**3GPP TSG RAN WG1 Meeting #101-e                     R1-200xxxx**

**e-Meeting, May 25th – June 5th, 2020**

**Agenda Item: 7.2.2.2.3**

**Source: Moderator (Huawei)**

**Title: Feature lead summary#1 on 101-e-NR-unlic-NRU-HARQ-02 (Type-3 HARQ-ACK codebook)**

**Document for: Discussion and Decision**

# Introduction

This document provides updated proposals on issues B2, B6 and B11 that are prioritized for RAN1#101e among the issues identified for the **NR-U Type-3 HARQ-ACK codebook** [1].

[101-e-NR-unlic-NRU-HARQ-02] Email discussion/approval on issues B2, B6 and B11 from R1-2004692 until 5/29; if necessary, endorse associated TPs by 6/4 – David (Huawei)

* Issue B2: Corrections in handling of spatial bundling
* Issue B6: Handling of collisions between SPS-release ACK and Type-3 HARQ-ACK codebook feedback
* Issue B11: Timeline for UCI Piggybacked on PUSCH for Type-3 HARQ-ACK codebook

Each sub-section per issue includes an initial FL proposal based on the summary of the submitted Tdocs, and provides a table for collecting companies’ views on the FL’s proposal.

# Issue B2

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| B2 | Corrections in handling of spatial bundling for Type-3 HARQ-ACK codebook |

A problem was found in TS38.913 clause 9.1.3.4 when if *harq-ACK-SpatialBundlingPUCCH* is provided; else and , then HARQ-ACK feedback is provided for just one TB even if *maxNrofCodeWordsScheduledByDCI* = 2 for serving cell , without AND operation. In the same case in case reporting of NDI is configured, then NDI for just one TB is reported.

The following alternatives have been proposed in contributions and during the feedback of the preparation phase of RAN1#101-e:

* Alt1: spatial bundling is never applied to type-3 HARQ-ACK codebook even if *harq-ACK-SpatialBundlingPUCCH* is provided.
* Alt2: spatial bundling is applied to type-3 HARQ-ACK codebook when *harq-ACK-SpatialBundlingPUCCH* is provided, with AND operation for 2 TBs and with AND operation for 2 NDIs corresponding to the 2 TBs.
* Alt3: Spatial bundling is applied to Type-3 HARQ-ACK codebook, with AND operation for 2 HARQ-ACKs corresponding to 2 TBs and with 1 NDI for the first TB.
* Alt4: spatial bundling is never applied to type-3 HARQ-ACK codebook with CBG-based HARQ configured, otherwise spatial bundling is applied to type-3 HARQ-ACK codebook when *harq-ACK-SpatialBundlingPUCCH* with AND operation for 2 TBs followed with NDI bits for each TB in order of increasing TB index.

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| **Company** | **Summary of proposals** |
| Huawei, HiSilicon (R1-2003514), Nokia (R1-2004257), Ericsson (R1-2003845), ZTE, Sanechips (R1-2003452), Qualcomm (prefer a simple correction, e.g. spatial bundling not allowed for Type-3), Nokia, NSB, ZTE, Mediatek, Sharp (when NDI is reported), Intel, OPPO | Alt1 (14 companies) |
| Lenovo, Motorola Mobility (R1-2003823) | Alt2 |
| LG (R1-2004015), Lenovo, Motorola Mobility | Alt3 |
| Vivo (R1-2003372), OPPO (R1-2004087), Samsung | Alt4 |

FL Proposal: agree on Alt1

* Spatial bundling is never applied to type-3 HARQ-ACK codebook even if harq-ACK-SpatialBundlingPUCCH is provided.
* Approve the corresponding TP below

**TP for TS 38.213 Clause 9.1.4**

============================= Unchanged part omitted ============================

Set to the value of *maxNrofCodeWordsScheduledByDCI* for serving cell.*harq-ACK-SpatialBundlingPUCCH* is not applicable.============================= Unchanged part omitted ============================

