**3GPP TSG RAN WG1 Meeting #104b-e R1-210xxxx**

e-Meeting, April 12-20, 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#104b e-meeting. The preparation phase (April 8th – 9th) determined that corrections labelled Type3CB#1 and Type3CB#1 are deemed as essential corrections, and will be discussed at RAN1#104b-e by email discussion.

[104b-e-NR-NRU-04] Email discussion/approval on HARQ enhancements until Apr-16 – David (Huawei)

* Type3CB#1, Type3CB#2

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| **Issue #** | **Issue summary** | **Contributions** |
| Type3CB#1 | **Type-3 HARQ-ACK codebook size ambiguity** **R1-2102325*****Observation***: in the pseudo-code of section 9.1.4 of TS38.213v16.5.0, in case NDI reporting is not configured for Type-3 HARQ-ACK codebook, if the UE has not yet obtained HARQ-ACK information for a TB corresponding to a scheduled PDSCH reception and the UE has detected a DCI format scheduling a PDSCH reception for the TB, the UE shall not include a bit for the corresponding TB and HARQ process in the Type-3 HARQ-ACK codebook.Whether the UE reports a bit impacts the Type-3 HARQ-ACK codebook size, so if any UE is implemented based on a different understanding than in the observation above, then codebook mismatch will occur when the gNB interpretation is consistent with the observation above, and vice-versa. A safer (and more robust) approach would be to define/reserve a bit to report.***Proposal 1***: in case NDI reporting is not configured for Type-3 HARQ-ACK codebook, if the UE has not yet obtained HARQ-ACK information for a TB corresponding to a scheduled PDSCH reception and the UE has detected a DCI format scheduling a PDSCH reception for the TB, the UE shall report NACK for the corresponding TB and HARQ process in the Type-3 HARQ-ACK codebook. (TP provided in R1-2102325)**R1-2102367*****Observation 1***: Type-3 HARQ-ACK codebook is also applicable to frequency band that does not require shared spectrum access. gNB cannot avoid a SPS PDSCH is transmitted before a type 3 CB without enough processing time when multiple SPS PDSCH configurations or SPS PDSCH configuration with short periodicity is configured to a UE.***Observation 2***: The size of Type-3 HARQ-ACK codebook will be changed when the UE has not obtained HARQ-ACK information for a HARQ process.***Proposal 1***: For a given HARQ process, if the UE has not obtained HARQ-ACK information,  should be reserved in the Type-3 HARQ-ACK codebook. (TP1 provided in R1-2102367) | R1-2102325 R1-2102367  |
| Type3CB#2 | **Correction on multiplexing timeline definition for Type-3 HARQ-ACK codebook*****Reason for change***: In current specification of multiplexing timeline definition in Clause 9.2.5, DCI format 1\_1 indicating a request for a Type-3 HARQ-ACK codebook report without scheduling PDSCH is missing for $T\_{proc,2}^{mux}$ calculation.***Summary of change***: Add the DCI format 1\_1 providing the indication of a request for a Type-3 HARQ-ACK codebook report without scheduling PDSCH in the paragraphs of $T\_{proc,2}^{mux}$ calculation in Clause 9.2.5.**Refer to R1-2102587 for the detailed CR.** | R1-2102587  |
| Type2CB#3 | **Assumption on NFI value for a PDSCH group not received at UE side when the UL DAI indicates a value not equal to 4 for that group*****Proposal #2***: For the case when a PDSCH group is not received at UE side and the UL DAI in UL grant DCI corresponding to the PDSCH group indicates a value not equal to 4, the following behavior is applied.* NFI value for the PDSCH group is assumed to be non-toggled from the latest value.
	+ Payload size of the HARQ-ACK on PUSCH is determined by the indicated UL DAI itself without accumulating the HARQ-ACKs in the previous PUCCH occasion (similarly as for the case when UE only receives DL fallback DCI and the UE would transmit HARQ-ACK on PUCCH).

