo-code

**Conclusion**

For SPS HARQ-ACK deferral, the operation in the ‘initial’ slot is further clarified as:

* The UE performs first the (Rel-16) UCI multiplexing operation. If after the UCI multiplexing operation into a PUCCH or PUSCH if any, and if the UE would be transmitting SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN which is not valid, the SPS HARQ-ACK configured for deferral is deferred.

**Agreement**

The maximum number of simultaneously configurable enhanced Type 3 CB is indicated by the UE through UE capability signaling from the set of {1, 2, 4, 8}.

**Agreement**

PUCCH cell switching between 2 cells is supported in Rel-17.

**Agreement**

For PUCCH repetition enhancements:

* Support *inter-slotFrequencyHopping* for PUCCH repetition operation of PUCCH Format 0 and Format 2 for slot-based PUCCH configurations.
* Support inter-subslot Frequency Hopping for PUCCH repetition operation of PUCCH Formats 0, 1, 2, 3 and 4 for 7OS slot-based PUCCH configurations.
  + The UE applies the inter-subslot FH operation from sub-slot to sub-slot, if configured with *inter-slotFrequencyHopping* in the respective PUCCH\_config.
* (Working Assumption) Support inter-subslot Frequency Hopping for PUCCH repetition operation of PUCCH Format 0 and Format 2 for 2OS slot-based PUCCH configurations.
  + The UE applies the inter-subslot FH operation from sub-slot to sub-slot, if configured with *inter-slotFrequencyHopping* in the respective PUCCH\_config.
* Note: As for Rel-15, the configuration / enabling of *inter-slotFrequencyHopping* and *intraSlotFrequencyHopping* is not supported.

**Agreement**

For sub-slot based PUCCH repetition, the following agreement from Cov. Enh. WI for slot-based PUCCH repetition is adopted also for sub-slot based PUCCH repetition:

|  |
| --- |
| Agreement   * In Rel-17, reuse the Rel-16 PUCCH repetition factors 2, 4, 8. * Do not support PUCCH repetition factor larger than 8 In Rel-17. |

**Agreement**

The RAN1#106-e agreement on the target slot definition is updated as follows (in RED):

|  |
| --- |
| **Agreement (from RAN1#106-e)**  For SPS HARQ-ACK deferral, the target PUCCH slot is defined as the next PUCCH slot, where after performing the (Rel-16) UCI multiplexing operation into a PUCCH or PUSCH if any, the UE would be either (i) transmitting HARQ-ACK using a PUCCH/PUSCH other than the PUCCH determined from *PUCCH SPS-PUCCH-AN-List-r16* or *n1PUCCH-AN* or (ii) would be transmitting HARQ-ACK using a PUCCH resource configured in *PUCCH SPS-PUCCH-AN-List-r16* or *n1PUCCH-AN* being regarded as valid.  *~~sps-PUCCH-AN-List-r16~~*~~or~~*~~n1PUCCH-AN~~*~~PUCCH resource is regarded as valid~~*~~,~~*~~or a PUCCH resource~~*~~(from PUCCH-ResourceSet, i.e. DG PDSCH HARQ multiplexed~~*~~) is dynamically indicated~~   * The target PUCCH slot determination is based on the total HARQ-ACK payload size including deferred SPS HARQ-ACK information and non-deferred HARQ-ACK information (if any) of a candidate target PUCCH slot * The final PUCCH resource selection in the target PUCCH slot in terms of PUCCH resource set and PUCCH resource ID follows the Rel-16 procedures. |

**Agreement**

Support PUCCH cell switching based on dynamic indication in the DCI using DCI format 1\_2 for a UE supporting DCI format 1\_2.

* The presence of the ‘PUCCH carrier switching’ bitfield in DCI format 1\_2 is RRC configured.

**Conclusion**

If the UE is not configured with Rel-17 Intra-UE multiplexing, SPS HARQ for deferral of different PHY priorities can be separately deferred with the target PUCCHs separately determinated according to their respective PHY priorities.

* FFS on the PHY priority handling for SPS HARQ deferral if the UE configured with Rel-17 Intra-UE multiplexing

**Agreement**

For one-shot HARQ re-transmission on PUCCH, the triggering DCI dynamically indicates a ‘HARQ re-tx offset’ which is used to define the offset in number of PUCCH slots/sub-slots between the triggering DCI and the PUCCH slot/sub-slot of the HARQ-ACK codebook to be re-transmitted. For the triggering DCI received in slot/sub-slot m, indicating the HARQ-ACK re-tx in slot/sub-slot m+k and indicating HARQ\_retx\_offset, the PUCCH slot/sub-slot n of the HARQ-ACK codebook to be re-transmitted is determined as either:

* Alt. 1: n = m - HARQ\_retx\_offset
* Alt. 2: n = m + k - HARQ\_retx\_offset
* FFS: value range of the HARQ-retx\_offset

**Agreement**

Down-select in RAN1#107-e from Alt. 1 & Alt. 3 below:

For PUCCH carrier switching based on semi-static operation, for the case the PCell slot to be longer than the target PUCCH cell slot or sub-slot (i.e. multiple target PUCCH cell slots overlapping with a single PCell slot),  the following PUCCH cell slot is used for UCI transmission:

* Alt. 1: the first target PUCCH slot overlapping with the PCell slot
* Alt. 3: using a relative slot-offset within the reference cell slot, the relative slot offset is configured in the time domain pattern (i.e. time domain pattern contains ‘cell index’ & ‘slot\_offset’ for each reference cell slot)
  + Note: different relative slot offset can be configured for each reference cell slot in the time domain pattern, details see R1-2108829

**Agreement**

Down-select in RAN1#107-e from Alt. 2 & Alt. 4 below:

For PUCCH carrier switching based on semi-static operation, for the case the PCell slot to be shorter than the target PUCCH cell slot,

* Alt. 2: the UE does not expect the same UCI type (i.e. HARQ-ACK, SR or CSI) from more than one PCell PUCCH slot to be overlapping with a single dynamically indicated PUCCH cell slot
  + *Note: there can be e.g. HARQ-ACK only be present in either of the overlapping slots, but not in more than one overlapping slot.*
* Alt. 4: the UE does not expect a semi-static PUCC cell configuration, where a single target PUCCH slot / sub-slot would be overlapping with more than one PCell slot/sub-slot.

**Conclusion**

There is no consensus to support multiplexing of HARQ-ACK (without dynamic PUCCH cell indication), SR and P/SP-CSI on the dynamically indicated PUCCH cell (other than PCell / PSCell / PUCCH-SCell) in Rel-17.

* FFS: further handling, incl. e.g., UE does not expect overlapping HARQ-ACK (without dynamic PUCCH cell indication), SR and P/SP-CSI or overlapping HARQ-ACK (without dynamic PUCCH cell indication), SR and P/SP-CSI is to be dropped
* FFS: overlapping definition for SR and P/SP-CSI in terms of PUCCH slot or PUCCH resource

**Agreement**

For one-shot triggering of HARQ-ACK re-transmission on PUCCH,

* in case the dynamic Type 2 HARQ-ACK codebook is configured, the HARQ-ACK codebook per PHY priority on the indicated PUCCH is constructed by appending the Type 2 HARQ-ACK codebook to be re-transmitted to the Type 2 HARQ-ACK codebook of the indicated PUCCH (carrying new, initial HARQ-ACK information) per PHY priority.
* in case the semi-static Type 1 HARQ-ACK codebook is configured, the HARQ-ACK codebook per PHY priority on the indicated PUCCH is constructed by appending the Type 1 HARQ-ACK codebook to be re-transmitted to the Type 1 HARQ-ACK codebook of the indicated PUCCH (carrying new, initial HARQ-ACK information) per PHY priority.

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

**Agreement**

The maximum SPS HARQ-ACK deferral value in terms of k1+k1def per SPS configuration is RRC configured from a value range of {1…32}.

**Agreement**

The list enhanced Type 3 HARQ-ACK codebooks is configured per PUCCH cell group (i.e., separately configurable for primary and secondary PUCCH cell group).

**Agreement**

The one-shot HARQ re-transmission on PUCCH is configured per PUCCH cell group (i.e., separately configurable for primary and secondary PUCCH cell group).

**Agreement**

For one-shot HARQ re-transmission on PUCCH, the ‘HARQ re-tx offset’ is determined as Alt. 1: *n = m - HARQ\_retx\_offset*

**Conclusion**

There is no consensus to support the simultaneous configuration of one-shot HARQ-ACK re-transmission and dynamic PUCCH cell switching in Rel-17.

**Conclusion**

For SPS HARQ-ACK deferral, if a UE is not configured with Rel-17 intra-UE multiplexing but configured with Rel-16 PHY prioritization, the UE first performs Rel-16 UCI multiplexing and PHY prioritization in both initial slot and target slot and if a LP SPS HARQ-ACK PUCCH is deprioritized, the LP SPS HARQ-ACK is not deferred.

* Note: If the SPS HARQ-ACK is deprioritized in any slot, no further deferral.

