**3GPP TSG RAN WG1 Meeting #105-e R1-210xxxx**

e-Meeting, May 19-27, 2021

**Agenda Item: 7.2.2**

**Source: Moderator (Huawei)**

**Title: Feature lead summary#1 on NR-U HARQ maintenance**

**Document for: Discussion and Decision**

# Introduction

Corrections on NR-U HARQ have been submitted at RAN1#105 e-meeting. This first summary asked for companies’ views on the criticality of the proposed corrections during the preparation phase (May 14-18), including whether discussion is needed for clarification before we can determine whether an issue is critical or essential.

After the preparation phase, the following email discussion was approved:

[105-e-NR-NRU-03] Email discussion/approval on HARQ enhancements focusing on the following from preparation phase summary until May 25 – David (Huawei)

* HARQ-1, HARQ-5, HARQ-6: Editorial
* HARQ-2 and HARQ-3

Section 3 provides dedicated sub-sections for each of the issues to discuss at RAN1#105e, with tables for collecting companies’ comments on the moderator’s questions.

# Preparation phase

The corrections proposed in 5 Tdocs to RAN1#105 are summarized in the table below.

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| **Issue #** | **Issue summary** | **Contributions** |
| HARQ1 | **Issue: text in TS38.300 limits re-transmission of HARQ-ACK feedback with enhanced type-2 codebook and type-3 codebook to shared spectrum access, whereas FGs 10-15/10-16 are applicable to licensed bands as well.**  --------------- Text Proposal TP#1 for 38.300, Section 5.2.5.4 ----------------------  \*\*\* Unchanged text omitted \*\*\* 5.2.5.4 HARQ Asynchronous Incremental Redundancy Hybrid ARQ is supported. The gNB provides the UE with the HARQ-ACK feedback timing either dynamically in the DCI or semi-statically in an RRC configuration. Retransmission of HARQ-ACK feedback is supported by using enhanced dynamic codebook and/or one-shot triggering of HARQ-ACK transmission for all configured CCs and HARQ processes in the PUCCH group.  The UE may be configured to receive code block group based transmissions where retransmissions may be scheduled to carry a sub-set of all the code blocks of a TB.  \*\*\* Unchanged text omitted \*\*\*  ------------------------------------ End Text Proposal --------------------------------- | R1-2104458 |
| HARQ2 | **Issue: enhanced dynamic HARQ-ACK codebook cannot be configured by *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16***  Proposal 1: Discuss and decide which solution to be adopted for the relationship between *pdsch-HARQ-ACK-Codebook-r16* and *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16*   * Solution 1: If *pdsch-HARQ-ACK-Codebook-r16* and *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16* are configured simultaneously, enhanced dynamic HARQ-ACK codebook is applied to primary PUCCH group, and semi-static or dynamic HARQ-ACK codebook configured by *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup* is applied to secondary PUCCH group. * Solution 2: If *pdsch-HARQ-ACK-Codebook-r16* is configured, the same RRC configuration *pdsch-HARQ-ACK-Codebook-r16* is applied to both primary PUCCH group and secondary PUCCH group if two PUCCH groups are configured regardless of whether *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16* is configured or not.   Proposal 2: If solution 1 is adopted, endorse TP1 and TP2 [in R1-2104476] for TS 38.212 and TS 38.213 respectively. Otherwise if solution 2 is adopted, send an LS to RAN2 to inform the conclusion*.* | R1-2104476 |
| HARQ3 | **Issue: potential inconsistency between RAN1 and RAN2 specifications about when a UE is expected to monitor a DCI scheduling re-transmission for a PDSCH that was scheduled with a NNK1 value.**  **Discussion in R1-2104764** (more details to be found in R1-2104764)  ***Observation 1: Based on RAN2 specification, if a NNK1 is indicated for one HARQ process, UE can immediately monitor the DCI for retransmission.***  Excerpt from RAN2 TS 38.321 clause 5.7 Discontinuous Reception (DRX):  3> if the PDSCH-to-HARQ\_feedback timing indicate a non-numerical k1 value as specified in TS 38.213 [6]:  4> start the *drx-RetransmissionTimerDL* in the first symbol after the PDSCH transmission for the corresponding HARQ process.  ***Observation 2: Based on RAN1 specification, the HARQ process cannot be rescheduled before the transmission of previous HARQ-ACK corresponding to the same HARQ process.***  Excerpt from RAN1 TS38.214:  The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Clause 9.2.3 of [6].  ***Proposal: Adopt TP for the scheduling order of the PDSCH with NNK1 in RAN1 specification.***  ------------------------ Start of TP 38.214 V16.5.0 section 5.1----------------------  5.1 UE procedure for receiving the physical downlink shared channel  <Unchanged parts are omitted>  A UE shall upon detection of a PDCCH with a configured DCI format 1\_0, 1\_1 or 1\_2 decode the corresponding PDSCHs as indicated by that DCI. For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to receive a PDSCH that overlaps in time with another PDSCH. The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for a first PDSCH for that HARQ process, where the timing is given by Clause 9.2.3 of [6], except for a PDSCH-to-HARQ\_feedback timing indicator field providing an inapplicable value for the first PDSCH. In a given scheduled cell, the UE is not expected to receive a first PDSCH and a second PDSCH, starting later than the first PDSCH, with its corresponding HARQ-ACK assigned to be transmitted on a resource ending before the start of a different resource for the HARQ-ACK assigned to be transmitted for the first PDSCH, where the two resources are in different slots for the associated HARQ-ACK transmissions, each slot is composed of symbols [4] or a number of symbols indicated by *subslotLengthForPUCCH* if provided, and the HARQ-ACK for the two PDSCHs are associated with the HARQ-ACK codebook of the same priority.  <Unchanged parts are omitted>  ------------------------ End of TP 38.214 V16.5.0 section 5.1------------------------  **Discussion in R1-2105461**  Issue: when the actual HARQ-ACK feedback timing is not provided further by gNB, whether there is occupation restriction for the HARQ process or not should be clarified   * **Option 1**: An applicable HARQ-ACK feedback timing should be provided later for the HARQ process with NNK1 by gNB, otherwise the HARQ process would be suspended without any further PDSCH reception allowed. In other words, the HARQ process can only be scheduled or configured with any new PDSCH reception after the applicable HARQ-ACK feedback timing is provided. * **Option 2**: An applicable HARQ-ACK feedback timing may not be provided for the HARQ process with NNK1 by gNB before a new PDSCH reception for the HARQ process is scheduled or configured. If no applicable timing is provided before the new PDSCH reception, there may be some limitations for the timing of the new PDSCH reception, e.g., it should be received after a time offset from the ending time of the PDSCH reception with NNK1. The time offset may be specified or configured by considering PDSCH decoding time, or N1, etc. Otherwise, the HARQ process can only be scheduled or configured with any new PDSCH reception after the latest provided applicable HARQ-ACK feedback timing, if any.   ***Proposal 4: When a HARQ process is scheduled with a PDSCH reception with NNK1, and the actual HARQ-ACK feedback timing is not provided, whether there is occupation restriction for the HARQ process or not should be clarified.*** | R1-2104764  R1-2105461 |
| HARQ4 | **NFI and DAI for the non-scheduled group when q=0**  *Proposal 1: For enhanced dynamic codebook, UE should ignore the NFI and DAI fields for the non-scheduled group in a DL DCI with q=0, and assume that the DL DCI does not include or provide an NFI for the non-scheduled group*  **NFI assumption for UL DAI when no DL DCI is detected**  *Proposal 3: No assumption for NFI is needed for a UL DAI different than 4 for a PDSCH group that was not scheduled for the UE.* | R1-2105461 |
| HARQ5 | **Issue: correct the use of a RRC parameter in TS38.212**  ------------------------------Start text proposal---------------------------------  7.3.1.2.2 Format 1\_1  ……  - Downlink assignment index – number of bits as defined in the following  - 6 bits if more than one serving cell are configured in the DL and the higher layer parameter *nfi-TotalDAI-Included=true ~~= enable~~*. The 4 MSB bits are the counter DAI and the total DAI for the scheduled PDSCH group, and the 2 LSB bits are the total DAI for the non-scheduled PDSCH group.  - 4 bits if only one serving cell are configured in the DL and the higher layer parameter *nfi-TotalDAI-Included=true ~~= enable~~.* The 2 MSB bits are the counter DAI for the scheduled PDSCH group, and the 2 LSB bits are the total DAI for the non-scheduled PDSCH group;  - 4 bits if more than one serving cell are configured in the DL, the higher layer parameter *pdsch-HARQ-ACK-Codebook=dynamic* or *pdsch-HARQ-ACK-Codebook-r16= enhancedDynamic*, and *nfi-TotalDAI-Included~~=true~~* is not configured, where the 2 MSB bits are the counter DAI and the 2 LSB bits are the total DAI;  - 4 bits if one serving cell is configured in the DL, and the higher layer parameter *pdsch-HARQ-ACK-Codebook=dynamic*, and the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with value 0 for one or more first CORESETs and is provided *coresetPoolIndex* with value 1 for one or more second CORESETs, and is provided *ackNackFeedbackMode = joint*, where the 2 MSB bits are the counter DAI and the 2 LSB bits are the total DAI;  - 2 bits if only one serving cell is configured in the DL, the higher layer parameter *pdsch-HARQ-ACK-Codebook=dynamic* or *pdsch-HARQ-ACK-Codebook-r16=enhancedDynamic*, and *nfi-TotalDAI-Included~~=true~~* is not configured, when the UE is not configured with *coresetPoolIndex* or the value of *coresetPoolIndex* is the same for all CORESETs if *coresetPoolIndex* is provided or the UE is not configured with *ackNackFeedbackMode = joint*, where the 2 bits are the counter DAI;  - 0 bits otherwise.  --------------------------End text proposal------------------------------- | R1-2105461 |
| HARQ6 | **Issue: correct the use of a RRC parameter in in TS38.213**    According to NR Rel-15, the PDSCH HARQ-ACK codebook could be either semi-static or dynamic by pdsch-HARQ-ACK-Codebook, as following:  pdsch-HARQ-ACK-Codebook ENUMERATED {semiStatic, dynamic},  tpc-SRS-RNTI RNTI-Value OPTIONAL, -- Need R  An enhanced dynamic codebook for PDSCH is designed for Rel-16 NR-U by pdsch-HARQ-ACK-Codebook-r16, as following:  pdsch-HARQ-ACK-Codebook-r16 ENUMERATED {enhancedDynamic} OPTIONAL, -- Need R  **Correction proposed for TS28.213 clause 9.1.3:**  if the UE is provided *pdsch-HARQ-ACK-Codebook-r16*, the UE receives the second DCI format later than the slot for HARQ-ACK information in response to a SPS PDSCH reception received after the PDSCH scheduled by the first DCI format, and the second DCI format indicates a HARQ-ACK information report for a same PDSCH group index as indicated by the first DCI format as described in Clause 9.1.3.3. | R1-2105753 |