**FL note: Discussed as issue A9 in the past** | R1-2103336  |

# Type3CB#1: Type-3 HARQ-ACK codebook size ambiguity

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| Type3CB#1 | **Type-3 HARQ-ACK codebook size ambiguity** **R1-2102325*****Observation***: in the pseudo-code of section 9.1.4 of TS38.213v16.5.0, in case NDI reporting is not configured for Type-3 HARQ-ACK codebook, if the UE has not yet obtained HARQ-ACK information for a TB corresponding to a scheduled PDSCH reception and the UE has detected a DCI format scheduling a PDSCH reception for the TB, the UE shall not include a bit for the corresponding TB and HARQ process in the Type-3 HARQ-ACK codebook.Whether the UE reports a bit impacts the Type-3 HARQ-ACK codebook size, so if any UE is implemented based on a different understanding than in the observation above, then codebook mismatch will occur when the gNB interpretation is consistent with the observation above, and vice-versa. A safer (and more robust) approach would be to define/reserve a bit to report.***Proposal 1***: in case NDI reporting is not configured for Type-3 HARQ-ACK codebook, if the UE has not yet obtained HARQ-ACK information for a TB corresponding to a scheduled PDSCH reception and the UE has detected a DCI format scheduling a PDSCH reception for the TB, the UE shall report NACK for the corresponding TB and HARQ process in the Type-3 HARQ-ACK codebook. (TP provided in R1-2102325)**R1-2102367*****Observation 1***: Type-3 HARQ-ACK codebook is also applicable to frequency band that does not require shared spectrum access. gNB cannot avoid a SPS PDSCH is transmitted before a type 3 CB without enough processing time when multiple SPS PDSCH configurations or SPS PDSCH configuration with short periodicity is configured to a UE.***Observation 2***: The size of Type-3 HARQ-ACK codebook will be changed when the UE has not obtained HARQ-ACK information for a HARQ process.An example is provided to illustrate how a missed DCI will result in a codebook size mismatch between the UE and gNB.***Proposal 1***: For a given HARQ process, if the UE has not obtained HARQ-ACK information,  should be reserved in the Type-3 HARQ-ACK codebook. (TP1 provided in R1-2102367) | R1-2102325 R1-2102367  |

Given the various observations and examples in R1-2102325 and R1-2102367, which illustrate various conditions under which a codebook size mismatch may occur between the UE and the gNB, it is proposed to ensure that the codebook size does not depend on whether a UE has obtained or not obtained HARQ-ACK information for a HARQ process.

**Proposal 1**: correct the generation of the Type-3 HARQ-ACK codebook to ensure that HARQ-ACK bit(s) are always included for each of the configured HARQ processes.

* If UE has neither reported nor obtained HARQ-ACK information for a HARQ process, UE reports NACK for the corresponding bit(s).

A corresponding TP1 is provided in Annex 1.

Companies are invited to comment on proposal 1 and TP1 using the table below.

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| **Company** | **Comment** |
| OPPO | We support this TP, without this TP, the type 3 CB size is dynamically determined. This problem should be corrected.  |
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# Type3CB#2: Correction on multiplexing timeline definition for Type-3 HARQ-ACK codebook

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| Type3CB#2 | **Correction on multiplexing timeline definition for Type-3 HARQ-ACK codebook*****Reason for change***: In current specification of multiplexing timeline definition in Clause 9.2.5, DCI format 1\_1 indicating a request for a Type-3 HARQ-ACK codebook report without scheduling PDSCH is missing for $T\_{proc,2}^{mux}$ calculation.***Summary of change***: Add the DCI format 1\_1 providing the indication of a request for a Type-3 HARQ-ACK codebook report without scheduling PDSCH in the paragraphs of $T\_{proc,2}^{mux}$ calculation in Clause 9.2.5.**Refer to R1-2102587 for the detailed CR.** | R1-2102587  |

**Proposal 2**: agree on the CR in R1-2102587

Companies are invited to comment on proposal 2 using the table below.

