**3GPP TSG RAN WG1 Meeting #103-e R1-200xxxx**

e-Meeting, October 26th – November 13th, 2020

**Agenda Item: 7.2.2**

**Source: Moderator (Huawei)**

**Title: [DRAFT] Feature lead summary#1 for NRU HARQ [103-e-NR-NRU-05]**

**Document for: Discussion and Decision**

# Introduction

Corrections on NR-U HARQ have been submitted at RAN1#103 e-meeting. The preparation phase of RAN1#103e prioritized the discussion on issue HARQ-OOO [R1-2008886, R1-2008888]:

[103-e-NR-NRU-05] Email discussion/approval on issue HARQ-OOO, in R1-2008888 until 10/29 with potential CRs by 11/4 – David (Huawei)

R1-2007609 (Huawei), R1-2007933 (Intel), R1-2007981 (Ericsson), R1-2008044 (LG), R1-2008128 (Samsung), R1-2008206 (Nokia) and R1-2008249 (OPPO) discussed the FFS point of the agreement made at RAN1#102e.

Agreement (RAN1#102e):

When a UE receives a second PDSCH (for DL SPS) after a first PDSCH, where the first PDSCH is not assigned an applicable K1 value in the corresponding first DCI format,

* the UE transmits HARQ-ACK for the first PDSCH:
  + if the UE detects a second DCI format in any PDCCH monitoring occasion after the first DCI format where the second DCI format assigns an applicable K1 value for the first PDSCH (as specified in TS38.213 section 9.1.3) that corresponds to HARQ-ACK timing no later than the HARQ-ACK timing assigned for the second PDSCH
* Otherwise, the UE does not multiplex the HARQ-ACK information for the first PDSCH in a PUCCH or PUSCH transmission, unless a HARQ-ACK information retransmission is requested later than the HARQ-ACK timing assigned for the second PDSCH.
* FFS: Which codebook type(s) can be used for the HARQ-ACK information retransmission

Conclusion (RAN1#102e):

If the UE is provided with *pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16*or with *pdsch-HARQ-ACK-OneShotFeedback-r16*:

* 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 initial HARQ-ACK transmission occasion assigned to be transmitted on a resource ending before the start of a different resource for the initial HARQ-ACK transmission occasion assigned to be transmitted for the first PDSCH.
* This clarifies that examples C4-Case1 and C4-Case2, as discussed in [R1-2007390](file:///D:\working_document\3GPP_5G_standadization\RAN\TSGR1_103-e\Inbox\drafts\7.2.2\Docs\R1-2007390.zip), are allowed

The views from the Tdocs are summarized here. Types of codebooks that allow a HARQ-ACK information retransmission request (i.e. that does not qualify as an out-of-order condition per RAN1#102e agreement):

* eType2 or Type3 CB
  + Huawei, Hisilicon, Intel, Ericsson, OPPO
  + Samsung (in case of eType2 CB only if feedback for both groups is requested)
* Type3 CB only
  + Nokia, Nokia Shanghai Bell
  + LG
* Type2 CB
  + OPPO (only when UE is also configured with Type 3 CB)

# Round 1

A proposal is provided based on the majority views to support such retransmission with Type-3 CB or eType-2 CB. Companies are invited to comment on the FL proposal by UTC 9:00 AM 10/27

FL proposal 1:

When a UE receives a second PDSCH (for DL SPS) after a first PDSCH, where the first PDSCH is not assigned an applicable K1 value in the corresponding first DCI format,

* if the UE didn’t detect a second DCI format in any PDCCH monitoring occasion after the first DCI format where the second DCI format assigns an applicable K1 value for the first PDSCH (as specified in TS38.213 section 9.1.3) that corresponds to HARQ-ACK timing no later than the HARQ-ACK timing assigned for the second PDSCH, the UE multiplexes the HARQ-ACK information for the first PDSCH in a PUCCH or PUSCH transmission only if a HARQ-ACK information retransmission is requested later than the HARQ-ACK timing assigned for the second PDSCH, and only if
  + The HARQ-ACK information retransmission uses Type-3 HARQ-ACK codebook; or
  + The HARQ-ACK information retransmission uses enhanced Type-2 HARQ-ACK codebook containing at least the PDSCH group assigned to the first PDSCH.