**Agreement**

Support simultaneous configuration of SPS HARQ-ACK deferral and PUCCH cell switching based on the semi-static time domain pattern:

For the target slot determination of SPS HARQ-ACK deferral,

* Step 1: the UE first determines a next PUCCH slot on the cell for PUCCH transmission using the semi-static time-domain PUCCH cell pattern and the related rules for semi-static PUCCH cell switching, followed by
* Step 2: the UE determines based on the SPS HARQ-ACK deferral rules if this PUCCH slot on the PUCCH cell for transmission is the target PUCCH slot or not.
* Note: In step 1, k is increased on PCell/PScell/PUCCH-Scell. “The next PUCCH slot” represents the slot on the PUCCH cell based on PUCCH cell pattern, which is mapped from the PCell/PScell/PUCCH-Scell slot with increased K1.
* Note: The maximum deferral limitation checking is based on the effective k + kdef value based on the granularity of PCell / PScell/PUSCCH-Scell

**Agreement**

Support simultaneous configuration of one-shot HARQ-ACK re-transmission and semi-static PUCCH cell switching:

* the ‘backward HARQ-ACK slot-offset’ is interpreted with the granularity of a PUCCH slot of the respective PHY priority of PCell /PSCell / PUCCH SCell

**Agreement**

Confirm the following RAN1 working assumption from RAN1#106bis-e with the additional agreement on UE capability (in RED):

|  |
| --- |
| * (Working Assumption) Support inter-subslot Frequency Hopping for PUCCH repetition operation of PUCCH Format 0 and Format 2 for 2OS slot-based PUCCH configurations.   + The UE applies the inter-subslot FH operation from sub-slot to sub-slot, if configured with *inter-slotFrequencyHopping* in the respective PUCCH\_config. |

* Support single UE capability indication of inter-subslot FH for PUCCH repetition operation.

**Agreement**

Apply a 1-bit triggering DCI field for triggering indication of one-shot HARQ re-transmission on PUCCH.

* The triggering DCI with the triggering bit set to ‘1’ is not able to schedule PDSCH.
* Some unused bit field in the DCI is used to indicate the HARQ slot offset.
* FFS: if the ‘one-shot HARQ-ACK request’ field can be reused
* FFS: which unsed DCI field in the DCI is used for HARQ slot offset indication
* FFS: The indication of whether the PDSCH is not scheduled will reuse Rel-16 type-3 HARQ ACK CB UE behavior

**Agreement**

The earlier RAN1 agreements on the valid symbol definition in the initial and target PUCCH slot for SPS HARQ-ACK deferral are further clarified as:

* For SPS HARQ-ACK deferral, for the determination of valid symbols in the initial and target PUCCH slot/sub-slot a collision with semi-static DL symbols, SSB and symbols indicated by *pdcch-ConfigSIB1* in *MIB* for a CORESET for Type0-PDCCH CSS set is regarded as ‘invalid’ or ‘no symbols for UL transmission’.

**Conclusion**

There is no consensus to support the simultaneous configuration of the Rel-16 Type 3 HARQ-ACK CB and Rel-17 one-shot re-tx HARQ triggering for a UE in Rel-17.

**Conclusion**

There is no consensus to support the simultaneous configuration of the Rel-17 Enhanced Type 3 HARQ-ACK CB and Rel-17 one-shot HARQ re-tx triggering for a UE in Rel-17.

**Agreement**

Support simultaneous configuration of enhanced Type 3 CB triggering and PUCCH cell switching.

**Conclusion**

For PUCCH cell switching DCI field size alignment is done by:

* For dynamic PUCCH cell switching, the bit width of the PDSCH-to-HARQ\_feedback timing indicator in DCI format 1\_1 and 1\_2 is determined by the largest K1 set among the K1 sets of all candidate PUCCH cells for PUCCH cell switching based on dynamic indication
  + i.e., a number of most significant bits with value set to '0' are inserted to smaller field until the bit width of the field for all the PUCCH cells are the same
  + *Note: for semi-static PUCCH cell switching only the K1 set of PCell is needed*
* For semi-static and dynamic PUCCH cell switching, the bit width of the PRI field in DCI format 1\_2 is determined by the largest value of *numberOfBitsForPUCCH-ResourceIndicatorDCI-1-2* of all PUCCH cells
  + i.e., a number of most significant bits with value set to '0' are inserted to smaller field until the bit width of the field for all the PUCCH cells are the same
* FFS: If similar handling is applied for *ChannelAccess-CPext* DCI field (0 or 2 bit)

**Agreement**

For PUCCH cell switching and a PUCCH transmission on the alternative PUCCH cell, the alternative PUCCH cell is used to derive the downlink pathloss estimate PLb,f,c(qd), i.e., replace in the main bullet of the PLb,f,c(qd) determination in Sec. 7.2.1 of 38.213 the ‘primary cell’ with ‘cell for PUCCH transmission’

**Agreement**

For PUCCH cell switching based on semi-static operation, for the case the PCell slot to be longer than the target PUCCH cell slot or sub-slot (i.e., multiple target PUCCH cell slots overlapping with a single PCell slot),  adopt Alt 1, i.e., the first target PUCCH slot overlapping with the PCell slot is used for UCI transmission.

**Agreement**

Support simultaneous configuration of Rel-16 Type 3 HARQ-ACK codebook or enhanced Type 3 HARQ-ACK codebook triggering and SPS HARQ-ACK deferral.

* In case a R16 Type 3 HARQ-ACK CB or an enhanced Type 3 HARQ-ACK codebook is triggered for transmission in a PUCCH slot, the UE stops the deferral procedure of pending SPS HARQ-ACK in that PUCCH slot and that PUCCH slot is not considered as a potential target slot for SPS HARQ-ACK deferral anymore.

**Agreement**

One enhanced Type 3 HARQ-ACK codebook is RRC configured either as:

* + - * 1. a subset of CC, i.e., all HARQ processes of the subset of CCs are part of the codebook, OR

|  |  |  |
| --- | --- | --- |
| pdsch-HARQ-ACK-enhType3perCC | Configure the one enhanced Type 3 HARQ-ACK codebook using per CC configuration | (1..maxNrofServingCells) of Integer (0,1) |

* + - * 1. a subset of configured HARQ processes per CC, i.e., different subsets of HARQ processes can be configured for each CC.

|  |  |  |
| --- | --- | --- |
| pdsch-HARQ-ACK-enhType3perHARQ | Configure the one enhanced Type 3 HARQ-ACK codebook using a per HARQ process and CC configuration | (1..maxNrofServingCells) of Bit String (Size (16)) |

**Agreement**

For one-shot triggering of HARQ re-transmission, introduce a new 1-bit DCI field in DCI format 1\_1 and in DCI format 1\_2 (if DCI format 1\_2 is configured with one-shot triggering of HARQ-ACK re-transmission).

**Agreement**

The time-domain pattern for semi-static PUCCH cell switching is separately configurable for the primary and secondary PUCCH cell group.

**Agreement**

The time-domain pattern for semi-static PUCCH cell switching is based on the reference SCS configuration provided by *tdd-UL-DL-ConfigurationCommon* and is common to every configured UL BWP (of PCell / SPCell / PUCCH SCell).

**Agreement**

For PUCCH cell switching based on semi-static operation, adopt Alt. 4, i.e., the UE does not expect a semi-static PUCCH cell configuration, where a single target PUCCH slot / sub-slot would be overlapping with more than one PCell slot/sub-slot.

**Agreement**

For semi-static PUCCH cell switching, if the alternative PUCCH cell (i.e. PUCCH sCell) is deactivated or the alternative PUCCH Cell is dormant, the UE does not apply time-domain pattern and the UCI is to be transmitted on PCell / SPCell / PUCCH SCell.

**Conclusion**

There is no consensus to support simultaneous configuration of semi-static PUCCH cell switching and dynamic PUCCH cell switching in Rel-17.

**Working Assumption**

For one-shot triggering of HARQ re-transmission, in addition to one-shot triggering of HARQ re-transmission after the initial PUCCH transmission slot, the triggering is supported before the initial PUCCH transmission slot

* Re-transmission triggering does not change processing for the initial PUCCH transmission (i.e., HARQ multiplexing / dropping / transmission)
* The UE expects the PUCCH carrying the HARQ-ACK re-transmission to be scheduled in a slot/sub-slot after the initial PUCCH transmission slot/sub-slot.
* The support for the triggering before the initial PUCCH transmission slot is subject to separate UE capability indication

**Agreement**

If more than one (M>1) enhanced Type 3 HARQ-ACK codebook is configured and the triggering DCI with the *‘one-shot HARQ-ACK request’* set to ‘1’,

* If the FDRA field is not valid, i.e. all “1s” or all “0s” as per Rel-16, then PDSCH is not scheduled:
  + If a new field with N=ceiling(log2 (M)**)** bits is configured in the triggering DCI, the UE uses this new field to indicate one of M configured e-Type 3 HARQ-ACK CBs
  + If the new field is not configured in the triggering DCI, the UE uses the MCS field to indicate one of M configured e-Type 3 HARQ-ACK CBs
* If the FDRA field is valid, then a PDSCH is scheduled
  + If a new field with N=ceiling(log2 (M)**)** bits is configured in the triggering DCI, the UE uses this new field to indicate one of M configured e-Type 3 HARQ-ACK CBs
  + If the new field is not configured in the triggering DCI, the UE selects the 1st indexed e-Type 3 HARQ-ACK CB in the M configured e-Type 3 HARQ-ACK CBs

**Agreement**

For one-shot HARQ-ACK re-transmission, the value range for HARQ re-tx offset is fixed in the specification

**Conclusion**

For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH PUCCH cell.

* The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the alternative PUCCH cell.

**RAN1#107bis-e (Jan. 2022)**

**Conclusion**

There is no consensus for introducing further specification support for the following

* PUCCH cell switching between cells with shared spectrum channel access (in any mode)
* PUCCH cell switching between a cell with licensed spectrum and a cell with shared spectrum channel access (in any mode)

**Agreement**

For one-shot HARQ-ACK re-transmission, the value range for HARQ re-tx offset is given by [*min\_HARQ\_retx\_offset\_value*, *max\_HARQ\_retx\_offset\_value*] with an indication of 1 slot / sub-slot within that range.

