**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 (R1-2003514), Nokia (R1-2004257), Ericsson (R1-2003845), ZTE (R1-2003452), Qualcomm (prefer a simple correction, e.g. spatial bundling not allowed for Type-3) | Alt1 |
| Lenovo (R1-2003823) | Alt2 |
| LG (R1-2004015) | Alt3 |
| Vivo (R1-2003372), OPPO (R1-2004087) | 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 |

# 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
  + Alt2b: Lenovo, Motorola Mobility
  + Alt2c-1: vivo, 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? |

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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. |

# Conclusions

TBD

# References

1. R1-2004692 FL summary\_1 for 72223 NRU HARQ moderator (Huawei), RAN1#101-e
2. R1-2003372 Remaining issues on HARQ operation for NR-U vivo
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
9. R1-2003862 HARQ enhancement for NR-U Samsung
10. R1-2004015 Remaining issues of HARQ procedure for NR-U LG Electronics
11. R1-2004087 Discussion on the remaining issues of HARQ enhancements OPPO
12. R1-2004257 Remaining issues on NR-U HARQ scheduling and feedback Nokia, Nokia Shanghai Bell
13. R1-2004325 Remaining issues and corrections on HARQ enhancement for NR-U Sharp
14. R1-2004445 TP for Enhancements to Scheduling and HARQ Operation for NR-U Qualcomm Incorporated
15. R1-2004529 Text proposal for enhanced dynamic HARQ procedures Google Inc.