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| **Company** | **Comment** |
| OPPO | We support this TP.  |
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# References

[R1-2102325](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102325.zip) Maintenance on channel access and HARQ procedures for NR Unlicensed Huawei, HiSilicon

[R1-2102367](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102367.zip) Discussion on the remaining issues of HARQ enhancements OPPO

[R1-2102587](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102587.zip) Correction on multiplexing timeline definition for Type-3 HARQ-ACK codebook CATT, Huawei, HiSilicon, OPPO

[R1-2103336](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103336.zip) Remaining issues of UL channels and HARQ procedure for NR-U LG Electronics

# Annex 1: TP1

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| ***Reason for change:*** | The construction of the Type-3 HARQ-ACK codebook may result in a codebook size mismatch between UE and gNB, if the UE determined that it has not yet obtained HARQ-ACK information for a TB corresponding to a scheduled PDSCH reception, but the gNB determined otherwise. |
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| ***Summary of change:*** | Specify that if the UE has not yet obtained HARQ-ACK information for a TB and a HARQ process, the UE shall report NACK for the corresponding TB and HARQ process in the Type-3 HARQ-ACK codebook. |
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| ***Consequences if not approved:*** | UE and gNB may have a different assumptions on the size (number of bits) reported by the UE in the Type-3 HARQ-ACK codebook, leading to HARQ failure. |

================== Start of TP#1 for TS 38.213 v16.5.0 ===================

**9.1.4 Type-3 HARQ-ACK codebook determination**

If a UE is provided *pdsch-HARQ-ACK-OneShotFeedback*, the UE determines $\tilde{o}\_{0}^{ACK},\tilde{o}\_{1}^{ACK},…,\tilde{o}\_{O\_{ACK}-1}^{ACK}$ HARQ-ACK information bits, for a total number of $O\_{ACK}$ HARQ-ACK information bits, of a Type-3 HARQ-ACK codebook according to the following procedure.

Set $N\_{cells}^{DL}$ to the number of configured serving cells

Set $N\_{HARQ,c}^{DL}$ to the value of *nrofHARQ-ProcessesForPDSCH* for serving cell $c$, if provided; else, set $N\_{HARQ,c}^{DL}=8$

Set $N\_{TB,c}^{DL}$ to the value of *maxNrofCodeWordsScheduledByDCI* for serving cell $c$ if *harq-ACK-SpatialBundlingPUCCH* is provided and $NDI\_{HARQ}=0$, or if *harq-ACK-SpatialBundlingPUCCH* is not provided, or if *maxCodeBlockGroupsPerTransportBlock* is provided for serving cell $c$; else, set $N\_{TB,c}^{DL}=1$

Set $N\_{HARQ-ACK,c}^{CBG/TB,max}$ to the number of HARQ-ACK information bits per TB for PDSCH receptions on serving cell $c$ as described in Clause 9.1.1 if *maxCodeBlockGroupsPerTransportBlock* is provided for serving cell $c$ and *pdsch-HARQ-ACK-OneShotFeedbackCBG* is provided; else, set $N\_{HARQ-ACK,c}^{CBG/TB,max}=0$

Set $NDI\_{HARQ}=0$ if *pdsch-HARQ-ACK-OneShotFeedbackNDI* is provided; else set $NDI\_{HARQ}=1$

Set $c=0$ – serving cell index

Set $h=0$ – HARQ process number

Set $t=0$ – TB index

Set $g=0$ – CBG index

Set $j=0$

while $c<N\_{cells}^{DL}$

while $h<N\_{HARQ,c}^{DL}$

if $NDI\_{HARQ}=0$

if $N\_{HARQ-ACK,c}^{CBG/TB,max}>0$

while $t<N\_{TB,c}^{DL}$

while $g<N\_{HARQ-ACK,c}^{CBG/TB,max}$

= HARQ-ACK information bit for CBG $g$ of TB $t$ for HARQ process number $h$ of serving cell $c$, if any; else, 

$j=j+1$

$g=g+1$

end while

= NDI value indicated in the DCI format corresponding to the HARQ-ACK information bit(s) for TB $t$ for HARQ process number $h$ on serving cell $c$, if any; else, 

$g=0$

$j=j+1$

$t=t+1$

end while

else

while $t<N\_{TB,c}^{DL}$

= HARQ-ACK information bit for TB $t$ for HARQ process $h$ of serving cell $c$, if any; else, 