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| **Company** | **Comments on FL proposal** |
| Ericsson | Agree with the proposal. |
| Nokia, NSB | Agree with QC, simple correction is preferred here. |
| QC | Agree with the proposal. |
| Samsung | Support Alt 4, because Alt 4 reuses Rel-15 rule for HARQ-ACK bundling and keeps separate NDI for scheduling flexibility. |
| ZTE | Agree with the proposal |
| MediaTek | Agree with the proposal |
| LG | Technically, considering the UE situation where spatial bundling needs to be configured for UL overhead, Alt 3 is desirable.  One question to Alt 1:  Does it mean that spatial bundling is not applied for both the case with NDI and the case without NDI? or spatial bundling is not applied only for the case with NDI while it is applied for the case without NDI? |
| Sharp | We are generally fine with the proposed TP, except for one concern: what if NDI reporting is configured to be off? The restriction then seems to be too much. |
| Lenovo, Motorola Mobility | Either Alt 2 or Alt 3 is preferred to us.  In addition, we have same question as LG. |
| vivo | Agree with Samsung, Alt 4 is preferred for compatibility with Rel-15 rules.  In addition, we have same question as LG. For the case without NDI, there is no any issue to support spatial bundling for type 3 codebook. |
| Intel | We prefer Alt 1 for the simplicity.  In fact, even Alt 3 or 4 is supported, the largest gain is 25% which is for the case that all cells are configured with 2 TBs. |
| OPPO | Although we prefer Alt-4, but for the sake of progress, we can accept majority view to go with FL’s proposal for simplicity. |
| FL summary | Thank you for the feedback. A large majority of 13 companies prefer Alt1 as a simple solution, while none of the other alternatives is supported by more than 3 companies.  Some companies who support Alt2/3/4 may be ok with Alt1 when reporting NDI is configured, but prefer to apply spatial bundling when reporting NDI is not configured.  There were questions for clarification on Alt1. The intent of Alt1 is to apply to all cases, whether reporting NDI is configured or not configured.  If reporting NDI is not configured, then Alt2/3/4 become the same except for a difference in Alt4, which is like Alt1 with CBG-based HARQ configured.  As a compromise, one possibility could be to consider supporting spatial bundling only when CBG-based HARQ is not configured and reporting NDI is not configured.  Further views from companies who support Alt1 are welcome. |
| Nokia, NSB | We are OK with both (i) not supported or (ii) supported only for the case without NDI configured |
| Intel | We agree with the proposal and are also OK to limit it to the case that the report of NDI is configured. One suggestion, to cover the case of HARQ-ACK on PUSCH, the proposal can be revised to   * Spatial bundling is never applied to type-3 HARQ-ACK codebook even if *harq-ACK-SpatialBundlingPUCCH* or *harq-ACK-SpatialBundlingPUSCH* is provided. |
| Lenovo, Motorola Mobility | For sake of progress, we are fine with adding restriction on spatial bundling.  So the modified proposal 1 could be listed below for reference:   * When spatial bundling is configured,   + if neither CBG-based retransmission nor NDI reporting is configured, spatial bundling is applied.   + Otherwise, spatial bundling is not applied. |
| QC | We prefer to not support in both cases of NDI is reported and NDI is not reported. Main reason is that this is a corner case (UE supports >4 layers is configured with spatial bundling) with marginal benefit (overhead reduction is not the main goal in Type-3) and perhaps changes the current pseudocode considerably (conditions / loops are different depending on CBG configuration / NDI reporting configuration). Having said that, we would be ok to limit it to the case that the report of NDI is configured, if majority support that option. |
| Samsung | For the sake of progress, we’re fine with FL’s proposal. |
| vivo | We still think Alt4 is reasonable to be compatible with NR Rel-15. As a compromise, we can accept to support spatial bundling only when CBG-based HARQ is not configured and reporting NDI is not configured. |
| LG | Given the situation and for the progress, I can live with FL’s proposal to support Alt 1 with the following condition and clarification.  - Alt 1 is only applied for the case with NDI report. In other words, spatial bundling configuration is still applied for the case without NDI report.  - Regarding the case with CBG retransmission, no clarification is needed since it had been concluded in Rel-15 that CBG retransmission and spatial bundling are never configured together. |
| OPPO | For NDI, we prefer a simple solution that does not differentiate report/non-report NDI cases.  For CBG, we agree with LG, no further clarifications are needed. |
| FL summary#2 | After the short online discussion, a possible compromise proposal is re-formulated as Alt5:  Alt5:   * UE is not expected to be configured simultaneously with Type-3 HARQ-ACK codebook, spatial bundling and CBG-based HARQ * If spatial bundling is configured and CBG-based HARQ is not configured   + spatial bundling is applied if NDI reporting is not configured in type-3 HARQ-ACK codebook,   + otherwise, spatial bundling is not applied.   There were questions on the complexity of the TP corresponding to the second sub-bullet. Related TPs were submitted in R1-2003823, R1-2004015, R1-2003372, R1-2004087. For example, OPPO’s TP in 4087 is the following:  if  <Unchanged parts are omitted>  else  while  if UE has reported HARQ-ACK information for TB for HARQ process number on serving cell and has not subsequently detected a DCI format scheduling a PDSCH reception, or received a SPS PDSCH, with TB for HARQ process number on serving cell  = NACK      end if  if UE has obtained HARQ-ACK information for TB for HARQ process number on serving cell 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 for HARQ process of serving cell    else  = binary AND operation of the HARQ-ACK information bits corresponding to first and second transport blocks for HARQ process of serving cell - if the UE receives one transport block, the UE assumes ACK for the second transport block;  end if    end if  end while |

# Issue B6

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| B6 | Handling of collisions between SPS-release Ack and type-3 HARQ-ACK codebook feedback, potential inclusion of a SPS release HARQ-ACK in Type 3 HARQ-ACK codebook (not currently specified) |

FL view: V16.1.0 of the specifications imply that SPS release HARQ-ACK would be dropped in case of collisions with reporting of type-3 HARQ-ACK codebook in the same slot. The discussion is on the case where different DCIs indicate the same slot for type-3 HARQ-ACK codebook feedback and HARQ-ACK feedback for SPS release.

The following alternatives have been proposed in contributions to RAN1#101-e.

If a UE is scheduled to report Type 3 HARQ-ACK codebook feedback and a HARQ-ACK bit corresponding to the SPS PDSCH release in the same PUCCH occasion:

* Alt1: Type 3 HARQ-ACK codebook does not include the HARQ-ACK for SPS release
* Alt2: allow reporting HARQ-ACK feedback for SPS release in a Type-3 HARQ-ACK codebook
  + Alt2a: the HARQ-ACK bit corresponding to the SPS PDSCH release is appended at the end of the Type 3 HARQ-ACK codebook, e.g. using a reserved bit
  + Alt2b: The HARQ-ACK bit corresponding to the SPS PDSCH release is placed at the first position then followed by the HARQ-ACK information bits for DL HARQ processes
  + Alt2c: HARQ-ACK bit corresponding to a SPS PDSCH release is mapped to a HARQ process in the Type-3 HARQ-ACK codebook
    - Alt2c-1: Explicit indication, e.g. by TDRA field in the DCI format indicating the SPS release, or as well as by the slot/symbol where the SPS release DCI is detected.
    - Alt2c-2: The HARQ-ACK information bit(s) of the HARQ process of the latest received SPS PDSCH in one-shot HARQ-ACK codebook is replaced by the HARQ-ACK information bit of the DCI indicating SPS release
    - Alt2c-3: A UE reports HARQ-ACK at HARQ process number corresponding to a earliest DL SPS PDSCH occasion after the SPS PDSCH release, where the earliest PDSCH occasions is defined as the earliest among the released DL SPS configuration(s), and at least N symbols after the SPS PDSCH release. HARQ process association between the DL SPS PDSCH occasion and HARQ process number is specified in [38.321 (MAC)]

An initial summary of companies’ views on the above alternatives (from submitted Tdocs) is the following:

Alt1: ZTE, Sanechips

Alt2: Huawei, HiSilicon, Ericsson, Qualcomm, OPPO, vivo, Lenovo, Motorola Mobility, Intel, Nokia, Nokia Shanghai Bell