# Discussion phase

## HARQ-1

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| **Issue #** | **Issue summary** | **Contributions** |
| HARQ1 | **Issue: text in TS38.300 limits re-transmission of HARQ-ACK feedback with enhanced type-2 codebook and type-3 codebook to shared spectrum access, whereas FGs 10-15/10-16 are applicable to licensed bands as well.**  --------------- Text Proposal TP#1 for 38.300, Section 5.2.5.4 ----------------------  \*\*\* Unchanged text omitted \*\*\* 5.2.5.4 HARQ Asynchronous Incremental Redundancy Hybrid ARQ is supported. The gNB provides the UE with the HARQ-ACK feedback timing either dynamically in the DCI or semi-statically in an RRC configuration. Retransmission of HARQ-ACK feedback is supported by using enhanced dynamic codebook and/or one-shot triggering of HARQ-ACK transmission for all configured CCs and HARQ processes in the PUCCH group.  The UE may be configured to receive code block group based transmissions where retransmissions may be scheduled to carry a sub-set of all the code blocks of a TB.  \*\*\* Unchanged text omitted \*\*\*  ------------------------------------ End Text Proposal --------------------------------- | R1-2104458 |

As proposed in R1-2104458, let’s first conclude on the recommended text proposal for TS38.300, then if such text proposal is agreeable we can proceed to draft a LS to RAN2.

**Is the correction for TS38.300 clause 5.2.5.4 proposed in R1-2104458 acceptable?**

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| **Company** | **Comment** |
| QC | Support. |
| vivo | Support. |
| OPPO | OK |
| Lenovo, Motorola Mobility | Support. |
| Intel | Support |
| Samsung | Support |
| Ericsson | Support |
| ITRI | Support |
| Sharp | Support |
| ZTE | Support |
| CATT | Support |
| Nokia, NSB | Support |
| MediaTek | Support |
| LG | Support |

**Moderator’s conclusion**: all responding companies support recommending the text proposal in R1-2104458 for TS38.300.

### Draft LS

A draft LS is provided for review in the second phase of this discussion. Please provide your comments (if any) on the draft LS. In the absence of comments the draft LS will be deemed acceptable.

[HARQ-1 R1-210xxxx DRAFT LS on correction to Rel-16 HARQ description in TS38.300 v001.docx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/7.2.2/105-e-NR-NRU-03/HARQ-1%20R1-210xxxx%20DRAFT%20LS%20on%20correction%20to%20Rel-16%20HARQ%20description%20in%20TS38.300%20v001.docx)

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| **Company** | **Comment** |
| QC | Support |

## HARQ-2

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| HARQ2 | **Issue: enhanced dynamic HARQ-ACK codebook cannot be configured by *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16***  Proposal 1: Discuss and decide which solution to be adopted for the relationship between *pdsch-HARQ-ACK-Codebook-r16* and *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16*   * Solution 1: If *pdsch-HARQ-ACK-Codebook-r16* and *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16* are configured simultaneously, enhanced dynamic HARQ-ACK codebook is applied to primary PUCCH group, and semi-static or dynamic HARQ-ACK codebook configured by *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup* is applied to secondary PUCCH group. * Solution 2: If *pdsch-HARQ-ACK-Codebook-r16* is configured, the same RRC configuration *pdsch-HARQ-ACK-Codebook-r16* is applied to both primary PUCCH group and secondary PUCCH group if two PUCCH groups are configured regardless of whether *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16* is configured or not.   Proposal 2: If solution 1 is adopted, endorse TP1 and TP2 [in R1-2104476] for TS 38.212 and TS 38.213 respectively. Otherwise if solution 2 is adopted, send an LS to RAN2 to inform the conclusion*.* | R1-2104476 |

**Moderator’s summary and further analysis:**

For background, here are the relevant RRC parameters in TS38.331v16.4.1:

*pdsch-HARQ-ACK-Codebook-r16 ENUMERATED {enhancedDynamic}*

*pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16 ENUMERATED {semiStatic, dynamic}*

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| ***pdsch-HARQ-ACK-Codebook***  The PDSCH HARQ-ACK codebook is either semi-static or dynamic. This is applicable to both CA and none CA operation (see TS 38.213 [13], clauses 9.1.2 and 9.1.3). If *pdsch-HARQ-ACK-Codebook-r16* is signalled, UE shall ignore the *pdsch-HARQ-ACK-Codebook* (without suffix). If the field *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup* is present, *pdsch-HARQ-ACK-Codebook* is applied to primary PUCCH group. Otherwise, this field is applied to the cell group (i.e. for all the cells within the cell group). |
| ***pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup***  The PDSCH HARQ-ACK codebook is either semi-static or dynamic. This is applicable to both CA and none CA operation (see TS 38.213 [13], clauses 9.1.2 and 9.1.3). It is configured for secondary PUCCH group*.* |

From the moderator’s perspective, current specifications seem to be consistent with solution 1 in R1-2104476. This means that the secondary PUCCH group cannot support configuration of enhanced Type-2 HARQ-ACK codebook.

Solution 2 described in R1-2104476 implies that as long as *pdsch-HARQ-ACK-Codebook-r16* is configured, then a secondary PUCCH group is configured and uses enhanced Type-2 codebook. It is unclear in solution 2 whether *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16* also needs to be configured in order to first configure a secondary PUCCH group, while the HARQ-ACK codebook type is then overridden by *pdsch-HARQ-ACK-Codebook-r16*.

A third type of solution (let’s say solution 3) could be to add the value *enhancedDynamic* to *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16*. This may be useful in NR-CA or NR-DC deployments where only the secondary cell group operates in unlicensed band, while the primary cell group operates in licensed band (and therefore does not require using enhanced Type-2 HARQ-ACK codebook). Solution 3 would completely decouple the configuration of enhanced Type-2 codebook for the primary and secondary PUCCH groups.