* FFS the fixed value of *min\_HARQ\_retx\_offset\_value*
* FFS the fixed value of *max\_HARQ\_retx\_offset\_value*

**Conclusion**

For one-shot HARQ re-transmission on PUCCH, the UE determines no PDSCH is scheduled when the triggering bit is set to ‘1’ (i.e. the UE does not need to in addition check any specific resource allocation setting).

**Agreement**

For PUCCH cell switching based on semi-static time domain pattern, the Type 1 HARQ-ACK codebook construction is based on the k1 set(s) of the PCell / SPCell / PUCCH SCell.

**Agreement**

Re-add the RRC parameter for the DCI field configuration in row 17 of the Enh. Type-3 HARQ-ACK codebook for the primary PUCCH cell group (that was lost when moving from v006 to v007 in the final RRC parameter discussions in RAN1#107-e, currently we only have the configuration for the secondary PUCCH cell group) i.e.,

|  |  |  |
| --- | --- | --- |
| pdsch-HARQ-ACK-enhType3DCIfield | Enables the enhanced Type 3 CB through a new DCI field to indicate the enhanced Type 3 HARQ-ACK codebook in the primary cell group if the more than one enhanced Type 3 HARQ-ACK codebook is configured for the primary PUCCH cell group. | Enabled |

**Agreement**

Support separate configuration of the DCI field presence for enh. Type 3 HARQ-ACK CB for DCI format 1\_2 (i.e. *pdsch-HARQ-ACK-enhType3DCIfieldDCI-1-2*as discussed in RAN1#107-e)

**Conclusion**

There is no consensus to support SPS HARQ-ACK deferral for half-duplex CA UEs in Rel-17.

**Agreement**

RAN1 confirms the following RAN1#107-e working assumption:

|  |
| --- |
| **Working Assumption**  For one-shot triggering of HARQ re-transmission, in addition to one-shot triggering of HARQ re-transmission after the initial PUCCH transmission slot, the triggering is supported before the initial PUCCH transmission slot   * Re-transmission triggering does not change processing for the initial PUCCH transmission (i.e., HARQ multiplexing / dropping / transmission) * The UE expects the PUCCH carrying the HARQ-ACK re-transmission to be scheduled in a slot/sub-slot after the initial PUCCH transmission slot/sub-slot. * The support for the triggering before the initial PUCCH transmission slot is subject to separate UE capability indication |

**Conclusion**

There is no consensus to support MAC CE activation indicating a set of values of *pucch-SpatialRelationInfoId* applicable to the alternative PUCCH sSCell for PUCCH cell switching in Rel-17.

**Conclusion**

There is no consensus to support joint operation of SPS HARQ-ACK deferral and PUCCH repetition in Rel-17.

**Conclusion**

The operation of simultaneous configuration of Rel-16 Type 3 HARQ-ACK codebook or enhanced Type 3 HARQ-ACK codebook triggering and SPS HARQ-ACK deferral is further clarified as:

* If the UE detects a DCI format in a PDCCH reception that triggers a PUCCH transmission with a Type-3 or enhanced Type-3 HARQ-ACK codebook in a slot, the UE stops the procedure to determine the earliest second slot in that slot.
* The pending SPS HARQ information for deferral is not appended to the Type-3 or enhanced Type 3 CB in that slot.

**Conclusion**

There is no consensus to support joint configuration of PUCCH cell switching based on dynamic indication and SPS HARQ-ACK deferral in Rel-17.

**Agreement**

For dynamic PUCCH cell switching, the Type 1 HARQ-ACK codebook construction is based on the k1 set(s) of the dynamically indicated PUCCH cell.

**Agreement**

The following TP to 38.213 is endorsed for the editor’s CR.

|  |
| --- |
| 9.2.5.4   UE procedure for deferring HARQ-ACK for SPS PDSCH  If a UE is provided *spsHARQdeferral* and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs in a first slot, the UE determines a PUCCH resource for a PUCCH transmission with first HARQ-ACK information bits for SPS PDSCH receptions that the UE would report for a first time, and the PUCCH resource   * is provided by *SPS-PUCCH-AN-List* as described in clause 9.2.1, or by *n1PUCCH-AN* if *SPS-PUCCH-AN-List* is not provided * overlaps with a symbol indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigDedicated*, or indicated for a SS/PBCH block by *ssb-PositionsInBurst*, or belonging to a CORESET associated with a Type0-PDCCH CSS set   the UE   * determines an earliest second slot and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs, a PUSCH or a PUCCH in the earliest second slot to multiplex HARQ-ACK information bits that include second HARQ-ACK information bits from the first HARQ-ACK information bits * if the UE detects a DCI format in a PDCCH reception that triggers a PUCCH transmission with a Type-3 HARQ-ACK codebook in a slot as described in clause 9.1.4, the UE stops the procedure to determine the earliest second slot **in the slot** * if the UE is provided a periodic cell switching pattern for PUCCH transmissions by *pucch-sSCellPattern*, the UE determines the earliest second slot and a corresponding cell based on the periodic cell switching pattern as described in clause 9.A |

**Agreement**

For one-shot HARQ-ACK re-transmission,

* the minimum value for the HARQ re-tx offset *min\_HARQ\_retx\_offset\_value* is -7.
* the maximum value for the HARQ re-tx offset *max\_HARQ\_retx\_offset\_value* is 24.
* *Note: UE capability reporting on the UE supported value range for HARQ\_retx\_offset* *in the scope of [min\_HARQ\_retx\_offset\_value, max\_HARQ\_retx\_offset\_value ]* *that can be indicated by the gNB for the UE can be further discussed in UE capabilities*

**Agreement**

For one-shot triggering of HARQ-ACK re-transmission, the *HARQ\_retx\_offset* is indicated by the bits of the MCS field for transport block 1.

**Agreement**

Support the simultaneous configuration of one-shot triggering of HARQ re-transmission and SPS deferral

* One-shot HARQ-ACK re-transmission can trigger re-transmission SPS HARQ-ACK enabled with deferring from the initial SPS HARQ deferral slot.
* If the PUCCH slot indicated by the *HARQ\_retx\_offset* is the ‘target’ or earliest ‘second’ slot for SPS HARQ-ACK deferral, the HARQ-ACK CB including the deferred SPS HARQ-ACK bits will be retransmitted in the new retransmission PUCCH triggered by one-shot triggering DCI.
* For the SPS HARQ-ACK deferral procedure, the PUCCH slot with a one-shot triggered HARQ-ACK CB is regarded as a valid potential target PUCCH slot for SPS HARQ-ACK deferral with same PHY priority (at least for operation with Rel-16 PHY prioritization) as the PHY priority of the triggered one-shot HARQ-ACK re-transmission.
  + - If the PUCCH slot with a one-shot triggered HARQ-ACK CB is determined by the UE as target or earliest second PUCCH slot for SPS HARQ-ACK deferral, the deferred SPS HARQ-ACK in a target slot is appended to the re-transmitted HARQ-ACK CB and initial, new HARQ-ACK (if any) following the operation of SPS HARQ-ACK deferral procedure.

**Conclusion**

There is no consensus on the support of HARQ-ACK CB size indication in the triggering DCI for HARQ-ACK re-transmission

**Conclusion**

There is no consensus to support the following in Rel-17:

* For one-shot HARQ re-transmission on PUCCH, if certain HARQ process IDs of the requested HARQ CB to be retransmitted is replaced by new HARQ bits, the UE transmits the new content of HARQ process(es) being updated.

**Agreement**

For PUCCH repetition and one-shot HARQ-ACK re-transmission, if the gNB triggers the HARQ-ACK CB re-transmission from a PUCCH slot indicated by *HARQ\_retx\_offset* where a HARQ-ACK in a first PUCCH is dropped due to overlapping with another, second PUCCH, where the first PUCCH and second PUCCH have the same L1 priority, and at least one of the first PUCCH and the second PUCCH is subject to a repetition, the UE re-transmits the HARQ-ACK CB of the second PUCCH from the slot.

# Appendix B: Summary of companies’ proposals

In here, the proposals and some example figures are collected for easier referencing.

### R1-2200959 UE feedback enhancements for HARQ-ACK Huawei, HiSilicon

***Proposal 1: The following joint operations can be straightforwardly supported with negligible spec impact:***

* ***Joint operation between dynamic PUCCH carrier switching and intra-UE multiplexing***
* ***Joint operation between semi-static PUCCH carrier switching and intra-UE multiplexing***
* ***Joint operation between PUCCH repetition and dynamic PUCCH carrier switching***
* ***Joint operation between PUCCH repetition and Type 3 CB / enhanced Type 3 CB***

***Proposal 2: Support simultaneous configuration of Rel-17 intra-UE multiplexing of different priorities and SPS HARQ-ACK deferral***

* ***The target slot/sub-slot for the LP SPS HARQ-ACK and HP SPS HARQ-ACK are separately determined based on separate LP/HP time units without considering the existence of the other priority, if they are both subject to deferral.***
* ***If after the inter-priority multiplexing operation, and if the UE would be transmitting the SPS HARQ-ACK of hybrid priorities on SPS PUCCH, and the SPS PUCCH is not valid in the initial/next PUCCH slot, both HP SPS HARQ-ACK and LP SPS HARQ-ACK are dropped without further deferral***

***Proposal 3: For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).***

* ***The UE does not expect to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI in a slot overlapping with a PCell / SPCell / PUCCH-SCell slot where SPS HARQ-ACK subject to another SPS config would be transmitted.***

***Proposal 4: For dynamic PUCCH cell switching, if the HARQ-ACK for the first SPS PDSCH is indicated on the PUCCH sSCell based on the activation DCI,***