$j=j+1$

= NDI value indicated in the DCI format corresponding to the HARQ-ACK information bit(s) for TB $t$ for HARQ process number $h$ on serving cell $c$, if any; else, 

$j=j+1$

$t=t+1$

end while

end if

$t=0$

else

if $N\_{HARQ-ACK,c}^{CBG/TB,max}>0$

while $t<N\_{TB,c}^{DL}$

if UE has reported HARQ-ACK information for TB $t$ for HARQ process number $h$ on serving cell $c$, and has not subsequently detected a DCI format scheduling a PDSCH reception, or received a SPS PDSCH, with TB $t$ for HARQ process number $h$ on serving cell $c$

while $g<N\_{HARQ-ACK,c}^{CBG/TB,max}$



$j=j+1$

$g=g+1$

end while

end if

if UE has obtained HARQ-ACK information for TB $t$ for HARQ process number $h$ on serving cell $c$ corresponding to a PDSCH reception and has not reported the HARQ-ACK information corresponding to the PDSCH reception

while $g<N\_{HARQ-ACK,c}^{CBG/TB,max}$

= HARQ-ACK information bit for CBG $g$ of TB $t$ for HARQ process number $h$ of serving cell $c$

$j=j+1$

$g=g+1$

end while

end if

if UE has not obtained HARQ-ACK information for TB $t$ for HARQ process number $h$ on serving cell $c$

while $g<N\_{HARQ-ACK,c}^{CBG/TB,max}$



$j=j+1$

$g=g+1$

end while

end if

$g=0$

$t=t+1$

end while

else

while $t<N\_{TB,c}^{DL}$

if UE has reported HARQ-ACK information for TB $t$ for HARQ process number $h$ on serving cell $c$ and has not subsequently detected a DCI format scheduling a PDSCH reception, or received a SPS PDSCH, with TB $t$ for HARQ process number $h$ on serving cell $c$

= NACK

$j=j+1$

$t=t+1$

end if

if UE has obtained HARQ-ACK information for TB $t$ for HARQ process number $h$ on serving cell $c$ corresponding to a PDSCH reception and has not reported the HARQ-ACK information corresponding to the PDSCH reception

if *harq-ACK-SpatialBundlingPUCCH* is not provided

= HARQ-ACK information bit for TB $t$ for HARQ process $h$ of serving cell $c$

else

= binary AND operation of the HARQ-ACK information bits corresponding to first and second transport blocks for HARQ process $h$ of serving cell $c$. If the UE receives one transport block, the UE assumes ACK for the second transport block

end if

$j=j+1$

$t=t+1$

end if

if UE has not obtained HARQ-ACK information for TB $t$ for HARQ process number $h$ on serving cell $c$

= NACK

$j=j+1$

$t=t+1$

end if

end while

end if

$t=0$

end if

$h=h+1$

end while

$h=0$

$c=c+1$

end while

If $N\_{TB,c}^{DL}>1$, when a UE receives a PDSCH with one transport block, the HARQ-ACK information is associated with the first transport block.

If a UE receives a SPS PDSCH, or a PDSCH that is scheduled by a DCI format 1\_0 for a serving cell $c$ and if *maxCodeBlockGroupsPerTransportBlock* is provided for serving cell $c$, and *pdsch-HARQ-ACK-OneShotFeedbackCBG* is provided, the UE repeats $N\_{HARQ-ACK,c}^{CBG/TB,max}$ times the HARQ-ACK information for the transport block in the PDSCH.

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.

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. The UE is expected to provide HARQ-ACK information in response to the request for the Type-3 HARQ-ACK codebook after $N$ symbols from the last symbol of a PDCCH providing the DCI format, where the value of $N$ for $μ=0,1,2$ is provided in Clause 10.2 by replacing "SPS PDSCH release" with "DCI format".

If a UE multiplexes HARQ-ACK information in a PUSCH transmission, the UE generates the HARQ-ACK codebook as described in this Clause except that *harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*.

================== End of TP#1 for TS 38.213 v16.5.0 ===================