**Comments are invited on the problem description, solution 1, solution 2 or other solutions, using the table below.**

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| **Company** | **Comment** |
| QC | Solution 1 is preferred, which means no change is needed as commented by moderator. Seems nothing is broken, and additional enhacements may require RRC change which should be avoided at this stage. |
| vivo | The third solution brought by FL may give more flexibility, but corresponding RRC change is expected which should be avoided at this stage.  On the contrary, Solution 2 can be considered, since similar solution has been adopted for the issue between *pdsch-HARQ-ACK-CodebookList-r16* and *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16*, the agreement for which is captured in the following.   |  | | --- | | * **The same RRC configuration pdsch-HARQ-ACK-CodebookList-r16 is applied to both primary PUCCH group and secondary PUCCH group if two PUCCH groups are configured.** |   In summary, Solution 2 is preferred in our opinion. |
| Lenovo, Motorola Mobility | Agree with Qualcomm. |
| Intel | We agree with Qualcomm in this quite late stage of Rel-16. |
| Samsung | Solution 3 provides more useful configuration for NR-U, considering some typical scenario for NR-CA or NR-DC with 1st group as licensed band and 2nd group as unlicensed band. But it is undesirable to introduce new RRC parameters at this late stage, thus we don’t prefer solution 3.  For solution 1 vs 2,   * Solution 1 is aligned with current spec, the drawback is, for scenario for NR-CA or NR-DC with 1st group as licensed band and 2nd group as unlicensed band, unlicensed band can not use enhanced Type-2 codebook. But HARQ-ACK retransmission can be supported by type-3 HARQ-ACK codebook. * Solution 2 requires modification in RAN2 spec. The drawback is, solution 2 would require the group for licensed band also use enhanced Type-2 codebook, if unlicensed band wants to use enhanced Type-2 codebook. It would lead to unnecessary larger DCI overhead in DCI for licensed band to support enhanced Type-2 codebook, if Type-2 codebook or semi-static codebook is sufficient for licensed band operation.   We slightly prefer solution 1 considering the current spec can work. |
| Ericsson | We support solution 3 by FL.  Other solutions are not justified. If there is a reason to configure enhanceType-2, why that reason should not be applicable to second PUCCH group?  With solution 1 and 2, one questions the benefit of enhacend Type-2 at all. |
| Sharp | If it is possible to modify RRC parameter, we prefere Solution 3.  If it is too late to modify RRC parameter at this stage, we prefer Solution 1, sharing the same view with Samsung. Then, this should be corrected in the next release. |
| ZTE | We prefer solution 1, sharing the similar view with Qualcomm and Samsung |
| CATT | Solution 3 is the most flexible solution but requires introducing new RRC parameter which we do not think it is feasible so it was not included in our proposal.  Between Solution 1 and 2, we do not have a strong preference. Solution 1 does not impact RAN2 but RAN1 spec update is needed as we proposed in R1-2104476. We appreciate if companies can check the TPs and comment if any. |
| Nokia, NSB | Although it is late to change the RRC spec, we prefer Solution 3. |
| MediaTek | We support the solution 3 by FL. We share a similar view with Ericsson that the other two solutions are not justified.  Though it is a late stage in term of R16 specification work in 3GPP, it is relatively an early state in term of NR-U product implementation in industry. To us, this is a specification bug which needs to be fixed. We strongly prefer solution 3 to avoid questions and confusion from our product team in the future. |
| LG | We also prefer Solution 3 if possible.  If not, we are fine with Solution 1. |

**Moderator’s summary**

The following views were expressed by responding companies:

Solution 1 (no change to current specs)

* Supported by (9): Qualcomm, Motorola Mobility, Lenovo, Intel, Samsung, Sharp (if RRC change is too late), ZTE, CATT, LG (second preference)

Solution 2 (secondary PUCCH group follows configuration of pdsch-HARQ-ACK-Codebook-r16)

* Supported by (2): vivo, CATT

Solution 3 (RRC change):

* Supported by (6): Ericsson, Sharp (if RRC change is not too late), Nokia, Nokia Shanghai Bell, MediaTek, LG
* Objected by (8): Qualcomm, vivo, Motorola Mobility, Lenovo, Intel, Samsung, ZTE, CATT

Based on the difficulty for a late change in RRC specifications, the majority of companies have concerns with solution 3 and rather support solution 1. However other companies as well as some companies supporting solution 1 recognize that the current specifications limit the scenarios since enhanced Type-2 HARQ-ACK codebook cannot be configured for a secondary PUCCH group in unlicensed band. In order to allow enhanced Type-2 HARQ-ACK codebook to be configured for a secondary PUCCH group in unlicensed band, these companies prefer solution 3 than solution 2.

A possible clarification to the earlier analysis is that for EN-DC within FR1 with a single PUCCH group for the NR cells, this is actually the primary PUCCH group, therefore pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16 is not necessary for supporting the NR cells in unlicensed band. Also for NR-CA between licensed and unlicensed bands, a single PUCCH group across all NR carriers could be used provided the UEs support the relevant capabilities.

### Second round

What solution 3 may entail would be something like:

* Defining a new RRC parameter, e.g.
  + pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-v1650 ENUMERATED {enhancedDynamic}
* Defining a new UE capability similar to FG 10-15 related to this new RRC parameter
* Corresponding changes to the RAN1 specifications

Based on the current status of the discussion, it is proposed to conclude with solution 1 for Rel-16 (no change to Rel-16 specifications), and note that companies are free to bring a TEI17 proposal to RAN1 in a later meeting for solution 3 or for solution 2.