* ***the UE determines for the first SPS PDSCH a k1 value from the PUCCH sSCell’s K1 set according to the K1 indicator field in the activation DCI***
* ***the UE determines for the other SPS PDSCHs without associated DCI a k1 value from PCell’s K1 set according to the K1 indicator field in the activation DCI***

***Proposal 5: RAN1 should adopt the following TP to capture the agreement on the not expected overlapping between dynamically indicated PUCCH slot on SCell and another UCI on PCell:***

|  |
| --- |
| **------------------ Text Proposal for 38.213 Clause 9.A ------------------**  9.A PUCCH Cell Switching  This clause is applicable when a UE is provided a PUCCH-sSCell by *pucch-sSCell* and the PUCCH-sSCell is activated and does not have a dormant UL/DL active BWP.  …  If a UE is provided *pucch-sSCellDyn* or *pucch-sSCellDynDCI-1-2*, a corresponding DCI format associated with generation of HARQ-ACK information by the UE can include a PUCCH cell indicator field, as described in [5, TS 38.212], that indicates whether the PUCCH transmission with the HARQ-ACK information by the UE is on the Pcell or on the PUCCH-sSCell.  The UE does not expect to be indicated by a DCI with the PUCCH cell indicator field to transmit HARQ-ACK information on a slot for the active UL BWP of the PUCCH-sSCell to overlap with a slot including another UCI on the active UL BWP of the PCell, unless the UCI on the active UL BWP of the PCell overlaps with a symbol indicated as downlink by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigDedicated, or indicated for a SS/PBCH block by ssb-PositionsInBurst, or belonging to a CORESET associated with a Type0-PDCCH CSS set, and is cancelled according to clause 11.1.  … |

***Proposal 6: For semi-static PUCCH cell switching, all PUCCH repetitions should be transmitted on the PUCCH cell of the first PUCCH repetition.***

* ***A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions, i.e., the repetition is postponed as in Rel-16.***

***Proposal 7:* *For PUCCH cell switching based on semi-static operation, for the case the PCell slot/sub-slot to be longer than the target SCell sub-slot and the earliest sub-slot of the target SCell is partially overlapping with the PCell slot/sub-slot, the first sub-slot of the target SCell fully overlapping with the PCell slot/sub-slot is used for UCI transmission.***

***Proposal 8: Support simultaneous configuration of intra-UE multiplexing and Type 3 CB/enhanced Type 3 CB.***

* ***The UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB with the same priority index as the enhanced Type 3 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB.***
* ***UE does not expect the overlapping between LP HARQ-ACK subject to Type 3 CB/enhanced Type 3 CB and HP HARQ-ACK.***

***Proposal 9: Support simultaneous configuration between intra-UE multiplexing and one-shot HARQ-ACK retransmission.***

* ***UE does not expect the overlapping between LP HARQ-ACK subject to one-shot retransmission and HP HARQ-ACK.***

### R1-2201002 HARQ-ACK Enhancements for IIoT/URLLC Ericsson

[Observation 1 When dynamic or semi-static PUCCH cell switching is enabled for a PUCCH group, at any given time the PUCCH resources would be allocated to a same cell (either PCell /PsCell / PUCCH SCell or PUCCH sScell).](#_Toc94824672)

[Observation 2 Once a target cell is determined based on a dynamic indication or time-domain pattern due to dynamic or semi-static PUCCH cell switching, respectively, the intra-UE multiplexing procedures can be applied to resolve collision in case of overlapping PUCCH resources on the target cell.](#_Toc94824673)

[Observation 3 Some limitations on PUCCH resource configurations and/or indication are needed to support PUCCH repetition on target PUCCH cells determined individually for each PUCCH repetition.](#_Toc94824674)

Based on the discussion in the previous sections we propose the following:

[Proposal 1 If after the Rel-17 multiplexing operation into a PUCCH or PUSCH if any, and if the UE would be transmitting SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN which is not valid, the SPS HARQ-ACK configured for deferral is deferred.](#_Toc94824675)

[Proposal 2 SPS HARQ-ACK of different PHY priorities can be separately deferred with the target PUCCHs separately determined according to their respective PHY priorities. Then depending on where the target slot(s) is/are located, Rel-17 intra UE multiplexing can be applied when applicable.](#_Toc94824676)

[Proposal 3 Joint configuration of dynamic/semi-static PUCCH cell switching and Rel-16/Rel-17 intra-UE multiplexing is supported.](#_Toc94824677)

[Proposal 4 For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported. A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions / the repetition is postponed as in Rel-16.](#_Toc94824678)

### R1-2201017 HARQ-ACK Feedback Enhancements for URLLC/IIoT Nokia, Nokia Shanghai Bell

On the **remaining issues of PUCCH cell switching** in Sec. 2, we have the following proposals:

* **Proposal 2.1:** **For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported** 
  + ***A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions***
* **Proposal 2.2: For dynamic PUCCH cell switching, the HARQ-ACK feedback for all SPS PDSCH(s), including the first SPS PDSCH after activation, are sent on PCell/ PSCell/PUCCH SCell.**

On the **interaction of Rel-17 Intra-UE multiplexing and Rel-17 HARQ-ACK enhancements** in Sec. 3, we have the following observations and proposals:

**On SPS deferral**

* ***Observation 3.1.1: If joint operation of Rel-17 Intra-UE multiplexing and SPS deferral is supported, performing the decision on the valid target slot / earliest second slot for SPS deferral after the full Rel-17 Intra-UE multiplexing procedure (i.e. after step 2) requires recursive operation of step 1 and step 2 of the Rel-17 Intra-UE multiplexing framework.***
* ***Observation 3.1.2:*** ***If joint operation of Rel-17 Intra-UE multiplexing and SPS deferral is supported, performing the decision on the valid target slot / earliest second slot for SPS deferral after the full Rel-17 Intra-UE multiplexing procedure (i.e. after step 2), may require more than 4 hypotheses on deferred SPS HARQ-ACK presence in step 2 which increases UE (& gNB implementation) complexity.***
* ***Observation 3.1.3: If joint operation of Rel-17 Intra-UE multiplexing and SPS deferral is supported, performing the decision on the valid target slot / earliest second slot for SPS deferral after the full Rel-17 Intra-UE multiplexing procedure (i.e. after step 2), an order of the LP & HP SPS HARQ-ACK deferral procedure for the earliest second slot determination would need to be defined (e.g. HP SPS HARQ-ACK considered first, followed by LP SPS HARQ-ACK).***
* ***Observation 3.1.4: If joint operation of Rel-17 Intra-UE multiplexing and SPS deferral is supported, performing the decision on the valid target slot / earliest second slot for SPS deferral already after step 1 of the Rel-17 Intra-UE multiplexing procedure would simplify UE & gNB implementation, avoids recursive processing of step 1 and step 2 hypothesis and allows to reuse the same implementation for the earliest second slot determination for Rel-16 PHY prioritization and Rel-17 Intra-UE multiplexing.***
* **Proposal 3.1.1: If joint operation of Rel-17 Intra-UE multiplexing and SPS deferral is supported in Rel-17, the determination of the valid target slot / earliest second slot for SPS deferral should be performed already after step 1 of the Rel-17 Intra-UE multiplexing procedure.**
* ***Observation 3.1.5: If joint operation of Rel-17 Intra-UE multiplexing and SPS deferral is supported, performing the decision on the SPS deferral in the initial slot already after step 1 of the Rel-17 Intra-UE multiplexing procedure could lead to SPS HARQ-ACK deferral even though the SPS HARQ is transmitted in the initial slot (after step 2 multiplexing).***
* **Proposal 3.1.2: If joint operation of Rel-17 Intra-UE multiplexing and SPS deferral is supported in Rel-17, the decision on SPS HARQ-ACK deferral in the initial SPS HARQ-ACK slot should be performed after step 2 of the Rel-17 Intra-UE multiplexing procedure (i.e. after the full Rel-17 Intra-UE multiplexing procedure).**
  + **If after the Rel-17 UCI multiplexing operation (including step 1 and step 2) into a PUCCH or PUSCH if any, and if the UE would be transmitting LP SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the first or second PUCCH configuration which is not valid, the LP SPS HARQ-ACK configured for deferral is deferred.**
  + **If after the Rel-17 UCI multiplexing operation (including step 1 and step 2) into a PUCCH or PUSCH if any, and if the UE would be transmitting HP SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN from the second PUCCH configuration which is not valid, the HP SPS HARQ-ACK configured for deferral is deferred.**
  + **LP SPS HARQ-ACK in step 2 that cannot be mapped to a HP PUCCH or HP PUSCH based on the Rel-17 Intra-UE multiplexing framework and is therefore dropped in step 2.1 or step 2.2, is not subject to deferral.**

**On One-shot HARQ-ACK re-tx**

* ***Observation 3.2: Joint operation of R17 Intra-UE multiplexing and One-shot HARQ re-transmission could be operated using the One-shot HARQ re-transmission framework by enabling independent triggering of LP HARQ CB re-transmission and HP HARQ CB re-transmission without any large changes by assuming the agreed restrictions are applicable per PHY priority.***
* **Proposal 3.2: Support joint operation of R17 Intra-UE multiplexing and One-shot HARQ re-transmission based on the following operation:** 
  + **A single DCI triggering the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB can trigger the re-transmission of HARQ-ACK information of only a single HARQ-ACK CB of a single PHY priority.**
  + **The UE does not expect more than one triggering DCI for Rel-17 one-shot feedback indicating the same PUCCH slot of a certain PHY priority in step 1 for the re-transmission of HARQ-ACK CBs of different PUCCH slots to be re-transmitted.** 
    - ***Note: In step 2, there could be still multiplexing of LP and HP HARQ-ACK CBs to be retransmitted on PUCCH or PUSCH.***
  + **The ‘backward HARQ-ACK slot-offset’ is interpreted with the granularity of a PUCCH slot of the respective PHY priority of step 1 of PCell /PSCell / PUCCH SCell**