* + Alt2a: Huawei, HiSilicon, Ericsson, Qualcomm, OPPO, Lenovo, Motorola Mobility, MediaTek, LG, Sharp, [ZTE Sanechips also for HARQ-ACK feedback for SCell dormancy]
    - Using one reserved bit: Qualcomm, Huawei, HiSilicon
    - Not using a reserved bit: Ericsson
  + Alt2b: Lenovo, Motorola Mobility
  + Alt2c-1:Intel
  + Alt2c-2: Samsung
  + Alt2c-3: Nokia, Nokia Shanghai Bell, vivo

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| **Company** | **Comments on the alternatives above** |
| Ericsson | Alt2a. However, we support to add the bit only when a DCI indicating SPS release and same PUCCH occasion is detected. and not to have a reserved bit that is always present. |
| Nokia, NSB | Alt 2 a/b: increases CB overhead and reduces reliability and requires specification effort of adding additional sub-codebook of up to 8bits per cell (8 configurations per BWP and cell are supported in R16), which was not welcome in case of NN-K1 and TYPE-1 CB.  Alt 2c solutions are simple, but we prefer Alt 2c-3 because  Alt 2c-1: TDRA may not have sufficient size in case of DCI format 1-1, i.e. it may not cover all HARQ processes  Time domain resource assignment – 0, 1, 2, 3, or 4 bits as defined in Clause 5.1.2.1 of [6, TS 38.214]. The bitwidth for this field is determined as bits, where *I* is the number of entries in the higher layer parameter *pdsch-TimeDomainAllocationList* if the higher layer parameter is configured; otherwise *I* is the number of entries in the default table.  Alt 2c-2: mixes HARQ processes of last DL SPS and DL SPS release, if release is transmitted before last DL SPS PDSCH HARQ-ACK, there is an ambiguity.  Alt 2c-3: the next HARQ process ID is used, which is deterministic and simple to implement. |
| QC | Support Alt2a. If a bit is added dynamically, there will be codebook size mismatch issues. If SPS is configured, the bit should be always there. The overhead (1 bit) is anyway negligible since the size of Type-3 codebook is large.  It should be noted that only 1 bit is enough in Alt2a.   * Within one CC: For the case of multiple SPS configurations, why would gNB releases multiple SPS configs at the same time within one CC using different DCIs? One DCI can release multiple SPS configs in Rel. 16, and in this case only 1 bit A/N is needed (this is the case also in Type-1/Type2 codebook). * Across CCs: Still 1 bit is enough in total. If SPS is released in different CCs at the same time (within the same HARQ-Ack opportunity), Ack is reported as long as at least one SPS release DCI is detected. Otherwise, Nack is reported. If gNB requires per SPS release DCI A/N while at the same time Type-3 is requested, it can release SPS configs in different CCs at different times. In other words, 1 bits (in total) for SPS release in Type-3 codebook per HARQ-Ack opportunity is sufficient.   Regarding Alt3, there are issues if the SPS release DCI is missed (UE reports Ack for that HARQ ID since the previous PDSCH for that HARQ-ID is successfully decoded, but gNB thinks that the Ack is for SPS release). |
| Samsung | It is not desirable to increase one-shot codebook size with many bits of SPS release HARQ-ACK. It is noted that, although Rel-16 supports multiple SPS release by single DCI, it is still possible that each release state only includes some of SPS configurations, e.g. totally 8 SPS configurations and ‘0’ indicates SPS configuration 1~4 and ‘1’ indicates SPS configuration 5~8. And also it is impossible to release SPS configurations of multiple CCs by single DCI. Consequently, it would require more than 1 bits for SPS release HARQ-ACK for more than 1 CC. To control codebook size increase, companies propose adding 1 bit. The problem is, with 1 bit HAR-ACK and “Ack is reported as long as at least one SPS release DCI is detected. Otherwise, Nack is reported”, gNB does not know which SPS release DCI is lost, then, gNB has to retransmit all SPS release DCIs again. Therefore, Alt 2a/2b is not preferred.  Alt 2c does not increase codebook size, and can support HARQ-ACK of single or multiple SPS release DCIs. We prefer Alt 2c-2. Typically, gNB releases a SPS PDSCH after gNB receives HARQ-ACK of this SPS PDSCH, so there is no ambiguity. |
| ZTE | Still we think this is not a critical issue since the gNB can avoid indicating the same slot for type-3 HARQ-ACK codebook feedback and HARQ-ACK feedback for SPS release.  If the majority think it should be specified, Alt.2a seems more acceptable as it is similar as that for enhanced type-2 codebook. Another relevant point is, if reporting HARQ-ACK feedback for SPS release in a Type-3 HARQ-ACK codebook is allowed, shall we also support the HARQ-ACK feedback for SCell dormancy in a Type-3 HARQ-ACK codebook? |
| MediaTek | Support Alt2a. Share similar view with QC. |
| LG | Alt2a is preferred.  That is, HARQ-ACK (1-bit) corresponding to the SPS PDSCH release is appended at the end of Type-3 codebook. |
| Sharp | We prefer Alt2a. As explained by QC, one dedicated bit for SPS release is sufficient, even for releasing multiple SPS. The solution of Alt2a is simple without ambiguity. The concern then is whether it is worth to add the dedicated bit. |
| Lenovo, Motorola Mobility | Either Alt 2a or Alt 2b is preferred to us.  Compared to possible huge HARQ-ACK codebook size for one-shot feedback, the overhead of adding one bit for indicating DL SPS release is negligible. |
| vivo | We prefer Alt 2c-3.  For Alt 2a/2b, we share the same view as Samsung. Compatibility with multiple SPS configurations per CC and for multiple CCs should be considered.  For Alt2c-1, as pointed out by Nokia, TDRA may not have sufficient size in case of DCI format 1-1 if the HARQ process ID is explicitly indicated by TDRA. So, we prefer to determine a SPS PDSCH occasion based on assistant information indicated by TDRA field, or as well as the slot/symbol where the SPS release DCI is detected. For example, the TDRA field of SPS release DCI could indicate a time domain offset for determining a SPS PDSCH occasion.  Alt 2c-2 has a drawback when both HARQ-ACK for the last SPS PDSCH and SPS release for this SPS configuration are needed to be fed back in the same PUCCH slot.  For Alt 2c-3, a HARQ process corresponding to the earliest SPS PDSCH occasion after the SPS release DCI is used. It is simple without ambiguity. |