**Proposed conclusion on issue HARQ-2**:

* **No change to RAN1 specifications in Rel-16 (a secondary PUCCH group cannot be configured with enhanced Type-2 HARQ-ACK codebook).**
* **Note: companies are free to bring a TEI17 proposal to RAN1 for solution 3 (to allow a secondary PUCCH group to be configured with enhanced Type-2 HARQ-ACK codebook with a new RRC parameter) or for solution 2 (secondary PUCCH group follows configuration of pdsch-HARQ-ACK-Codebook-r16).**

Comments on the proposed conclusion

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| **Company** | **Comment** |
| QC | Ok, but suggest removing the Note (of course companies are free to do so, but this is abvious) |

## HARQ-3

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| HARQ3 | **Issue: potential inconsistency between RAN1 and RAN2 specifications about when a UE is expected to monitor a DCI scheduling re-transmission for a PDSCH that was scheduled with a NNK1 value.**  **Discussion in R1-2104764** (more details to be found in R1-2104764)  ***Observation 1: Based on RAN2 specification, if a NNK1 is indicated for one HARQ process, UE can immediately monitor the DCI for retransmission.***  Excerpt from RAN2 TS 38.321 clause 5.7 Discontinuous Reception (DRX):  3> if the PDSCH-to-HARQ\_feedback timing indicate a non-numerical k1 value as specified in TS 38.213 [6]:  4> start the *drx-RetransmissionTimerDL* in the first symbol after the PDSCH transmission for the corresponding HARQ process.  ***Observation 2: Based on RAN1 specification, the HARQ process cannot be rescheduled before the transmission of previous HARQ-ACK corresponding to the same HARQ process.***  Excerpt from RAN1 TS38.214:  The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Clause 9.2.3 of [6].  ***Proposal: Adopt TP for the scheduling order of the PDSCH with NNK1 in RAN1 specification.***  ------------------------ Start of TP 38.214 V16.5.0 section 5.1----------------------  5.1 UE procedure for receiving the physical downlink shared channel  <Unchanged parts are omitted>  A UE shall upon detection of a PDCCH with a configured DCI format 1\_0, 1\_1 or 1\_2 decode the corresponding PDSCHs as indicated by that DCI. For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to receive a PDSCH that overlaps in time with another PDSCH. The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for a first PDSCH for that HARQ process, where the timing is given by Clause 9.2.3 of [6], except for a PDSCH-to-HARQ\_feedback timing indicator field providing an inapplicable value for the first PDSCH. In a given scheduled cell, the UE is not expected to receive a first PDSCH and a second PDSCH, starting later than the first PDSCH, with its corresponding HARQ-ACK assigned to be transmitted on a resource ending before the start of a different resource for the HARQ-ACK assigned to be transmitted for the first PDSCH, where the two resources are in different slots for the associated HARQ-ACK transmissions, each slot is composed of symbols [4] or a number of symbols indicated by *subslotLengthForPUCCH* if provided, and the HARQ-ACK for the two PDSCHs are associated with the HARQ-ACK codebook of the same priority.  <Unchanged parts are omitted>  ------------------------ End of TP 38.214 V16.5.0 section 5.1------------------------  **Discussion in R1-2105461**  Issue: when the actual HARQ-ACK feedback timing is not provided further by Gnb, whether there is occupation restriction for the HARQ process or not should be clarified   * **Option 1**: An applicable HARQ-ACK feedback timing should be provided later for the HARQ process with NNK1 by Gnb, otherwise the HARQ process would be suspended without any further PDSCH reception allowed. In other words, the HARQ process can only be scheduled or configured with any new PDSCH reception after the applicable HARQ-ACK feedback timing is provided. * **Option 2**: An applicable HARQ-ACK feedback timing may not be provided for the HARQ process with NNK1 by Gnb before a new PDSCH reception for the HARQ process is scheduled or configured. If no applicable timing is provided before the new PDSCH reception, there may be some limitations for the timing of the new PDSCH reception, e.g., it should be received after a time offset from the ending time of the PDSCH reception with NNK1. The time offset may be specified or configured by considering PDSCH decoding time, or N1, etc. Otherwise, the HARQ process can only be scheduled or configured with any new PDSCH reception after the latest provided applicable HARQ-ACK feedback timing, if any.   ***Proposal 4: When a HARQ process is scheduled with a PDSCH reception with NNK1, and the actual HARQ-ACK feedback timing is not provided, whether there is occupation restriction for the HARQ process or not should be clarified.*** | R1-2104764  R1-2105461 |

**Moderator’s summary and further analysis:**

The problem discussed in R1-2104764 and R1-2105461 is the scenario where a PDSCH is scheduled with NNK1 value but subsequently the UE is not provided with a feedback timing for reporting HARQ information for this HARQ process. Then the UE may assume that it doesn’t have to monitor DCI for this HARQ process any longer (forever?), based on the specification text in 38.213.

Let’s consider the following cases and nalyse whether a situation where feedback timing is missing may happen:

* Case 1: UE is configured with Type-3 HARQ-ACK codebook in addition to another HARQ-ACK codebook
* Case 2: UE is configured with enhanced Type-2 HARQ-ACK codebook
* Case 3: UE is configured with (non-enhanced) Type-2 HARQ-ACK codebook (but not Type-3 HARQ-ACK CB)

In case 1, as long as the Gnb triggers one-shot feedback, then the HARQ process ID can start being scheduled again once the UE has reported the Type-3 HARQ-ACK codebook. A UE will not miss every DCI triggering one-shot feedback, so at some point in time the UE will be able to resume monitoring DCI for that HARQ process. So there seems to be no critical issue in case 1.