**On enhanced Type 3 CB:**

* **Proposal 3.3: Support simultaneous configuration of enhanced Type 3 CB triggering and Rel-17 Intra-UE multiplexing (i.e. *UCI-MuxWithDifferentPriority*)**
  + **The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size.**
  + **The A/N of HARQ processes is mapped to the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size irrespective of the PHY priority of the ‘A/N’ of the HARQ processes.**
  + **The enhanced Type 3 HARQ-ACK has the same structure, size and content (in terms of HARQ-IDs, CCs) irrespective of the PHY priority.**
  + **The UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook in neither step 1 nor step 2 of the Rel-17 Intra-UE multiplexing framework.**

**On PUCCH cell switching:**

* **Proposal 3.4.1: Support joint operation of semi-static PUCCH cell switching and Rel-17 Intra-UE prioritization.**
  + **The Rel-17 Intra-UE multiplexing operation including step 1 and step 2 are performed on the applicable target PUCCH cell.**
* **Proposal 3.4.2: Joint operation of dynamic PUCCH carrier switching and Intra-UE Multiplexing is not supported in Rel-17.**

In Sec. 4 presents the following **two TPS on joint operation of SPS deferral and one-shot HARQ-ACK re-transmission** on top of the draft 38.213 editor CR:

|  |
| --- |
| 9.1.5 HARQ-ACK codebook retransmission ….  If in slot the UE performs a procedure for deferring first HARQ-ACK information for SPS PDSCH receptions, as described in clause 9.2.5.4, and the first HARQ-ACK information has same priority value as a priority value indicated by the DCI format triggering the PUCCH transmission in slot , the UE multiplexes in the PUCCH transmission in slot second HARQ-ACK information with the priority value that results in slot according to the procedure in this clause. If the UE would also multiplex in the PUCCH transmission in slot third HARQ-ACK information with the priority value, the UE appends the second HARQ-ACK information to the third HARQ-ACK information before multiplexing the first HARQ-ACK information into the PUCCH transmission as described in clause 9.2.5.4. The UE determines to multiplex the third HARQ-ACK information in the PUCCH transmission in slot as described in clause 9.2.3. |

|  |
| --- |
| 9.2.5.4 UE procedure for deferring HARQ-ACK for SPS PDSCH …  - the second HARQ-ACK information bits, generated as described in clause 9.1.2, are appended in a HARQ-ACK codebook the UE generates as described in clauses 9.1.2, 9.1.2.1, ~~or~~ 9.1.3.1 or 9.1.5  - if the UE would receive a PDSCH providing a TB for a same HARQ process as a HARQ-ACK information bit from the second HARQ-ACK information bits prior to transmitting the PUCCH or the PUSCH, the UE does not include the HARQ-ACK information bit in the HARQ-ACK information bits. |

### R1-2201021 Remaining issues for HARQ-ACK feedback enhancements New H3C Technologies Co., Ltd.

**Proposal 1: For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported**

* **A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions / the repetition is postponed as in Rel-16. Example figure for 4 repetitions:**

**Proposal 2: For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).**

* **The UE does not expected to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI in a slot overlapping with a PCell / SPCell / PUCCH-SCell slot with UCI.**

### R1-2201090 Remaining issues on HARQ-ACK enhancements for Rel-17 URLLC vivo

*Observation 1: Interaction between enhanced Type-3 codebook and PUCCH repetition can be supported naturally without any clarification.*

***Proposal 1:*** ***Consider the text proposal for enhanced Type-3 codebook determination in TS38.213.***

***Proposal 2:*** ***Clarify the following as a conclusion:***

* ***When a UE receives a one-shot triggering DCI for HARQ-ACK re-transmission, and did not generate an HARQ-ACK codebook with the indicated PHY priority for corresponding PUCCH transmission in the original PUCCH slot, the UE ignores the triggering DCI, without determining corresponding PUCCH transmission in the PUCCH slot designated for HARQ-ACK re-transmission.***

***Proposal 3:*** ***For dynamic PUCCH cell switching, SPS HARQ-ACK is always transmitted on the PCell/PSCell/PUCCH-SCell, and HARQ-ACK corresponding to the PDSCH scheduled by an SPS activation DCI is reported on the target PUCCH cell indicated by the SPS activation DCI.***

* ***The UE does not expect to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI in a PUCCH slot overlapping with a PUCCH slot on the PCell/PSCell/PUCCH-SCell where SPS HARQ-ACK corresponding to another SPS Config, as well as other UCI, if any, would be transmitted.***

***Proposal 4:*** ***For dynamic PUCCH cell switching, when HARQ-ACK corresponding to the PDSCH scheduled by an SPS activation DCI is indicated to be reported on the PUCCH sSCell, the K1 value for SPS PDSCH(s) corresponding to the SPS activation DCI is determined based on the K1 indicator field in the SPS activation DCI, as well as the K1 set for the PCell/PSCell/PUCCH-SCell.***

***Proposal 5:*** ***For dynamic PUCCH cell switching, further clarify that SR resource configuration(s) and/or CSI report configuration(s) cannot be configured in the PUCCH Config(s) for the PUCCH sSCell.***

***Proposal 6: For semi-static PUCCH cell switching in conjunction with PUCCH repetition, a PUCCH repetition mapping to a different target PUCCH cell from the target PUCCH cell of the first PUCCH repetition is not supported.***

***Proposal 7: For semi-static PUCCH cell switching, where there are potentially two PUCCH cells providing SPS HARQ-ACK PUCCH resources for an SPS Config, how to understand or extend SPS-Config->n1PUCCH-AN should be determined, and the following two alternatives can be considered:***

* ***Alt. 1: SPS-Config->n1PUCCH-AN corresponds to a configured PUCCH resource on the PCell/PSCell/PUCCH-SCell, as well as a configured PUCCH resource on the PUCCH sSCell, where the two configured PUCCH resources have the same resource ID.***
* ***Alt. 2: SPS-Config->n1PUCCH-AN can be extended so that two resource IDs can be configured independently for the PCell/PSCell/PUCCH-SCell and the PUCCH sSCell, respectively.***

***Proposal 8: For semi-static PUCCH cell switching, when an SR configuration is triggered, PUCCH resource(s) of the associated SR resource configuration(s) on corresponding PUCCH cell(s) will be validated based on the time domain pattern.***

***Proposal 9: For semi-static PUCCH cell switching, when CSI reporting on PUCCH is configured on both the PCell/PSCell/PUCCH-SCell and the PUCCH sSCell, corresponding CSI PUCCH resource(s) on a PUCCH cell will be validated based on the time domain pattern.***

***Proposal 10: Support*** ***simultaneous configuration of Rel-17 intra-UE multiplexing of different PHY priorities and SPS HARQ-ACK deferral.***

***Proposal 11: Support*** ***simultaneous configuration of Rel-17 intra-UE multiplexing of different PHY priorities and enhanced Type-3 codebook.***

***Proposal 12: Support*** ***simultaneous configuration of Rel-17 intra-UE multiplexing of different PHY priorities and one-shot triggering.***

***Proposal 13: Support*** ***simultaneous configuration of Rel-17 intra-UE multiplexing of different PHY priorities and dynamic PUCCH cell switching.***

***Proposal 14: Support*** ***simultaneous configuration of Rel-17 intra-UE multiplexing of different PHY priorities and semi-static PUCCH cell switching.***

*Observation 2: Each feature of HARQ-ACK enhancements can be configured jointly with Rel-17 simultaneous PUCCH/PUSCH transmission without additional complexity.*

### R1-2201161 Discussion on HARQ-ACK enhancements for eURLLC ZTE

***Proposal 1:*** *For SPS HARQ-ACK deferral, RAN1 should clarify the UE behavior in the initial slot and the target slot where there is only one SPS HARQ-ACK* *provided and no other UCIs and PUSCH (i.e., no UCI multiplexing being performed).*

***Proposal 2:*** *Adopt the TP as below:*

|  |
| --- |
| TS38.213h00  9.2.5.4 UE procedure for deferring HARQ-ACK for SPS PDSCH  If a UE is provided *spsHARQdeferral* and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs in a first slot if any, the UE determines a PUCCH resource for a PUCCH transmission with first HARQ-ACK information bits for SPS PDSCH receptions that the UE would report for a first time, and the PUCCH resource  - is provided by *SPS-PUCCH-AN-List* as described in clause 9.2.1, or by *n1PUCCH-AN* if *SPS-PUCCH-AN-List* is not provided  - overlaps with a symbol indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigDedicated*, or indicated for a SS/PBCH block by *ssb-PositionsInBurst*, or belonging to a CORESET associated with a Type0-PDCCH CSS set  the UE  - determines an earliest second slot and, after performing the procedures in clauses 9 and 9.2.5 to resolve overlapping among PUCCHs and PUSCHs if any, a PUSCH or a PUCCH in the earliest second slot to ~~multiplex~~transmit HARQ-ACK information bits that include second HARQ-ACK information bits from the first HARQ-ACK information bits  ... |

***Proposal 3:*** *If the UE needs to generate a Type1 codebook in slot n, and the target slot of the delayed SPS HARQ-ACK is also slot n*, *then the following rules are proposed:*