| Intel | Alt 2a/2b have large overhead to be a robust solution, which should be a critical design target for one-shot feedback. Otherwise, if one-shot feedback is not robust, we fail to see the value to introduce it.  In Alt 2a/2b, if multiple SPS configurations are configured and UE only report single bit for SPS release, gNB cannot know if UE actually release a SPS PDSCH or not. How about HARQ-ACK feedback in next PUCCH location for a potentially released SPS configuration? There is confusion on codebook size if gNB and UE has different understanding.  We prefer Alt 2c-1.  Alt 2c-1 is more flexible comparing with Alt-2c-2/-3, since gNB has the freedom to select an unused HARQ process number. We confirm the comments from Nokia that it is up to gNB to select bit size of TDRA field. However, in normal case, TDRA should not be too small size, otherwise a most important feature of NR is lost. Even in case bit size < 4, it is up to gNB to assign a HARQ process number by limit-size TDRA, which is still applicable. |
| OPPO | Alt-2a |
| FL summary | Here is a brief summary, suggesting that we may continue the discussion on Alt2a (10 companies) vs. Alt2c-3 (3 companies), and stop discussing the other alternatives that are not supported by more than 1 or 2 companies.  Alt2b: According to Lenovo’s feedback we may be able to remove Alt2b.  Alt2c-1: concerns on insufficient size of TDRA field, no additional support was expressed for this alternative, and if other fields should also be considered to increase the bit-size then the proposal is not complete. Vivo expressed a preference for Alt2c-3, leaving Alt2c-1 the preference of a single company.  Alt2c-2: two companies mentioned that there is there is an ambiguity if release is transmitted before last DL SPS PDSCH HARQ-ACK, while Alt2c-2 is supported by just one company.  Alt2c-x (including Alt2c-3): concerns on the robustness to missing a SPS release DCI, leading to ambiguity for the HARQ process(es) assumed by gNB for SPS release bit(s) in the Type-3 HARQ-ACK codebook..  Alt2a: concerns on overhead, but there is no common understanding on the number of bits to be added to the type-3 codebook: 1 (Qualcomm) or up to 8 (Nokia). Intel pointed out that if only 1 bit is used for SPS release and if one SPS release DCI is missed, there might be ambiguity for the corresponding HARQ process ID in the next HARQ-ACK report (e.g. in Type-2 HARQ-ACK codebook).  Let’s try to clarify the understanding on the overhead of Alt2a, and on the robustness of Alt2a and Alt2c-3. Companies are also invited to provide their views on Alt2a, whether a reserved bit is used or a bit is appended only if the UE received a DCI with a SPS release validation.  So let’s continue the discussion on Alt2a and Alt2c-3. Please use further rows below to address the remaining questions on Alt1a and Alt2c-3. Thank you.   * Alt2a: Huawei, HiSilicon, Ericsson, Qualcomm, OPPO, Lenovo, Motorola Mobility, MediaTek, LG, Sharp, [ZTE, Sanechips]   + Using one reserved bit: Qualcomm, Huawei, HiSilicon   + Not using a reserved bit: Ericsson * Alt2c-3: Nokia, Nokia Shanghai Bell, vivo |
| Nokia, NSB | We understand that there are in fact 3 alternatives on the table   * Alt2a: Huawei, HiSilicon, Ericsson, Qualcomm, OPPO, Lenovo, Motorola Mobility, MediaTek, LG, Sharp, [ZTE, Sanechips]   + Alt2a-1:Using one reserved bit: Qualcomm, Huawei, HiSilicon   + Alt2a-2:Not using a reserved bit: Ericsson * Alt2c-3: Nokia, Nokia Shanghai Bell, vivo   **Overhead**  How many bits are needed in Alt2a, depends on whether gNB bundles SPS configuration in *ReleaseStateList* or not. It may prefer to have flexibility to release each configuration separately, based on scenario. 1 bit is insufficient.  If a UE is provided more than one configurations for UL grant Type 2 PUSCH or for SPS PDSCH  - if the UE is provided *Type2Configuredgrantconfig-ReleaseStateList* or *SPS-ReleaseStateList*, a value of the HARQ process number field in a DCI format indicates a corresponding entry for scheduling release of one or more UL grant Type 2 PUSCH or SPS PDSCH configurations  - if the UE is not provided *Type2Configuredgrantconfig-ReleaseStateList* or *SPS-ReleaseStateList*, a value of the HARQ process number field in a DCI format indicates a release for a corresponding UL grant Type 2 PUSCH or for a SPS PDSCH configuration with a same value as provided by *Configuredgrantconfig-index* or by *SPSconfig-index*, respectively  **Robusteness**  the issue pointed out by QC can be handled by gNB   1. If gNB does not configure NDI in TYPE-3 CB, no issue 2. If gNB does configure NDI in TYPE-3 CB, then if gNB schedules TYPE-3 CB between DL SPS release and next DL SPS PDSCH occasion, then indeed gNB could report HARQ-ACK for the previous TB scheduled long time ago. This can be avoided by gNB, and if this corner case is deemed to be addressed, there are two simple options    1. UE toggles NDI for SPS release in HARQ-ACK CB    2. UE resets TB and HARQ-ACK of HARQ-process ID for DL SPS PDSCH occasion n after DL SPS PDSCH occasion n-1 |
| Intel | There are multiple combinations of error cases of reporting single bit for SPS release in Alt 2a. Please find just one of them.  Assuming 2 SPS release are transmitted by gNB but UE only receives one of them. In fact, gNB doesn’t know which SPS release is missed by UE.  - UE misses the last dynamic DCI scheduling PDSCH, so number of HARQ-ACK for dynamic PDSCH is reduced by 1;  - For the SPS process that is missed by UE, i.e. UE will still append a bit for SPS PDSCH for the SPS process, which results in one extra reported bit;  Finally, by combining above two bullets, UE gets a codebook size which is exactly expected by gNB. gNB cannot differentiate if UE receives all dynamic PDSCHs or wrongly appends a bit for SPS.  I hope companies can reconsider Alt2c-2. Alt2c-3 just give one HARQ process number, which Alt2c-2 allows one from multiple values. Therefore, Alt2c-2 is at least not worse than Alt2c-3. |
| Lenovo, Motorola Mobility | For Alt 2a, we support the number of HARQ-ACK info bits for DL SPS release is reserved in Type 3 HARQ-ACK codebook since Type 3 HARQ-ACK codebook size is mainly dependent on RRC configured numbers, e.g., RRC configured number of DL HARQ processes, RRC configured number of cells, RRC configured number of CBGs per TB, etc.  Regarding the number of reserved bits for DL SPS release, it can be set to the number of activated SPS configurations. |