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| **Company** | **Comments** |
| OPPO | We are fine with FL proposal. |
| ZTE | Support FL proposal. |
| Sharp | We support FL proposal 1. |
| Intel | We are fine with FL proposal |
| Samsung | We are fine with FL proposal |
| Nokia, NSB | We support |
| LG | We still don’t see the essentiality to include such OOO HARQ-ACK feedback functionality in the enhanced Type-2 codebook which has been designed so complicated already. Considering the case operating with Type-1/2 CB, in the end, Type-3 CB would anyway need to be additionally configured for the UE if the gNB want to handle the OOO event caused by the combination of NNK1 and SPS. Given that, even in case operating with the enhanced Type-2 CB is configured, the gNB could handle such OOO case by additionally configuring Type-3 CB, without putting additional complexity to the (already complicated) enhanced Type-2 CB.  BTW, one question to the above FL proposal 1 is, what would be the next step after the proposal if agreed. (additional modification to the proposal? or develop TP corresponding to the proposal?) |
| Ericsson | Fine with the proposal |
| QC | We have same view as LG. Also, we do not see the necessity of this proposal. If the intention is to discuss the FFS part of the previous agreement, then only that part can be discussed (i.e. no need to reformulate the agreement, which may create confusion as it is not exactly aligned with the previous agreement).  For the FFS part of the previous agreement, we support Type-3 CB only.  It is preferred to discuss the TP at this point. For the TP, we prefer LG or Nokia’s TP. |
| vivo | We are fine with FL proposal |

# Round 2

Based on the first round of discussion, the situation is the following:

* 9 companies support FL proposal 1 (eType2 CB and Type3 CB)
* 2 companies prefer to limit to Type3 CB only

Concerns on supporting eType2 codebook were expressed in terms of specification complexity. In order to better understand the concerns, it was deemed useful to continue the discussion on potential TPs to help understand the specification complexity.

**Approach #1: TP for TS 38.214 clause 5.1, example with 2 sub-bullets for Type3 CB and eType2 CB:**

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 *subslotLength-ForPUCCH* if provided, and the HARQ-ACK for the two PDSCHs are associated with the HARQ-ACK codebook of the same priority, except if one of the conditions below is fulfilled:

* the UE is provided *pdsch-HARQ-ACK-OneShotFeedback-r16* and the DCI format that schedules PDSCH reception for the first PDSCH includes a PDSCH-to-HARQ\_feedback timing indicator field providing an inapplicable value from dl-DataToUL-ACK and the DCI format that schedules PDSCH reception for the second PDSCH had its CRC scrambled by a CS-RNTI and the UE detected another DCI format that includes a One-shot HARQ-ACK request field with value 1 later than the resource for the HARQ-ACK assigned to be transmitted for the second PDSCH
* the UE is provided *pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16* and the first DCI format that scheduled PDSCH reception for the first PDSCH included a PDSCH-to-HARQ\_feedback timing indicator field providing an inapplicable value from dl-DataToUL-ACK and the DCI format that scheduled PDSCH reception for the second PDSCH had its CRC scrambled by a CS-RNTI and the UE detected another DCI format later than the resource for the HARQ-ACK assigned to be transmitted for the second PDSCH and that DCI format indicates a HARQ-ACK information report for a same PDSCH group index as indicated by the first DCI format.

**Approach #2: TP for TS 38.213 clause 9.1.3, example for Type3 CB (revised TP from Nokia):**

This clause applies if the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16*. Unless stated otherwise, a PDSCH-to-HARQ\_feedback timing indicator field provides an applicable value.

A UE does not expect to multiplex in a Type-2 HARQ-ACK codebook HARQ-ACK information that is in response to a detection of a DCI format that does not include a counter DAI field.

If a UE receives a first DCI format that the UE detects in a first PDCCH monitoring occasion and includes a PDSCH-to-HARQ\_feedback timing indicator field providing an inapplicable value from *dl-DataToUL-ACK*,

-     if the UE detects a second DCI format, the UE multiplexes the corresponding HARQ-ACK information in a PUCCH or PUSCH transmission in a slot that is indicated by a value of a PDSCH-to-HARQ\_feedback timing indicator field in the second DCI format, where

-     if the UE is not provided *pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16*, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one

-     if the UE is provided *pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16*, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one, 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

-     if the UE is provided *pdsch-HARQ-ACK-OneShotFeedback-r16*, the first DCI format does not indicate SPS PDSCH release or SCell dormancy, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one, and the second DCI format includes a One-shot HARQ-ACK request field with value 1, the UE includes the HARQ-ACK information in a Type-3 HARQ-ACK codebook, as described in Clause 9.1.4.

-  and where the slot indicated by the value of the PDSCH-to-HARQ\_feedback timing indicator field in the second DCI format is no later than a slot assigned for HARQ-ACK information of a PDSCH, if any, with CRC scrambled by a CS-RNTI and received after the PDSCH scheduled by the first DCI format.

-  or if UE receives a third DCI format not indicating SPS PDSCH release or SCell dormancy and being later than the HARQ-ACK timing assigned for the PDSCH with CRC scrambled by a CS-RNTI and received after the PDSCH scheduled by the first DCI format, and the third DCI format includes a One-shot HARQ-ACK request field with value 1 the UE includes the HARQ-ACK information in a Type-3 HARQ-ACK codebook, as described in Clause 9.1.4.