* *If the slot with SPS PDSCH is contained in the slots corresponding to a Type 1 codebook for the DG PDSCHs, then UE only generates the Type 1 codebook.* 
  + *Note the Type 1 codebook can naturally include the deferred SPS HARQ-ACK of the SPS PDSCH and HARQ-ACKs of the DG PDSCHs according to the current Type 1 codebook mechanism.*
* *Otherwise, the UE generates the Type 1 codebook according to the current Type 1 codebook mechanism and concatenates the deferred SPS HARQ-ACK after the Type 1 codebook for DG PDSCHs.*

***Proposal 4:*** *Support simultaneous configuration of Rel-17 intra-UE multiplexing of different priorities and SPS HARQ-ACK deferral.*

* *If after the Rel-17 multiplexing operation into a PUCCH or PUSCH if any, and if the UE would be transmitting SPS HARQ-ACK using the PUCCH provided by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN of any priority,* 
  + *which is not valid in the initial slot, the SPS HARQ-ACK configured for deferral is deferred.*
* *SPS HARQ-ACK deferral of a given priority, the target PUCCH slot is defined as the next PUCCH slot, where after performing the (Rel-17) UCI multiplexing operation into a PUCCH or PUSCH if any, the UE would be either (i) transmitting HARQ-ACK using a PUCCH corresponding to high priority UCI or PUSCH other than the PUCCH determined from SPS-PUCCH-AN-List-r16 or n1PUCCH-AN or (ii) transmitting HARQ-ACK using a PUCCH resource configured in SPS-PUCCH-AN-List-r16 or n1PUCCH-AN of any priority being regarded as valid.*

***Proposal 5:*** *Support simultaneous configuration of semi-static PUCCH cell switching and SPS HARQ-ACK deferral.*

* *For the initial slot in PCell, if the UE performs UCI multiplexing to determine whether the SPS HARQ-ACK is deferred, it should consider multiplexing the SPS HARQ-ACK to the overlapping PUCCH slot of the Scell based on the PUCCH cell switching pattern.* 
  + *If the multiplexed PUCCH is valid in Scell slot, the SPS HARQ-ACK is transmitted in the multiplexed PUCCH slot; otherwise, the SPS HARQ-ACK is deferred.*

***Proposal 6:*** *Support the simultaneous configuration of semi-static PUCCH cell switching and PUCCH repetition transmission at least for the case where the slots of PCell/SPCell/PUCCH SCell and PUCCH sScell are of equal length.*

* *For a PUCCH that is repeatedly transmitted, PUCCH cells and PUCCH slots corresponding to PUCCH repetitions other than the first PUCCH repetition are determined based on the semi-static PUCCH cell switching pattern.*
  + *PUCCH resources corresponding to PUCCH repetitions other than the first PUCCH repetition are determined from the determined PUCCH cell based on the PRI in the (activated) DCI corresponding to the PUCCH.*
  + *UE expects that PUCCH resources from PCell/SPCell/PUCCH SCell and PUCCH sScell have the same number of symbols for different PUCCH repetitions.*

***Proposal 7:*** *The Type 1 HARQ-ACK codebook construction for PUCCH cell switching is based on the k1 set(s)*

* *of the PCell / SPCell / PUCCH Scell for semi-static PUCCH cell switching*
* *If the determined PUCCH cell for transmitting the Type 1 codebook is PCell, the determined PUCCH slot is regarded as "slot n", and then UE completes the Type 1 codebook construction based on "slot n" by reusing the current Type 1 codebook construction mechanism.*
* *Otherwise, the slot of the PCell that overlaps the determined PUCCH slot is regarded as "slot n", then UE completes the Type 1 codebook construction based on "slot n" by reusing the current Type 1 codebook construction mechanism.*
* *of the dynamically indicated PUCCH cell for dynamic PUCCH cell switching*
* *If the indicated PUCCH cell for transmitting Type 1 codebook is PCell, then UE completes the Type 1 codebook construction based on indicated PUCCH slot by reusing the current Type 1 codebook construction mechanism.*
* *Otherwise, the indicated PUCCH cell is regarded as "Nominal PCell", the PCell is regarded as "Nominal Scell", and the indicated PUCCH slot is regarded as "Nominal slot n", then UE completes the Type 1 codebook construction based on "Nominal slot n" by reusing the current Type 1 codebook construction mechanism between the "Nominal PCell" and the "Nominal Scell".*

### R1-2201295 HARQ-ACK enhancements for Rel-17 URLLC/IIoT OPPO

***Proposal 1: If SPS HARQ-ACK corresponding to a SPS PDSCH with a certain HARQ process number is deferred to a target PUCCH/PUSCH, and a later PDSCH with the same HARQ process number is received prior to the target PUCCH/PUSCH,***

* + ***If the later PDSCH and the target PUCCH/PUSCH satisfy Rel-15 multiplexing timeline, the deferred SPS HARQ-ACK is dropped;***
  + ***Otherwise, the deferred SPS HARQ-ACK is transmitted in the target PUCCH/PUSCH.***

***Proposal 2: If an eType 3 HARQ-ACK CB is triggered in a given subslot, the HARQ-ACK information in a Type 1/2 HARQ-ACK CB to be transmitted in a slot/subslot overlapping with the given subslot should be mapped to the eType 3 HARQ-ACK CB.***

### R1-2201356 UE feedback enhancements for HARQ-ACK CATT

***Observation 1: It is straightforward to support simultaneous configuration of Rel-17 intra-UE multiplexing and enhanced Type 3 CB without any impact.***

***Observation 2: It is straightforward to support simultaneous configuration of Rel-17 intra-UE multiplexing and semi-static PUCCH cell switching without any impact.***

***Proposal 1: For semi-static PUCCH carrier switching, UE applies PUCCH cell switching pattern based on the following time point:***

* ***If UE receives in a PDSCH an activation command for the SCell ending in slot n, UE applies the PUCCH cell switching time-domain pattern from the first slot after SCell is active, where the active timing is determined based on the minimum requirement defined in [10, TS 38.133].***
* ***If UE receives in a PDSCH a deactivation command for the SCell ending in slot n, the UE would not apply the PUCCH cell switching time-domain pattern from slot n, where slot is defined in section 4.3 of TS38.213.***
* ***If the sCellDeactivationTimer associated with the SCell expires in slot n, the UE would not apply the PUCCH cell switching time-domain pattern from the first slot that is after slot  where  is the SCS configuration for PDSCH reception on the secondary cell.***
* ***If UE detects a DCI indicating SCell dormancy, the UE would not apply the PUCCH cell switching time-domain pattern from the first slot after slot , where slot is the slot indicated for PUCCH transmission with HARQ-ACK information corresponding to the DCI and is the SCS configuration for the PUCCH.***

***Proposal 2: Semi-static PUCCH cell switching should be performed before UCI multiplexing/prioritization.***

***Proposal 3: For simultaneous configuration of PUCCH cell switching and PUCCH repetition, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported, and a PUCCH slot mapped to a different PUCCH cell is considered as invalid for PUCCH repetition and the PUCCH repetition is deferred.***

***Proposal 4: For joint operation of dynamic PUCCH cell switching and SPS HARQ-ACK, either one of the following proposals can be agreed.***

|  |
| --- |
| Mod Proposal 5: For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).   * The UE does not expected to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI.   Alternative Proposal 5 (from HW): For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).   * The UE does not expected to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI in a slot overlapping with a PUCCH slot with UCI on PCell / SPCell / PUCCH-SCell ~~slot where SPS HARQ-ACK subject to another SPS config would be transmitted.~~   + The UCI on PCell /SPCell / PUCCH SCell dropped due to collision with semi-static DL symbols, SSB, and symbols indicated by pdcch-ConfigSIB1 in MIB for a CORESET for Type0-PDCCH CSS set is exempted and is not multiplexed on the PUCCH on the PUCCH sScell. |

***Proposal 5: For simultaneous configuration of Rel-17 intra-UE multiplexing and SPS HARQ-ACK deferral, a target PUCCH slot for SPS HARQ-ACK deferral is determined after performing the Rel-17 intra-UE multiplexing operation. In addition, SPS HARQ-ACK of different PHY priorities are separately deferred with target PUCCH slots separately determined according to their respective PHY priorities.***

***Proposal 6: For simultaneous configuration of Rel-17 intra-UE multiplexing and one-shot HARQ-ACK retransmission, for a PUCCH carrying HARQ-ACK with different priorities, only HARQ-ACK with same priority as the triggering DCI indication can be triggered for one-shot HARQ-ACK re-transmission.***

***Proposal 7: For simultaneous configuration of Rel-17 intra-UE multiplexing and dynamic PUCCH cell switching, LP HARQ-ACK would not be multiplexed with HP UCI if they are on different PUCCH cells.***

### R1-2201475 Discussion on HARQ-ACK feedback enhancements for Rel.17 URLLC NTT DOCOMO, INC.

**Proposal 1: Keep the same sub-slot/slot configuration for corresponding priority on the multiple PUCCH cells.**

**Proposal 2: When CSI reporting on PUCCH is configured on both PCell/PScell/PUCCH-Scell and alternate Scell, PUCCH cell pattern is applied to determine whether CSI PUCCH will be transmitted or not.**

**Proposal 3: Support HARQ-ACK of SPS PDSCH without associated DCI (including the first SPS PDSCH activated by Activation DCI) to be transmitted on PCell / SPCell / PUCCH-SCell.**

**Proposal 4: For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported. A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and the PUCCH repetition is dropped (i.e. total number of repetitions not guaranteed).**

### R1-2201544 Discussion on HARQ-ACK feedback enhancements for Rel-17 URLLC Spreadtrum Communications

In this contribution, we made the following proposals.