In case 2, as long as Gnb would schedule another PDSCH in the same PDSCH group then feedback timing is provided to the UE for the first PDSCH. It should be a corner case that the Gnb never schedules that PDSCH group again. If scheduling of that PDSCH group comes late then the HARQ feedback may become useless, but from the UE perspective this will allow the UE to be scheduled with that HARQ process again. It is up to the network to avoid long delays for scheduling the same PDSCH group again. So there seems to be no critical issue in case 2.

In case 3, the feedback timing is provided as long as a second DCI format is received indicating a value of PDSCH to HARQ feedback timing indicator and the feedback slot is no later than a slot for HARQ-ACK information in response to a SPS PDSCH reception. If the slot provided is later than a slot for HARQ-ACK information in response to a SPS PDSCH reception then the UE behaviour is undefined and there is no more opportunity for the UE to report the HARQ information (there is no one-shot codebook in case 3), thus the corresponding HARQ process may be suspended. Even though this may not be an expected Gnb behaviour, it may happen if the UE misses all DCIs before the next slot for HARQ-ACK information in response to a SPS PDSCH reception. So case 3 may be problematic.

Perhaps there are higher-layer procedures that allow the HARQ process to stop being suspended, such as an expired timer or after RLC-HARQ feedback is triggered for the TB, and that would unlock the HARQ process in case 3? One possibility could be to ask clarification from RAN2.

**Companies are invited to provide their understanding of the potential issue raised in R1-2104764 and R1-2105461 and the analysis above, using the table below.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | We agree with the analysis from moderator that Case 3 can be problematic, i.e., whenever we get to the “otherwise” part bellow, it implies that HARQ ID can never be used again:  - otherwise, the UE does not multiplex the corresponding HARQ-ACK information in a PUCCH or PUSCH transmission.  At the same time, if we agree to fix the issue above, it is better to do so irrespective of Case 1/2/3. We prefer one of the following solutions:   * Solution 1: Same HARQ-ID can be resused again after X symbols/slots/ms after the PDSCH scheduled with NNK1, where X is such that it is at least as large as PDSCH processin timeline (Tproc,1) * Solution 2: Same HARQ-ID can be resused again after transmission of HARQ-Ack triggered by a second (subsequent) DCI irrespective of whether the HARQ-Ack includes the feedback for the first PDSCH scheduled with NN-K1 or not.   Also, relaxing the constrain for NN-K1 altogether does not work as UE may not be able to process a PDSCH with the same HARQ-ID before processing the first PDSCH.  We think sending LS to RAN2 is unnecessary as this is a RAN1 issue. The DRX description in RAN2 is not related (the UE may not be even configured with DRX, but this clarification may still be needed). |
| Vivo | We agree with FL that Case 3 may be problematic. Besides, Case 1 may also be problematic. For example, when UE is configured with both Type-1 codebook and Type-3 codebook, and a HARQ process n is scheduled with PDSCH1 and provided with NNK1. There may be the case where a subsequent SPS PDSCH will occupy the HARQ process n, but there is no change for Gnb to trigger a Type-3 codebook before the subsequent SPS PDSCH, or one or more DCIs to trigger a Type-3 codebook have been miss-detected by the UE. Should the UE receive this SPS PDSCH? When the periodicity for the corresponding SPS Config is smaller, or multiple SPS Configs have been configured, the aforementioned case may happen more frequent.  We agree with QC that relaxing the constraint for NNK1 altogether does not work as UE may not be able to process a subsequent PDSCH with the same HARQ-ID before processing the previous PDSCH. Furthermore, Solution 1 proposed by QC is much aligned with Option 2 in our contribution. We think it is simple and straightforward, thus is preferred. |
| OPPO | In our contribution, we think that there is a mis-match between RAN1 and RAN2, when DRX is configured, and the HARQ retransmission timer is started right after the PDSCH reception scheduled by a DCI assigning a NNK1. But we think that the solutions proposed by QC can resolve our concern. Among solution 1 and solution 2, we prefer solution 2. |
| Intel | We don’t think this is a real issue. For a PDSCH with NNK1, if a next DCI with valid K1 is not received until a slot for a SPS PDSCH reception, what should a smart UE think? 1) the UE miss the next DCI scheduled by a smart Gnb; or 2) the UE thinks Gnb is stupid to make a suspended HARQ process. We think the UE should assume the next DCI missing (i.e. Gnb assigns a valid timing, but the UE miss it). Therefore, UE assumes that the HARQ process can be scheduled after the SPS PDSCH. |
| Samsung | Thanks for the analysis provided by FL.  For case 3, yes, it is problematic if UE misses all DCIs after the DCI indicates NNK1 and before the HARQ-ACK feedback for SPS PDSCH, but it would a rare case. Maybe we can first check whether existing RAN2 mechanism can resolve such rare error case as suggested by FL. |
| Ericsson | Thank FL for the provided analysis.  We share same view as Intel and Samsung that this is a corner case. If gNB schedules a PDSCH with NN-K1, the gNB would like to receive the feedback for that PDSCH as well.  The gNB is aware of the expected procedures related to NN-K1 and if it uses that, should also considers the timing to request the feedback.  We shouldn’t specify to cover error cases. Both UE and gNB implementation should deal with error cases. |
| ZTE | We share the same view as Intel, Samsung and Ericsson that this should a corner case, and it can be left to gNB implementation whether or not to reuse the HARQ process ID. |
| Nokia, NSB | We agree that it is a rare case, and could be handlerd with proper implementation. |
| LG | We also share the same view with other companies.  This is to be considered as a corner case, then could be handled with proper gNB implementation. |

**Moderator’s summary**

The following views were expressed by responding companies:

* Case 3 is problematic and should be fixed by RAN1 (and it is unrelated to DRX configuration)
* Supported by (3): Qualcomm, vivo, OPPO
  + Solution 1: Same HARQ-ID can be reused again after X symbols/slots/ms after the PDSCH scheduled with NNK1, where X is such that it is at least as large as PDSCH processin timeline (Tproc,1)
    - Qualcomm, vivo, OPPO (second preference)
  + Solution 2: Same HARQ-ID can be reused again after transmission of HARQ-Ack triggered by a second (subsequent) DCI irrespective of whether the HARQ-Ack includes the feedback for the first PDSCH scheduled with NN-K1 or not.
    - Qualcomm, OPPO (first preference)
* Cases 1, 2 and 3 are corner cases that can be avoided or handled (in case of missed DCI) by implementation
* Supported by (7): Intel, Samsung, Ericsson, ZTE, Nokia, Nokia Shanghai Bell, LG

### Second round

Based on the views expressed, it seems unlikely to reach consensus for handling the error case with specification support. It may however still be worth spending a bit of time understanding if there is an expected UE behaviour in case 3, e.g. as described by Intel. Simply assuming that literal compliance with the specification means that the HARQ process ID can never be used again, but this is likely not what would happen in a real network.

Assuming that case 3 happens (because of a missed DCI), the gNB would handle this case as if it missed the PUCCH and may schedule a PDSCH re-transmission or a new PDSCH transmission with this HARQ process ID, and subsequently the UE receives a PDCCH scheduling PDSCH reception and indicating the “suspended” HARQ process ID. What are companies’ views on the possible UE behaviour(s) in this case? Some alternatives are provided below.

Alt1: UE ignores any such PDCCH and corresponding PDSCH(s) and UE doesn’t report the corresponding PUCCH(s)

* If NDI is not toggled:
* If NDI is toggled:

Alt2: UE ignores the PDCCH and corresponding PDSCH and UE reports NACK for this PDSCH

* If NDI is not toggled:
* If NDI is toggled:

Alt3: UE decodes the PDSCH and reports the corresponding HARQ-ACK information

* If NDI is not toggled:
* If NDI is toggled:

Alt4: UE behaviour is undefined

* gNB can never use this HARQ process ID again for the UE:
* gNB can apply some RRC re-configuration to reset the UE HARQ:

Companies may add their name after the UE behaviour(s) they think may happen in real network. A table is provided below for further comments.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | In the absence of specification clarification, then it means Alt4 from our point of view (up to UE implementation). gNB is free to use that HARQ ID again, but it is up to UE to treat it based on Alt 1-3 or any other Alt. |

## HARQ-5

|  |  |  |
| --- | --- | --- |
| HARQ5 | **Issue: correct the use of a RRC parameter in TS38.212**  ------------------------------Start text proposal---------------------------------  7.3.1.2.2 Format 1\_1  ……  - Downlink assignment index – number of bits as defined in the following  - 6 bits if more than one serving cell are configured in the DL and the higher layer parameter *nfi-TotalDAI-Included=true ~~= enable~~*. The 4 MSB bits are the counter DAI and the total DAI for the scheduled PDSCH group, and the 2 LSB bits are the total DAI for the non-scheduled PDSCH group.  - 4 bits if only one serving cell are configured in the DL and the higher layer parameter *nfi-TotalDAI-Included=true ~~= enable~~.* The 2 MSB bits are the counter DAI for the scheduled PDSCH group, and the 2 LSB bits are the total DAI for the non-scheduled PDSCH group;  - 4 bits if more than one serving cell are configured in the DL, the higher layer parameter *pdsch-HARQ-ACK-Codebook=dynamic* or *pdsch-HARQ-ACK-Codebook-r16= enhancedDynamic*, and *nfi-TotalDAI-Included~~=true~~* is not configured, where the 2 MSB bits are the counter DAI and the 2 LSB bits are the total DAI;  - 4 bits if one serving cell is configured in the DL, and the higher layer parameter *pdsch-HARQ-ACK-Codebook=dynamic*, and the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with value 0 for one or more first CORESETs and is provided *coresetPoolIndex* with value 1 for one or more second CORESETs, and is provided *ackNackFeedbackMode = joint*, where the 2 MSB bits are the counter DAI and the 2 LSB bits are the total DAI;  - 2 bits if only one serving cell is configured in the DL, the higher layer parameter *pdsch-HARQ-ACK-Codebook=dynamic* or *pdsch-HARQ-ACK-Codebook-r16=enhancedDynamic*, and *nfi-TotalDAI-Included~~=true~~* is not configured, when the UE is not configured with *coresetPoolIndex* or the value of *coresetPoolIndex* is the same for all CORESETs if *coresetPoolIndex* is provided or the UE is not configured with *ackNackFeedbackMode = joint*, where the 2 bits are the counter DAI;  - 0 bits otherwise.  --------------------------End text proposal------------------------------- | R1-2105461 |

For background, here is the relevant RRC parameter in TS38.331v16.4.1:

nfi-TotalDAI-Included-r16 ENUMERATED {true} OPTIONAL

Some of the corrections proposed in R1-2105461 are still leaving text such as *nfi-TotalDAI-Included=true ~~= enable~~*, where “=true” should also be deleted.

A revised TP is provided below.

------------------------------Start text proposal---------------------------------

**7.3.1.2.2 Format 1\_1**

……

- Downlink assignment index – number of bits as defined in the following

- 6 bits if more than one serving cell are configured in the DL and the higher layer parameter *nfi-TotalDAI-Included~~=true = enable~~ is configured*. The 4 MSB bits are the counter DAI and the total DAI for the scheduled PDSCH group, and the 2 LSB bits are the total DAI for the non-scheduled PDSCH group.