| QC | From robustness point of view, we still think that Alt2a-1 is the best option. From overhead point of view, Alt2a-1 only adds one bit, which is negligible.  Response to Nokia: Regarding number of bits, we do see any reason why 1 bit cannot work. Also, SPS activation / release is not a frequently-sent DCI. Now, what are the chances that multiple SPS’s are released at the same time, with different DCIs, and simultaneously Type-3 is requested? Even if this happens, gNB is aware of the fact that Ack means at least one of them is received while Nack means none of them are received, and nothing breaks.  You mentioned the robustness issue in Alt2c can be handled by gNB, but the solutions seem to have specification impact. Even then, there are issues: In option a), how does the gNB distinguish between previous DCI scheduling the TB for that HARQ-ID is missed or SPS release is missed (In both cases, from gNB point of view, a toggled NDI with Ack is received).  Response to Intel: The case you mentioned cannot happen in Alt2a-1 as 1 bit is always appended. If last DCI is missed, the codebook size is not matched. Not sure if you had other alternatives in mind for the example. |
| Samsung | For Alt 2a, as we previously commented and also mentioned by other companies, if HARQ-ACK of more than one SPS release DCIs in one PUCCH, error case happens. If gNB only knows at least one of SPS release DCI is received without knowing which release DCI is lost, how to gNB know whether to retransmit which release DCI, and which SPS PDSCHs are released so that no HARQ-ACK of these SPS PDSCHs expected in next PUCCH (next PUCCH maybe a type-2 codebook, and codebook size ambiguity happens as mentioned by Intel). If we restrict only single SPS release DCI in one PUCCH, the scheduling flexibility is obviously degraded. In scenarios gNB firstly transmits DCIs indicating type-2 codebook, gNB may not predict whether to trigger type-3 codebook later. If type-3 codebook can only support 1 bit for SPS release DCI, gNB should avoid HARQ-ACK of multiple SPS release DCIs in one PUCCH even for type-2 codebook. Consequently, both type-2 and type-3 codebook suffers undesirable scheduling restriction.  For Alt 2c-3, the ambiguity happens if (1) NDI is configured in type-3 codebook (2) NDI is the same for SPS release DCI and the corresponding HARQ process. It seems gNB can avoid such ambiguity by proper scheduling as mentioned by Nokia. So, we support Alt 2c-3. |
| vivo | For the overhead of Alt2a, 1 bit is not sufficient for flexibility to release a SPS configuration the case of multiple SPS configurations,  For the ambiguity issue raised for Alt2c-3, it can be solved by gNB implementation. |
| Ericsson | we are not sure why we are considering complicated optimization when this whole issue is not a common case. We keep complicating the design by focusing on corner cases. We are not OK with adding reserved bits to the codebook to resolve a corner case of missing DCIs. Please remember that the gNB has the flexibility to NOT request the feedback for an SPS release and Type 3 HARQ codebook in the same PUCCH. Having said that, we do not accept include the feedback for SPS release in a Type-3 codebook by assigning a HARQ ID to it. This will cause other issues if the gNB actually is using this HARQ process in a dynamically scheduled PDSCH. and we also do not accept to take the overhead hit by reserving bits. QC questions the probability of sending multiple SPS releases at the same time, we would also question the probability of sending SPS release and one feedback trigger at the same time and in the same PUCCH resource.  If companies think that missing the SPS release DCI is an issue, we prefer to assume that the gNB will not trigger and SPS release ACK and Type 3 codebook in the same PUCCH and not to discuss any of those optimizations .. |
| LG | We agree with QC that the alternatives using HARQ-ACK bit corresponding certain HARQ process index would cause potential critical DTX-to-ACK problem which would be involved with RLC retransmission and other side effect. Thus, Alt2a is preferred for avoidance of such critical error case. |
| OPPO | We agree with QC. |
| FL summary#2 | Views are still split mostly among multiple alternatives:   * Alt1: gNB avoids collisions of SPS release feedback and type-3 CB   + - Supported by: ZTE, Sanechips     - Acceptable to Ericsson * Alt2a: the HARQ-ACK bit corresponding to the SPS PDSCH release is appended at the end of the Type 3 HARQ-ACK codebook   + - Supported by: Huawei, HiSilicon, Ericsson, Qualcomm, OPPO, Lenovo, Motorola Mobility, MediaTek, LG, Sharp,     - Acceptable to ZTE Sanechips     - Concerns from Nokia, NSB, vivo, Intel, Samsung   + Alt2a-1: Alt2a using one reserved bit:     - Supported by Qualcomm, Huawei, HiSilicon     - Concerns from Ericsson   + Alt2a-2: Alt2a using one or more reserved bits     - Supported by: Lenovo, Motorola Mobility   + Alt2a-3: Alt2a not using a reserved bit     - Supported by: Ericsson * Alt2c: HARQ-ACK bit corresponding to a SPS PDSCH release is mapped to a HARQ process in the Type-3 HARQ-ACK codebook   + - Supported by: Intel, Samsung, Nokia, NSB, vivo     - Concerns from Qualcomm, Ericsson, OPPO, LG   + Alt2c-1:     - Supported by: Intel   + Alt2c-2:     - Supported by: Samsung   + Alt2c-3:     - Supported by: Nokia, NSB, vivo, Samsung   Alt1 was re-instated as it would be the de-facto consequence if no consensus can be found on a variant of Alt2a or Alt2c. Alt1 would not require a TP. |
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| **Company** | **Summary of proposals from submitted Tdocs** |
| vivo  (R1-2003372) | Proposal 7: Support HARQ-ACK feedback for SPS PDSCH release in one-shot HARQ-ACK codebook. HARQ-ACK corresponding to a SPS PDSCH release is mapped to a HARQ process in the one-shot feedback, where the HARQ process is determined based on the HARQ process ID derivation for SPS PDSCH in TS38.321 and the SPS PDSCH location for the derivation is determined based on the following options:  • Option 1: A SPS PDSCH location in time domain explicitly indicated by the SPS release DCI, e.g. by TDRA field in the DCI, or as well as by the slot/symbol where the SPS release DCI is detected.  • Option 2: A SPS PDSCH location in time domain implicitly derived according to the SPS configuration to which the SPS release DCI corresponds, e.g. the next SPS PDSCH occasion corresponding to the SPS configuration after the reception of the SPS release DCI. |
| ZTE  (R1-2003452) | For DCI Format 1\_1 with CRC scrambled by CS-RNTI used for SPS-release, if one-shot HARQ-ACK request field is present, UE ignores the value of one-shot HARQ-ACK request field.  Issue B6 can be avoided by gNB scheduling that Type 3 HARQ-ACK codebook does not include the HARQ-ACK for SPS release. |