-  otherwise, the UE does not multiplex the corresponding HARQ-ACK information in a PUCCH or PUSCH transmission.

Companies are invited to comment on the potential TPs above and on the specification impact for allowing the OOO exception between DL SPS and eType2 codebook.

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| **Company** | **Comments** |
| OPPO | The TP with approach#1 is fine to us. For approach#2, we would like to know if it is just an example for Type 3 CB, and e-type 2 CB will be discussed too, or it is the final TP proposal. If it is just an example, we would like to see how the approach#2 with example for e-type 2 CB would look like. |

# Round 3

# Summary

# Annex: proposals from Tdocs

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| **Company** | **Summary of proposals and further comments** |
| Huawei  R1-2007609 | Observation 1: Any HARQ information transmission for a PDSCH initially scheduled with NNK1 value should be considered as a HARQ re-transmission by the network and by the UE.  Proposal 1: gBN can choose either Type3 codebook or enhanced Type2 codebook for requesting HARQ-ACK information retransmission of a first PDSCH (initially scheduled with NNK1 value earlier than a DL SPS PDSCH), where the request for HARQ-ACK information retransmission is received later than the HARQ-ACK timing assigned for the DL SPS PDSCH. |
| Intel  R1-2007933 | HACK-ACK transmission for PDSCH 1 after PUCCH1 should be considered as retransmission for the HARQ-ACK information. According to the above conclusion from last meeting, OOO checking doesn’t apply to the HARQ-ACK retransmission for PDSCH1.  Proposal 2: Both enhanced Type2 HARQ-ACK codebook and Type3 HARQ-ACK codebook are allowed for the HARQ-ACK retransmission of PDSCH1 after the timing of PUCCH1 for the SPS PDSCH. |
| Ericsson  R1-2007981 | The agreement should be applicable irrespective of the codebook type used for requesting the retransmission. Update the agreement by simply removing the FFS. The agreed behavior is aligned with what is already in the specification. Additionally, a conclusion was made last meeting about excluding retransmissions from the existing rel-15 OOO behavior. Therefore, no TP is needed. |
| LG  R1-2008044 | Proposal: One-shot Type-3 codebook can be used for the HARQ-ACK retransmission in potential OOO case caused by combination of NNK1 indication and SPS PDSCH.  If a UE receives a first DCI format that the UE detects in a first PDCCH monitoring occasion and includes a PDSCH-to-HARQ\_feedback timing indicator field providing an inapplicable value from *dl-DataToUL-ACK*,  - if the UE detects a second DCI format not including a One-shot HARQ-ACK request field with value 1 and a value of a PDSCH-to-HARQ\_feedback timing indicator field in the second DCI indicates a slot with the earliest one among PUCCH or PUSCH transmission(s) carrying HARQ-ACK corresponding to the PDSCH received after the first PDSCH reception that satisfies the timing conditions in Clause 9.2.5, the UE multiplexes the corresponding HARQ-ACK information in ~~a~~ the PUCCH or PUSCH transmission ~~in a slot that is indicated by a value of a PDSCH-to-HARQ\_feedback timing indicator field in the second DCI format~~, where  - if the UE is not provided *pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16*, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one  - if the UE is provided *pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16*, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one, 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  - if the UE is provided *pdsch-HARQ-ACK-OneShotFeedback-r16*, the first DCI format does not indicate SPS PDSCH release or SCell dormancy, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one, and the second DCI format includes a One-shot HARQ-ACK request field with value 1, the UE includes the HARQ-ACK information in a Type-3 HARQ-ACK codebook, as described in Clause 9.1.4.  - otherwise, the UE does not multiplex the corresponding HARQ-ACK information in a PUCCH or PUSCH transmission. |
| Samsung  R1-2008128 | For a UE configured with both enhanced type-2 codebook and type-3 codebook, if a second DCI triggers type-3 codebook, or requests HARQ-ACK of both PDSCH groups by enhanced type-2 codebook, HARQ-ACK of all previous PDSCHs are reported, thus it makes sense to also support HARQ-ACK feedback of first PDSCH with NNK1 together with HARQ-ACK of other PDSCHs in the same PUCCH. If a second DCI triggers only single PDSCH group by enhanced type-2 codebook, it violates OOO rule, so that the UE does not multiplex the HARQ-ACK for the first PDSCH in the PUCCH indicated by the second DCI.  