- 4 bits if only one serving cell are configured in the DL and the higher layer parameter *nfi-TotalDAI-Included~~=true = enable~~ is configured.* The 2 MSB bits are the counter DAI for the scheduled PDSCH group, and the 2 LSB bits are the total DAI for the non-scheduled PDSCH group;

- 4 bits if more than one serving cell are configured in the DL, the higher layer parameter *pdsch-HARQ-ACK-Codebook=dynamic* or *pdsch-HARQ-ACK-Codebook-r16= enhancedDynamic*, and *nfi-TotalDAI-Included~~=true~~* is not configured, where the 2 MSB bits are the counter DAI and the 2 LSB bits are the total DAI;

- 4 bits if one serving cell is configured in the DL, and the higher layer parameter *pdsch-HARQ-ACK-Codebook=dynamic*, and the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with value 0 for one or more first CORESETs and is provided *coresetPoolIndex* with value 1 for one or more second CORESETs, and is provided *ackNackFeedbackMode = joint*, where the 2 MSB bits are the counter DAI and the 2 LSB bits are the total DAI;

- 2 bits if only one serving cell is configured in the DL, the higher layer parameter *pdsch-HARQ-ACK-Codebook=dynamic* or *pdsch-HARQ-ACK-Codebook-r16=enhancedDynamic*, and *nfi-TotalDAI-Included~~=true~~* is not configured, when the UE is not configured with *coresetPoolIndex* or the value of *coresetPoolIndex* is the same for all CORESETs if *coresetPoolIndex* is provided or the UE is not configured with *ackNackFeedbackMode = joint*, where the 2 bits are the counter DAI;

- 0 bits otherwise.

--------------------------End text proposal-------------------------------

**Is the TP above acceptable?**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | Support |
| vivo | Fine with it. |
| OPPO | OK |
| Lenovo, Motorola Mobility | Support. |
| Intel | Support |
| Samsung | Support |
| Ericsson | Support |
| ITRI | support |
| Sharp | Support |
| ZTE | Support |
| CATT | Support |
| Nokia, NSB | Support |
| MediaTek | Support |
| LG | Support |

**Moderator’s conclusion**: all responding companies support the correction.

### Draft CR

A CR draft is provided for review in the second phase of this discussion, including cover sheet. Please provide your comments (if any) on the CR draft. In the absence of comments the CR draft will be deemed acceptable.

[HARQ-5 R1-210xxxx Correction on HARQ-ACK codebook RRC parameter in TS38.212 v001.docx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/7.2.2/105-e-NR-NRU-03/HARQ-5%20R1-210xxxx%20Correction%20on%20HARQ-ACK%20codebook%20RRC%20parameter%20in%20TS38.212%20v001.docx)

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | Support. |

## HARQ-6

|  |  |  |
| --- | --- | --- |
| HARQ6 | **Issue: correct the use of a RRC parameter in in TS38.213**    According to NR Rel-15, the PDSCH HARQ-ACK codebook could be either semi-static or dynamic by pdsch-HARQ-ACK-Codebook, as following:  pdsch-HARQ-ACK-Codebook ENUMERATED {semiStatic, dynamic},  tpc-SRS-RNTI RNTI-Value OPTIONAL, -- Need R  An enhanced dynamic codebook for PDSCH is designed for Rel-16 NR-U by pdsch-HARQ-ACK-Codebook-r16, as following:  pdsch-HARQ-ACK-Codebook-r16 ENUMERATED {enhancedDynamic} OPTIONAL, -- Need R  **Correction proposed for TS28.213 clause 9.1.3:**  if the UE is provided *pdsch-HARQ-ACK-Codebook-r16*, the UE receives the second DCI format later than the slot for HARQ-ACK information in response to a SPS PDSCH reception received after the PDSCH scheduled by the first DCI format, and the second DCI format indicates a HARQ-ACK information report for a same PDSCH group index as indicated by the first DCI format as described in Clause 9.1.3.3. | R1-2105753 |

**Is the correction for TS28.213 clause 9.1.3 proposed in R1-2105753 acceptable?**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | Support. |
| Vivo | OK. |
| OPPO | OK |
| Lenovo, Motorola Mobility | Support. |
| Intel | Support |
| Samsung | Support |
| Ericsson | Support |
| ITRI | Support |
| Sharp | Support |
| ZTE | Support |
| CATT | Support |
| Nokia, NSB | Support |
| MediaTek | Support |
| LG | Support |

**Moderator’s conclusion**: all responding companies support the correction.

### Draft CR

A CR draft is provided for review in the second phase of this discussion, including cover sheet. Please provide your comments (if any) on the CR draft. In the absence of comments the CR draft will be deemed acceptable.

[HARQ-6 R1-210xxxx Correction on HARQ-ACK codebook RRC parameter in TS38.213 v001.docx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/7.2.2/105-e-NR-NRU-03/HARQ-6%20R1-210xxxx%20Correction%20on%20HARQ-ACK%20codebook%20RRC%20parameter%20in%20TS38.213%20v001.docx)

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | Support. |

# Conclusion

TBD

# References

[R1-2104458](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104458.zip) Corrections related to HARQ Ericsson

[R1-2104476](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104476.zip) Discussion on enhanced dynamic HARQ-ACK codebook for secondary PUCCH group CATT

[R1-2104764](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104764.zip) Discussion on the remaining issues of HARQ enhancements OPPO

[R1-2105461](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105461.zip) Maintenance on HARQ operation for NR-U vivo

[R1-2105753](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105753.zip) Correction of higher layer parameter name for NR-U ITRI