| Huawei  (R1-2003514) | ***Proposal 5: One bit at the end of Type-3 codebook could be reserved for SPS PDSCH release.***  **TP#7 for TS 38.213 Clause 9.1.4**  === Unchanged part omitted ===  end while      end while    if the UE receives a PDCCH indicating SPS PDSCH release and indicating a same slot for Type-3 codebook transmission by PDSCH-to-HARQ\_feedback timing indicator field  = ACK  else  = NACK  If a UE receives a SPS PDSCH, or a PDSCH that is scheduled by a DCI format 1\_0 for a serving cell and if *maxCodeBlockGroupsPerTransportBlock* is provided for serving cell , and *pdsch-HARQ-ACK-OneShotFeedbackCBG-r16* is provided, the UE repeats times the HARQ-ACK information for the transport block in the PDSCH.  === Unchanged part omitted === |
| Lenovo  (R1-2003823) | The bit for DL SPS release is placed at the first position then followed by the HARQ-ACK information bits for DL HARQ processes.  Proposal 2: HARQ-ACK information bit for DL SPS release is included in Type 3 HARQ-ACK codebook when it is to be transmitted in same slot with the Type 3 HARQ-ACK codebook. |
| Intel  (R1-2003730) | Proposal 2: For SPS PDSCH release, the associated HARQ process ID is indicated by TDRA field in DCI 1\_0 for SPS PDSCH release. 9.1.4 Type-3 HARQ-ACK codebook determination If a UE is provided *pdsch-HARQ-ACK-OneShotFeedback-r16*, the UE determines a Type-3 HARQ-ACK codebook according to the following procedure.  …  If a UE receives a SPS PDSCH, or a PDSCH that is scheduled by a DCI format 1\_0 for a serving cell and if *maxCodeBlockGroupsPerTransportBlock* is provided for serving cell , and *pdsch-HARQ-ACK-OneShotFeedbackCBG-r16* is provided, the UE repeats times the HARQ-ACK information for the transport block in the PDSCH. If a UE receives a SPS PDSCH release, the HARQ process number used in Type-3 HARQ-ACK codebook determination is indicated by time domain resource assignment field in the DCI carrying the SPS PDSCH release.  If the 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 Clause 9.2.5. The UE multiplexes only the Type-3 HARQ-ACK codebook in the PUCCH or the PUSCH for transmission in the slot. |
| Samsung  (R1-2003862) | Proposal 3: Support HARQ-ACK multiplexing of SPS release and one-shot HARQ-ACK feedback at least for the following two cases,  Case a) A first DCI indicates SPS release and a second DCI indicates one-shot HARQ-ACK feedback with HARQ-ACK in the same PUCCH slot.  Case b) One DCI indicates both SPS release and one-shot HARQ-ACK feedback.  Proposal 4: For HARQ-ACK multiplexing of SPS release and one-shot HARQ-ACK feedback, for a SPS PDSCH configured in a serving cell, the HARQ-ACK information bit(s) of the HARQ process of the latest received SPS PDSCH in one-shot HARQ-ACK codebook is replaced by the HARQ-ACK information bit of the DCI indicating SPS release.  **TS 38.213**  **9.1.4 Type-3 HARQ-ACK codebook determination**  ------------------ Unchanged part omitted ------------------------  If a UE receives a SPS PDSCH, or a PDSCH that is scheduled by a DCI format 1\_0 for a serving cell and if *maxCodeBlockGroupsPerTransportBlock* is provided for serving cell , and *pdsch-HARQ-ACK-OneShotFeedbackCBG-r16* is provided, the UE repeats 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 the UE detects a DCI format indicating SPS release for a serving cell c with HARQ-ACK in the same PUCCH slot, the HARQ-ACK information bit(s) of the HARQ process of the latest received SPS PDSCH is replaced by the HARQ-ACK information bit of the DCI format indicating SPS release.  ------------------ Unchanged part omitted ------------------------ |
| Nokia  (R1-2004257) | **Proposal 8:** *A UE reports HARQ-ACK at HARQ process number corresponding to a earliest DL SPS PDSCH occasion after the SPS PDSCH release, where the earliest PDSCH occasions is defined as*   * *the earliest among the released DL SPS configuration(s), and* * *at least N symbols after the SPS PDSCH release.*   *HARQ process association between the DL SPS PDSCH occasion and HARQ process number is specified in [38.321 (MAC)].*  **TP associated with Proposal 8:** 9.1.4 Type-3 HARQ-ACK codebook determination <unchanged text omitted >  If a UE receives a SPS PDSCH, or a PDSCH that is scheduled by a DCI format 1\_0 for a serving cell and if *maxCodeBlockGroupsPerTransportBlock* is provided for serving cell , and *pdsch-HARQ-ACK-OneShotFeedbackCBG-r16* is provided, the UE repeats times the HARQ-ACK information for the transport block in the PDSCH.  If the 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 Clause 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 receives a SPS PDSCH release, UE reports HARQ-ACK at HARQ process number corresponding to the earliest DL SPS PDSCH occasion after the SPS PDSCH release, where the earliest PDSCH occasions is defined as   * the earliest among the released DL SPS configuration(s), and * at least N symbols after the SPS PDSCH release.   HARQ process association between the DL SPS PDSCH occasion and HARQ process number is specified in [38.321 (MAC)]. N is defined in sub-clause 10.2.  <unchanged text omitted > |
| OPPO  (R1-2004087) | Proposal 1: If a UE is triggered to report both one-shot and HARQ-ACK feedback for SPS PDSCH release in the same slot, the HARQ-ACK bit corresponding to the SPS PDSCH release is appended to the HARQ-ACK bits of all HARQ processes. |
| Ericsson  (R1-2003845) | If a UE is scheduled to report Type 3 HARQ-ACK codebook feedback and a HARQ-ACK bit corresponding to the SPS PDSCH release in the same PUCCH occasion, the HARQ-ACK bit corresponding to the SPS PDSCH release is appended at the end of the Type 3 codebook |
| Qualcomm  (R1-2004445) | Proposal 1. If UE is configured with a SPS configuration, one bit is appended to the end of Type-3 HARQ-Ack codebook. If UE detects a DCI format releasing an SPS configuration and indicates the slot in which the Type-3 HARQ-Ack is reported, the bit is set to Ack; otherwise, the bit is set to Nack.   * UE does not expect NN-K1 in a SPS release DCI.   The following two TPs address issue 1.  ==TP for 38.213 Section 9.1.3.3===  --Unchanged part omitted------------------------  Set – serving cell index  Set – HARQ process number  Set – TB index  Set – CBG index  Set  while  while  --Unchanged part omitted------------------------    end while      end while  if UE is provided with *sps-Config* or *sps-ConfigList-r16*  if UE has detected a DCI format corresponding to a valid release of DL SPS as described in Clause 10.2, and the DCI format indicates the slot in which the Type-3 HARQ-Ack is reported  =ACK  else  =NACK  end if  end if  --Unchanged part omitted------------------------ |