Proposal: HARQ-ACK retransmission for a PDSCH with NNK1 for both type-3 codebook and enhanced type-2 codebook for both PDSCH groups is supported. To support efficient HARQ-ACK feedback for NR-U, it is proposed to update the previous agreement as below:  When a UE receives a second PDSCH (for DL SPS) after a first PDSCH, where the first PDSCH is not assigned an applicable K1 value in the corresponding first DCI format,   * the UE transmits HARQ-ACK for the first PDSCH:   + if the UE detects a second DCI format in any PDCCH monitoring occasion after the first DCI format where the second DCI format assigns an applicable K1 value for the first PDSCH (as specified in TS38.213 section 9.1.3) that corresponds to HARQ-ACK timing no later than the HARQ-ACK timing assigned for the second PDSCH * Otherwise, the UE does not multiplex the HARQ-ACK information for the first PDSCH in a PUCCH or PUSCH transmission, unless a HARQ-ACK information retransmission is requested by the second DCI which includes one-shot HARQ-ACK request field with value 1 or requests feedback for both PDSCH groups later than the HARQ-ACK timing assigned for the second PDSCH |
| Nokia  R1-2008206 | When it comes to FFS, we believe that both TYPE-3 and e-TYPE-2 could be supported for re-tx. On the other hand, we understand that re-transmission with TYPE-3 has less impact on the implementation, if any, because construction is HARQ-process based, i.e. no special DAI keeping is necessary for the dropped HARQ-ACK  Proposal: At least TYPE-3 CB can be used for the HARQ-ACK information retransmission  9.1.3 Type-2 HARQ-ACK codebook determination  This clause applies if the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16*. Unless stated otherwise, a PDSCH-to-HARQ\_feedback timing indicator field provides an applicable value.  A UE does not expect to multiplex in a Type-2 HARQ-ACK codebook HARQ-ACK information that is in response to a detection of a DCI format that does not include a counter DAI field.  If a UE receives a first DCI format that the UE detects in a first PDCCH monitoring occasion and includes a PDSCH-to-HARQ\_feedback timing indicator field providing an inapplicable value from *dl-DataToUL-ACK*,  - if the UE detects a second DCI format, the UE multiplexes the corresponding HARQ-ACK information in a PUCCH or PUSCH transmission in a slot that is indicated by a value of a PDSCH-to-HARQ\_feedback timing indicator field in the second DCI format, where  - if the UE is not provided *pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16*, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one  - if the UE is provided *pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16*, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one, 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  - if the UE is provided *pdsch-HARQ-ACK-OneShotFeedback-r16*, the first DCI format does not indicate SPS PDSCH release or SCell dormancy, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one, and the second DCI format includes a One-shot HARQ-ACK request field with value 1, the UE includes the HARQ-ACK information in a Type-3 HARQ-ACK codebook, as described in Clause 9.1.4.  - and where the slot indicated by the value of the PDSCH-to-HARQ\_feedback timing indicator field in the second DCI format is no later than a slot assigned for HARQ-ACK information of a second PDSCH, if any, with CRC scrambled by a CS-RNTI and received after the PDSCH scheduled by the first DCI format. |
| OPPO  R1-2008249 | Proposal 1: When a UE receives a SPS PDSCH after a first PDSCH, where the first PDSCH is assigned with NNK1:   * When at least one of e-type 2 codebook and type 3 codebook is configured, a DCI assigning an applicable K1 value for the first PDSCH with type 2, e-type 2 or type 3 codebook, the UE will consider as the retransmission of the HARQ-ACK corresponding to the first PDSCH. * When only type 2 codebook is configured, if the UE does not receive a DCI assigning an applicable K1 value for the first PDSCH that corresponds to HARQ-ACK timing no later than HARQ-ACK timing assigned for the SPS PDSCH before t0, the UE can skip the processing of the first PDSCH or SPS PDSCH, where t0 is determined based on the starting of PUCCH assigned for the SPS PDSCH and PDSCH processing timeline. |

# References

R1-2007609 Maintenance on HARQ-ACK enhancement Huawei, HiSilicon

R1-2007933 Remaining issues on NR-U Intel Corporation

R1-2007961 Text proposals on type-3 HARQ-ACK codebook and multi-PUSCH scheduling ZTE, Sanechips

R1-2007981 HARQ Corrections Ericsson

R1-2008044 Remaining issues of HARQ procedure for NR-U LG Electronics

R1-2008128 Remaining issues on HARQ Samsung

R1-2008206 Remaining issues on NR-U HARQ and Initial Access Procedures Nokia, Nokia Shanghai Bell

R1-2008249 Discussion on the remaining issues of HARQ enhancements OPPO

R1-2008661 Remaining issues on HARQ operation for NR-U vivo

R1-2008886 FL summary\_1 for NRU HARQ 103e v002 Moderator (Huawei)

R1-2008888 Preparation phase email discussion for NR-U Moderator (Qualcomm Incorporated)