1. ***If the UE is configured with Rel-17 Intra-UE multiplexing, SPS HARQ for deferral of different PHY priorities can be separately deferred with the target PUCCHs separately be determinated according to their respective PHY priorities.***
2. ***If a LP SPS HARQ-ACK PUCCH is dropped according to Rel-17 intra-UE multiplexing, the LP SPS HARQ-ACK is not deferred.***
3. ***Support Mod Proposal 11:***

***For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported***

***A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions / the repetition is post-poned as in Rel-16.***

1. **Support Alt 1 in Mod proposal 5.**

***Mod Proposal 5: For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).***

* ***Alt. 1 (proposed by ZTE, Nokia online):*** 
  + ***The UE does not expected to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI.***

### R1-2201579 Remaining issues on HARQ-ACK enhancements for URLLC Sony

**Observation 1: When Rel-17 intra-UE UCI multiplexing is enabled, if the deferred SPS HARQ-ACKs contain HP HARQ-ACKs, a first available PUCCH that is LP may not provide the required reliability for the HP HARQ-ACKs. However, avoiding the first available LP PUCCH leads to increase in latency.**

**Proposal 1: Support joint operations of SPS HARQ-ACK deferral and Rel-17 intra-UE UCI multiplexing of different L1 priorities.**

**Proposal 2: When Rel-17 intra-UE UCI multiplexing is enabled and if the deferred SPS HARQ-ACKs contain HP HARQ-ACKs, the resource for the target PUCCH is selected from the 2nd PUCCH Config, regardless of the L1 priority of the originally scheduled target PUCCH.**

### R1-2201599 UE feedback enhancements for HARQ-ACK CAICT

***Proposal 1: For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).***

* ***The UE does not expected to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI in a slot overlapping with a PCell / SPCell / PUCCH-SCell slot where SPS HARQ-ACK subject to another SPS config would be transmitted.***

***Proposal 2: When dynamic PUCCH cell switching is configured, if the DCI is for SPS PDSCH activation, the PDSCH-to-HARQ\_feedback timing indicator field value maps to the Pcell’s K1 set.***

***Proposal 3: For semi-static PUCCH cell switching, a PUCCH repetition transmission on a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported.***

* ***A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions / the repetition is post-poned as in Rel.16.***

### R1-2201608 Discussion on remaining issues on PUCCH carrier switching Panasonic

**Proposal 1: For dynamic PUCCH cell switching, the HARQ-ACK of SPS activation is transmitted on the indicated Cell, while the HARQ-ACK for SPS without a DCI is carried on PCell / PSCell.**

**Proposal 2: The carrier switching should be supported over a PUCCH repetition bundle in order to reduce the latency. The required number of repetition is derived according to the defined number of repetition associated to the cell initiating the PUCCH repetitions. For the other cell, the effective PUCCH transmission is counted towards the required number of repetitions.**

**Proposal 3: If the carrier switching is not supported over the PUCCH repetition bundle, a PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions.**

### R1-2201611 UE feedback enhancements for HARQ-ACK ETRI

Regarding HARQ-ACK deferral,

**Proposal 1: It is allowed to multiplex deferred SPS HARQ-ACK bits onto a HARQ codebook from any usage scenario.**

Regarding HARQ-ACK retransmissions,

**Proposal 2: Support multiplexing HARQ codebooks where one HARQ codebook is retransmitted.**

**Proposal 3: The maximum number for keeping HARQ codebooks can be configured.**

Regarding PUCCH carrier switching,

**Proposal 4: Either dormant BWP is allowed to configure or is prohibited to configure to the PUCCH-sSCell.**

### R1-2201693 Open issues on UE HARQ feedback enhancements Intel Corporation

**Proposal 1**

* *The UE ignores the one-shot triggering DCI for new PUCCH determination if it schedules a re-transmission of HARQ-ACK information from a PUCCH slot/sub-slot on which the UE did not generate a valid HARQ-ACK CB*

**Proposal 2**

* *For PUCCH carrier switching based on dynamic indication and/or semi-static pattern,*
  + *When the indicated PUCCH resource is associated with > 1 repetitions, the cell for PUCCH repetitions transmission is fixed to the same cell as the initial PUCCH repetition*
  + *Alt. 1:*
    - *A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and the PUCCH repetition is dropped*
  + *Alt.2:*
    - *A UE does not expect the cell switching pattern to indicate a different cell for a PUCCH repetition comparing to the initial PUCCH repetition*

**Proposal 3**

* *For PUCCH carrier switching based on dynamic indication and/or semi-static pattern, a UE does not expect the size/presence of ‘ChannelAccess-CPext’ DCI field to vary across PCell / SPCell / PUCCH SCell and sSCell*

**Proposal 4**

* *For PUCCH carrier switching based on dynamic indication and/or semi-static pattern,*
  + *Apply the same handling for ‘Second TPC command for scheduled PUCCH’* *field size determination and zero-bit padding as for PRI and PDSCH-to-HARQ\_feedback*

**Proposal 5**

* *For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI uses the PUCCH cell based on the indication in the activation DCI* 
  + *Alt. 1 The UE does not expect to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI in a slot overlapping with a PCell / SPCell / PUCCH-SCell slot where SPS HARQ-ACK subject to another SPS config would be transmitted.*
  + *Alt.2 The UE does not expect to be dynamically indicated for PUCCH transmission on the PUCCH sSCell in the SPS activation DCI*

**Proposal 6**

* *For the case when R17 intra-UE multiplexing is configured together with SPS HARQ-ACK deferral, the deferral is checked after resolving overlapped UL channels between different priorities (i.e., deferral is determined after step 2, if any).*
  + *If the resultant UL channel is a PUCCH resource for SPS PUCCH for priority i, then, defer the SPS HARQ-ACK for priority i*

**Proposal 7**

* *For the conclusion that “For dynamic PUCCH cell switching, the UE does not expect a PUCCH slot with UCI on PCell /SPCell / PUCCH SCell to overlap with a PUCCH slot with HARQ-ACK on the dynamically indicated alternative PUCCH cell”,*
  + *Clarify that the valid PUCCH resource on Pcell means PUCCH resources before multiplexing on Pcell*
  + *Clarify that for different priority UCI, any PUCCH resource before multiplexing/prioritization is considered*

**Proposal 8**

* *For phy prioritization between LP/HP PUCCH carrying (e)Type3 CB and HP/LP PUCCH carrying HARQ-ACK using Release 16 dropping*
  + *UE may expect eType3 CB to not contain a HARQ process for a bit overlapping with the same PUCCH resource as the eType3 CB*
  + *LP PUCCH is dropped according to Release 16 procedures*
* *For phy prioritization between LP/HP PUCCH carrying (e)Type3 CB and HP/LP PUCCH carrying HARQ-ACK using Release 17 multiplexing, follow the agreed behavior*

**Proposal 9**

* *For one-shot triggering of a PUCCH which is a mix of LP and HP HARQ-ACK according to R17 multiplexing, the one-shot trigger only instructs to retransmit HARQ-ACK of priority j which is indicated in the triggering DCI*

### R1-2201769 Remaining issues in UE feedback enhancements for HARQ-ACK Apple

**Observation 1: joint operation of intra-UE MUX and SPS HARQ deferral can be supported.**

**Observation 2: joint operation of intra-UE MUX and one-shot HARQ retransmission can be supported.**

**Proposal 1: When UCI part 1 or UCI part 2’s capacity is exceeded, part of the HARQ-ACK feedback (initial HARQ bits / Type 1 or Type 2 codebook/deferred SPS HARQ-ACK) can be dropped.**

**Proposal 2: When UCI part 1 or UCI part 2’s capacity is exceeded, part of the HARQ-ACK feedback (initial HARQ codebook/retransmitted HARQ codebook) can be dropped.**

### R1-2201903 UE feedback enhancements for HARQ-ACK NEC

**Proposal 1:**

* *For joint operation of semi-static PUCCH cell switching and PUCCH repetition, Alt.2A is preferred.*
  + *A PUCCH slot mapped to different PUCCH cell is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions / the repetition is postponed as in Rel-16.*

**Proposal 2:**

* *For joint operation of semi-static PUCCH cell switching and PUCCH repetition, if Alt.1 that PUCCH cell switching within the repetition bundle is supported,* 
  + *UE determines the PUCCH resource for repetition on each target cell based on the same PUCCH resource indicator value from the different PUCCH resource sets of the corresponding PUCCH cells.*

**Proposal 3:**

* *For joint operation of semi-static PUCCH cell switching and PUCCH repetition, if Alt.1 that PUCCH cell switching within the repetition bundle is supported,* 
  + *In case of more than one overlapping PUCCH slot on the PUCCH SCell with a single PUCCH slot on PCell, PUCCH repetitions are mapped to each of the overlapping PUCCH slot on the PUCCH sSCell.*

**Proposal 4:**

* *When UE is configured with PUCCH cell switching based on dynamic indication,* 
  + *the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI.*
  + *Only the HARQ-ACK corresponding to the first SPS PDSCH activated by activation DCI uses the PUCCH cell based on the indication in the activation DCI (based on the earlier agreement).*