# Issue B11

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| B11 | Timeline for UCI Piggybacked on PUSCH for Type-3 HARQ-ACK codebook |

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| **Company** | **Summary of proposals** |
| OPPO  (R1-2004087) | In Rel-15, the PDSCH/PDCCH received after a UL grant, the corresponding HARQ-ACK cannot be indicated to the slot for PUSCH transmission. Such limitation should also be supported for the DCI triggering one-shot HARQ-ACK feedback.  ***Proposal 5: Adopt TP3 for type-3 HARQ-ACK codebook piggybacked on PUSCH.***  -------------------------------Start of TP3 38.213 V16.1.0 section 9-------------------------------  9 UE procedure for reporting control information  <Unchanged parts are omitted>  A UE does not expect to detect a DCI format scheduling a PDSCH reception or a SPS PDSCH release or a DCI format including a One-shot HARQ-ACK request field with value 1 and indicating a resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot if the UE previously detects a DCI format scheduling a PUSCH transmission in the slot and if the UE multiplexes HARQ-ACK information in the PUSCH transmission.  ------------------------------End of TP3 38.213 V16.1.0 section 9--------------------------------- |

FL Proposal: agree on TP3 in R1-2004087.

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| **Company** | **Comments on FL proposal** |
| Ericsson | To our understanding, the rel-15 restriction is related to the transmissions that would require generation of new feedback. The restriction avoids scheduling PDSCH/PDCCH that requires generation of new feedback after the UL grant was already transmitted. The situation is different here, since the one-shot feedback is about reporting already available feedback without processing of new PDSCH. we do not understand the technical need to include the one-shot feedback here. Therefore, we propose no change. |
| Nokia, NSB | We support the TP, particularly, if DCI format triggering TYPE-3 CB also schedules PDSCH, it also generates new HARQ-ACK. |
| QC | Support the TP. If a DL DCI is detected after UL DCI, and if the DL DCI indicates the same slot for HARQ-Ack (for any HARQ-Ack codebook type), there are additional issues and that is the reason that this is an error case in Rel. 15. This is not only due to generation of new feedback. Same issue exists if PRI in the later DL DCI changes the PUCCH resource. For example, consider this sequence of DCIs: DL DCI 1 🡪 UL DCI 🡪 DL DCI 2. UE determines to multiplex HARQ-Ack with PUSCH after decoding UL DCI. But then, DL DCI 2 indicates a different PUCCH resource, which makes it to not overlap with the PUSCH (based on last PRI rule). Then, this should be an error case. Otherwise, a timeline is needed for canceling the multiplexing with PUSCH, preparing the PUSCH again, etc. |
| Samsung | Support the TP. No matter the DCI format triggering type-3 CB with or without PDSCH, UE still needs time to prepare PUSCH multiplexing with newly determined HARQ-ACK bit length. |
| ZTE | We support the TP, and the wording can be refined to “ or a DCI format including a One-shot HARQ-ACK request field with value 1 and with PDSCH scheduling .” As only the DCI format triggering TYPE-3 CB schedules PDSCH may generate new HARQ-ACK information. |
| MediaTek | Support the TP. No matter the DCI format triggering type-3 CB with or without PDSCH scheduling. Even PDSCH is not scheduled, the codebook multiplexed in PUSCH could be different if one-shot feedback is triggered.  BTW, the sentence “a DCI format scheduling a PDSCH reception” already includes the case “a DCI format including a One-shot HARQ-ACK request field with value 1 and scheduling a PDSCH reception”. |
| LG | Support the TP based on same view with Samsung. |
| Lenovo, Motorola Mobility | Support the TP and share same views with MediaTek. |
| vivo | Support the TP. At least the HARQ-ACK codebook size, as well as PRI and PUCCH resource, could be changed, which will have an impact on UCI multiplexing. |
| Intel | We support the TP based on same view with Samsung |
| OPPO | We support the TP.  To Ericsson’s comment: firstly, a DCI format triggering one-shot does not necessarily mean no new PDSCH scheduling, e.g. DCI scheduling PDSCH and triggering one-shot. Secondly, after UL grant being received by a UE, the UE might already start to prepare the PUSCH multiplexing with a determined codebook, then later on the UE receives another DCI triggering one-shot. Thus the UE needs to re-prepare a new codebook multiplexing with PUSCH. This is complicated to implement. We need to redefine some timeline here. Due to the time limit, we propose to follow a similar principle to R15. |
| Ericsson | The case in which the DCI scheduled PDSCH and triggers one shot feedback is already covered by the existing specification as pointed out by MediaTek.  On the argument from many companies that UE needs to prepare PUSCH and eventually multiplex UCI form PUCCH on it, that is a separate thing, and as long as there is enough processing time provided for both for the generation of PUSCH and PUCCH, as it is in 214 and for UCI multiplexing as it is in 213, clause 9.2.5, it should not be an issue.  As for the example from Qualcomm, I do not understand why the gNB would configure like this. And I do not see it as a good reason to introduce a “no use zone for one shot feedback”. The restriction will forbid the use of one shot feedback in other situations even if the processing time is still enough and there is no contradicting information about PUCCH is signaled. |
| QC\_2 | Timeline condition in Section 9.2.5 of 38.213 is different that timeline required in the absence of this correction.  Consider the example given above again (DL DCI1🡪 UL DCI 🡪 DL DCI2). When DL DCI 2 points to a PUCCH resource (that does not overlap with the PUSCH) and is after the PUSCH but in the same slot, all timeline conditions in Section 9.2.5 can be fine (e.g. UL DCI to PUSCH, DL DCI2 to the new PUCCH resource). However, one additional timeline is also required, which is DL DCI2 to PUSCH (even though PUSCH does not carry HARQ-Ack). This is because UCI multiplexing on PUSCH is canceled by DL DCI2, and this impacts the PUSCH processing.  Similar additional timeline already exists in Rel. 15 for the case of PRI overwriting for the same exact reason:  “If a UE detects a first DCI format indicating a first resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot and also detects at a later time a second DCI format indicating a second resource for a PUCCH transmission with corresponding HARQ-ACK information in the slot, the UE does not expect to multiplex HARQ-ACK information corresponding to the second DCI format in a PUCCH resource in the slot if the PDCCH reception that includes the second DCI format is not earlier than …”  Whether gNB schedules like this or not, if such a case is allowed by specification, the additional timeline should also be specified.  As a side note, this is no different than the current restriction for SPS release DCI in the current spec (SPS release cannot be after UL DCI if the feedback is to be multiplexed on PUSCH). Then, why Rel. 15 disallows this if the limitation is only about “processing of new PDSCH”? |
| FL summary | All companies except Ericsson support the TP.  It seems to be the common understanding that the current specification text already covers the case where type-3 HARQ-ACK codebook is triggered and a PDSCH reception is scheduled by the same DCI. So the clarification for B11 is intended to cover for the missing case where PDSCH reception is not scheduled by the DCI that requests type-3 HARQ-ACK codebook feedback.  Assuming Ericsson’s view is changed according to the clarifications from Qualcomm, the proposal is still to agree to TP3 in R1-2004087.  The FL welcomes further feedback from Ericsson. |
| Ericsson | Firstly, we would like to clarify that definitely the majority view in this case is fine with us, since the outcome just outs a restriction that in our view is not well justified, but on the other hand, is not critical at all.  **Hence for the FL, it is OK to support the proposal.**  However, it is important for us to be convinced with the arguments, and **most importantly have an aligned understanding on the timelines involved (that is definitely more critical that the TP under discussion).**  On the points raised by QC, and the scenario illustrated, all the timelines are in place and all should be fulfilled. It doesn’t mean that we have to keep on introducing new timeline for any combination that we end up with. Let me summarize our understanding as the following:   * Timeline is defined if the PUCCH resource in a slot for a codebook transmission is changed (Tproc N3 based..) * Timeline is defined for PUCCH transmission (Tproc N1 based..) * Timeline is defined for PUSCH transmission (Tproc N2 based..) * Timeline is defined for overlapping PUCCH/PUSCH (Trpoc,mux in 9.2.5 ..)   + This timeline includes the case if there is a change in a planned PUCCH or PUSCH transmission.   + Hence, I disagree with QC comment that there is a need for introducing new timeline if a scheduled was supposed to be multiplexed with AN and a later DCI ,, indicates AN should be transmitted in another non-overlapping resource.  PUSCH transmission. The whole purpose of UCI multiplexing timeline was to take into account enough time in case the transmission plan changes with new DCI, etc. * Timeline is defined for cancellation of PUSCH transmission (Tproc N based..) * Timeline is define for CSI computation .. * Other timelines …   Hence, for the example by QC, all N3,N1,N2,and Tproc,mux should be fulfilled with the corresponding reference points. As long as there are fulfilled, UE is expected to cope with change of plans. Hence, we disagree with the arguments made.  However, the only thing that is left is the “side note” that DL SPS release is not allowed,which is a good point. The reason could be that a HARQ could be generated for validation of release? But maybe not. our guess is that it went through the same approach here: Simply keep the zone free and don’t allow anything.  So, eventually, that is the only logic that is left for me. Keep the zone free and don’t allow anything. |
| FL summary #2 | All companies have accepted TP3 in R1-2004087. If companies still wish to further clarify the understanding on the processing or cancellation timelines, they are welcome to do so either here or offline. However, no more discussion on the proposal is expected, unless some critical issue is discovered. |

# Conclusions

TBD

# References

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3. R1-2003452 Remaining issues on the HARQ for NR-U ZTE, Sanechips
4. R1-2003514 Maintenance on HARQ-ACK enhancement Huawei, HiSilicon
5. R1-2003658 Remaining issues on HARQ operation for NR-U MediaTek Inc.
6. R1-2003730 Enhancements to HARQ for NR-unlicensed Intel Corporation
7. R1-2003823 Text proposals for HARQ enhancement for NR-U Lenovo, Motorola Mobility
8. R1-2003845 HARQ enhancement Ericsson
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15. R1-2004529 Text proposal for enhanced dynamic HARQ procedures Google Inc.