**Proposal 5:**

* *Adopt following text change for clause 9.1.2.1 in TS 38.213.*

|  |
| --- |
| 9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel  For a serving cell , an active DL BWP, and an active UL BWP, as described in clause 12, the UE determines a set of occasions for candidate PDSCH receptions for which the UE can transmit corresponding HARQ-ACK information in a PUCCH in slot . If serving cell is deactivated, the UE uses as the active DL BWP for determining the set of occasions for candidate PDSCH receptions a DL BWP provided by *firstActiveDownlinkBWP-Id*. The determination is based:  a) on a set of slot timing values associated with the active UL BWP on the primary cell or, if the PUCCH transmission is indicated by a DCI format to be on the PUCCH-sSCell as described in clause 9A, on a set of slot timing values associated with the active UL BWP on the PUCCH-sSCell  [….]  Set  - index of occasion for candidate PDSCH reception or SPS PDSCH release  Set  Set  Set  to the cardinality of set  Set *k* =0 – index of slot timing values , in descending order of the slot timing values, in set  for serving cell  If a UE is not provided *ca-SlotOffset* for any serving cell of PDSCH receptions and for the serving cell of corresponding PUCCH transmission with HARQ-ACK information  while  if or *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook  Set  – index of a DL slot overlapping with an UL slot  Set to a number of DL slots overlapping with UL slot if *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook; otherwise,  while  Set  to the set of rows  Set  to the cardinality of  Set  – index of row in set  if slot  starts at a same time as or after a slot for an active DL BWP change on serving cell  or an active UL BWP change on the PCell or an active UL BWP change on the PUCCH-sSCell and slot is before the slot for the active DL BWP change on serving cell  or the active UL BWP change on the PCell or an active UL BWP change on the PUCCH-sSCell, or *subslotLengthForPUCCH* is provided for the HARQ-ACK codebook and slot overlaps with UL slot , , where is a DL slot with a smallest index among DL slots overlapping with UL slot ,;  else  [….] |

**Proposal 6:**

* *Further study the enhancements on current DRX mechanism to better support dynamic requested HARQ-ACK retransmission. E.g.,* 
  + *Start drx-RetransmissionTimerDL in the first symbol after the corresponding cancelled PUCCH transmission to ensure that UE has chance to receive the PDCCH for triggering HARQ-ACK retransmission.*

### R1-2202009 Maintenance on HARQ-ACK feedback enhancements Samsung

**Proposal 1: RRC-based cell switching is supported for repetitions of a PUCCH transmission using a same PUCCH resource on the PCell and PUCCH-sSCell. If more than one slot on the PUCCH-sSCell overlaps with a slot on the PCell, all slots where the PUCCH can be transmitted on the PUCCH-sSCell are used.**

**Proposal 2: For DCI-based PUCCH cell switching, all PUCCH transmissions with HARQ-ACK for SPS PDSCH receptions of a SPS configuration are on the cell indicated by the DCI format activating the SPS PDSCH receptions.**

### R1-2202134 HARQ-ACK enhancement for IOT and URLLC Qualcomm Incorporated

***Observation 1: RAN 1 to clarify the UE behavior with regards to SPS HARQ bits in pending/ongoing SPS HARQ deferral procedure, when SPS HARQ Deferral and Rel. 17 Type 3 HARQ CB are jointly configured; what should the UE behavior be after Rel. 17 Type 3 HARQ CB transmission in the following cases:***

1. ***Rel. 17 Type 3 HARQ CB does contain (entirely or partly) the deferred SPS HARQ bits***
2. ***Rel. 17 Type 3 HARQ CB does not contain any of the deferred SPS HARQ bits***

***Observation 2: RAN 1 to clarify the UE behavior with regards to the time requirement for the UE to cancel/stop an ongoing SPS HARQ deferral procedure.***

***Observation 3***: **RAN 1 to clarify the UE behavior for one-shot HARQ CB retransmission in the case the requested HARQ CB is not available at the UE.**

***Observation 4***: ***For triggered HARQ CB retransmission, the UE has to store the list of HARQ Process contained in each HARQ CB so as to keep track of the DRX timers per HARQ Process.***

In summary, we make the following proposals for HARQ-ACK feedback enhancement for Rel-17 IOT and URLLC.

***Proposal 1: In case of joint SPS HARQ Deferral and Rel. 17 Type 3 HARQ CB and after the Rel. 17 Type 3 HARQ CB transmission, the UE***

* ***Stops/cancels the transmission of pending/ongoing SPS HARQ bits to be deferred at the first available uplink resource, if at least a part of the SPS HARQ bits to be deferred is already transmitted via Rel. 17 Type 3 HARQ CB,***
* ***transmits the SPS HARQ bits to be deferred at the first available uplink resource after the Rel. 17 Type 3 HARQ CB transmission, if none of the deferred SPS HARQ bits is transmitted via Rel. 17 Type 3 HARQ CB.***

***Proposal 2: Adopt the existing timeline in terms of uplink cancellation for the SPS HARQ deferral cancellation/stopping: Tproc,2.***

***Proposal 3: Following the #107bis-e conclusion not allowing joint configuration of SPS HARQ Deferral and PUCCH repetitions, the UE is not expecting to be configured with both SPS HARQ deferral and PUCCH repetitions; such a joint configuration is treated as an error case.***

***Proposal 4:******RAN 1 to clarify that the maximum deferral time, k1def\_max, is applicable only for SPS configured with deferral and without SPS PUCCH repetitions.***

***Proposal 5:******In case the requested for retransmission HARQ CB is not available, the UE does not transmit anything for the requested HARQ CB. In case, there are other HARQ CBs or deferred SPS HARQ CBs, or PUSCH on the slot indicated for the HARQ CB retransmission, then, the new HARQ CBs or deferred SPS HARQ CBs, or PUSCH only are transmitted.***

***Proposal 6: If the content of one or more HARQ process of the requested for retransmission HARQ CB has changed, i.e. is replaced by new HARQ bits, the UE considers the request for HARQ CB retransmission void and transmits nothing.***

***Proposal 7:*** ***The CRC of the DCI triggering HARQ CB retransmission is not scrambled with CS-RNTI.***

***Proposal 8:*** ***For “triggered HARQ CB reTx” in case of multi-DCI configuration in multi-TRP, and for multiple HARQ CBs in the same slot, the UE identifies the requested HARQ CB for retransmission through the TRP from which the request originates; the TRP issuing the request for HARQ CB retransmission is identified via the CORESET index used in DCI transmission.***

***Proposal 9: Support PUCCH repetition with semi-static PUCCH cell switching, by adopting either one of the following two options:***

* ***Option 1: The first PUCCH repetition follows the semi-static PUCCH cell switch configuration. For the rest PUCCH repetitions, a PUCCH slot mapped to different PUCCH cell is considered as invalid and is not counted towards the total number of PUCCH repetitions. The rest repetitions are postponed as in Rel-16.***
* ***Option 2: all PUCCH repetitions are allowed to switch between Pcell and PUCCH sScell. A UE does not expect different number of REs in the PUCCH resources to transmit the repetitions.***

***Proposal 10: Support joint operation of PUCCH cell switch and simultaneous PUCCH/PUSCH transmissions.***

***Proposal 11: Support semi-static PUCCH carrier switching per PHY priority.***

***Proposal 12: Support semi-static PUCCH carrier switching for SPS HARQ corresponding to SPS occasion about to expire, i.e. N slots prior to the arrival of the new SPS occurrence.***

### R1-2202341 Discussion on UE feedback enhancement for HARQ-ACK LG Electronics

Proposal #1: For semi-static PUCCH cell switching, a PUCCH repetition is transmitted on the target PUCCH cell with the first PUCCH occasion.

* A PUCCH slot mapped to the PUCCH cell different from the target PUCCH cell with the first PUCCH occasion is considered as invalid for PUCCH repetition and is not counted towards the total number of PUCCH repetitions / the repetition is postponed as in Rel-16.

Proposal #2: For dynamic PUCCH cell switching, the HARQ-ACK of SPS PDSCH without associated DCI is to be transmitted on PCell / SPCell / PUCCH-SCell independently of the dynamically indicated PUCCH cell in the SPS activation DCI. Only the HARQ-ACK corresponding to the first SPS PDSCH activated by the activation DCI uses the PUCCH cell based on the indication in the activation DCI

Proposal #3: At least the following conditions are kept for SPS HARQ deferral in case configured with intra-UE multiplexing.

* SPS HARQ-ACK deferral is enabled in RRC
* PUCCH given by n1PUCCH or SPS-PUCCH-AN-List-r16 is considered as final PUCCH after intra-UE UL multiplexing
* PUCCH resource are overlaps in time with semi-static DL symbol, SSB and/or CORESET#0

Proposal #4: If a SPS HARQ-ACK in a slot meets the deferring condition before inter-priority multiplexing and the SPS HARQ-ACK cannot be transmitted after inter-priority multiplexing, the SPS HARQ-ACK can be deferred.

Proposal #5: Rel-17 inter-UE multiplexing can be considered to determine valid target slot for SPS HARQ-ACK deferral.

Proposal #6: To determine the priority of deferred SPS HARQ-ACK from the PUCCH multiplexed with different priority, HARQ-ACK priority is given by corresponding SPS configuration regardless of deferred PUCCH resource in initial slot.

Proposal #7: For One-shot HARQ-ACK retransmission of the PUCCH multiplexed with different priority, only the HARQ-ACK codebook having indicated priority index is to be retransmitted.

* HARQ offset of triggering DCI is determined based on slot length of the indicated priority in the triggering DCI.

Proposal #8: For the type-3 or enhanced type-3 HARQ-ACK codebook transmission in case configured with intra-UE multiplexing, one of following alternatives is adopted.

* Alternative 1: UE does not expect that type-3 or enhanced type-3 triggering DCI indicates lower priority transmission
* Alternative 2: UE assumes that type-3 or enhanced type-3 triggering DCI corresponds to higher priority transmission (regardless of the value of priority indication field)

Proposal 9: Consider to introduce new UE capability indicating how many HARQ-ACK codebooks can be stored for one-shot HARQ-ACK retransmission afterward.

* UE reports the number X, which indicates the maximum number of HARQ-ACK codebooks stored simultaneously in the UE side.
  + gNB would be able to trigger one-shot HARQ-ACK retransmission for one of latest X scheduled HARQ-ACK codebooks.