**March 1st – March 26th, 2021**

**Source: Moderator (InterDigital, Inc.)**

**Title: Additional discussions on CSI feedback enhancements for enhanced URLLC/IIoT after RAN1#104-e**

**Document for: Discussion**

# Introduction

In RAN1#104-e, the following conclusion was taken for CSI feedback enhancements for enhanced URLLC/IIoT:

|  |
| --- |
| **Conclusion:** Continue evaluation of new reporting Case 1 and Case 2 for the schemes identified in Appendix B of [R1-2102131](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_104\Docs\R1-2102131.zip).   * Companies are encouraged to provide their views on each scheme against each criterion in respective Tables in Appendix B. * Companies are encouraged to provide additional evaluation results for as many schemes as possible, based on assumptions agreed in RAN1#102-e. * Aim for down-selection at RAN1#104-b-e by taking into account evaluation results and assessment against criteria from Appendix B. |

This document is to gather questions, comments and views in support of the evaluation of each scheme.

Companies are invited to add their input to Appendix B of this document to:

* Ask or answer questions for each scheme in “additional clarifications/details” before March 12.
* Provide their views for each criterion (Performance, complexity, specification impact, etc.) for each scheme before March 26 (note: no need to wait until March 12).

# Summary

[To be completed at the end of the discussion.]

# References

1. RP-201310 Revised WID: Enhanced IIoT and URLLC support for NR, Nokia, Nokia Shanghai Bell.
2. R1-2100037 CSI feedback enhancements for URLLC FUTUREWEI
3. R1-2100102 Discussion on CSI feedback enhancements for eURLLC ZTE
4. R1-2100182 CSI feedback enhancements for URLLC OPPO
5. R1-2100227 CSI feedback enhancements Huawei, HiSilicon
6. R1-2100269 CSI Feedback Enhancements for IIoT/URLLC Ericsson
7. R1-2100377 CSI feedback enhancements CATT
8. R1-2100437 CSI feedback enhancements for Rel-17 URLLC vivo
9. R1-2100575 CSI feedback enhancements for URLLC MediaTek Inc.
10. R1-2100650 CSI feedback enhancements for URLLC/IIoT Intel Corporation
11. R1-2100790 Discussion on CSI feedback enhancements Spreadtrum Communications
12. R1-2100830 CSI feedback enhancements InterDigital, Inc.
13. R1-2100835 CSI feedback enhancements for URLLC/IIoT use cases Nokia, Nokia Shanghai Bell
14. R1-2100856 Considerations on CSI feedback enhancements Sony
15. R1-2100881 Discussion on CSI feedback enhancements for URLLC LG Electronics
16. R1-2100994 CSI feedback enhancements for IIoT/URLLC Lenovo, Motorola Mobility
17. R1-2101014 Discussion on CSI feedback enhancements Panasonic Corporation
18. R1-2101040 Discussion on CSI feedback enhancements for URLLC CMCC
19. R1-2101202 Improving MCS Selection for URLLC Samsung
20. R1-2101379 Views on CSI feedback enhancements Apple
21. R1-2101460 CSI enhancement for IOT and URLLC Qualcomm Incorporated
22. R1-2101613 Discussion on CSI feedback enhancements for Rel.17 URLLC NTT DOCOMO, INC.
23. R1-2008160 CSI feedback enhancements for URLLC Samsung

# Appendix A: Previous agreements

Agreements from RAN1#104-e:

**Conclusion:** Continue evaluation of new reporting Case 1 and Case 2 for the schemes identified in Appendix B of [R1-2102131](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_104\Docs\R1-2102131.zip).

* Companies are encouraged to provide their views on each scheme against each criterion in respective Tables in Appendix B.
* Companies are encouraged to provide additional evaluation results for as many schemes as possible, based on assumptions agreed in RAN1#102-e.

Aim for down-selection at RAN1#104-b-e by taking into account evaluation results and assessment against criteria from Appendix B.

Agreements from RAN1#103-e:

Agreements

* No change of CSI processing time relative to Rel-16 CSI in this WI
* CSI processing time specific to a new CSI reporting quantity/type (if supported) can be studied

Agreement:

* For Case-2 new reporting, continue studying with focus on the new reporting type based on PDSCH decoding for OLLA performance enhancement for initial and re-transmissions of PDSCH.

Agreements:

For Case-1 New reporting, the following candidate schemes have been identified to address the fast interference change over time. Continue studying with focus on the identified schemes below for further study and evaluation.

* Scheme 1a: New reporting quantity based on CQI/SINR statistics, e.g.,
  + CQI/SINR statistics (e.g., mean, variance, etc.)
  + CSI prediction
* Scheme 1b: New reporting quantity of interference statistics (e.g., mean, variance, interference covariance matrix, etc.)
* Scheme 1c: New reporting quantity based on modifying existing reporting format, e.g.,
  + CQI reporting considering the worst subbands
  + Subband CQI granularity enhancement
* Scheme 1d: New reporting quantity related to CSI expiration time
* Scheme 1e: New reporting quantity with partial information update, e.g.,
  + CSI reporting with interference update only

Companies are encouraged to investigate the above schemes, aiming for down-selection in RAN1#104-e

Agreements from RAN1#102-e:

Agreement:

* CSI feedback enhancement for Multi-TRP transmission is not to be discussed further under IIoT/URLLC enhancement WI

Agreements:

* Baseline assumptions are used as the required minimum to be simulated for the evaluation of candidate CSI enhancement schemes
  + Reuse the assumptions in TR 38.824 and TR 38.901 as a starting point
  + Companies shall report additional parameters (e.g., CSI measurement settings, CSI reporting schemes) used in their evaluation
  + FFS details of baseline assumptions
* Companies can bring additional simulation results with other set(s) of assumptions

Agreements:

* Study/evaluate further on following CSI enhancement schemes in terms of technical benefit, specification and implementation impacts.
  + New triggering methods for A-CSI and/or SRS
  + New reporting based on one or more of the following:
    - Case 1: channel/interference measurement for new CSI reporting, considering aspects such as one or more of the following:
      * Reporting more accurate interference characteristics
      * Reduced CSI feedback overhead (e.g., reporting interference measurement only)
      * Enhanced CSI reporting such as WB/SB CQI
    - Case 2: other measurement (other than channel/interference) for additional information
      * E.g., PDCCH/PDSCH decoding, recommended HARQ RV sequence, etc.
    - It targets to help gNB scheduler for better link adaptation of (re)transmission
  + [Reduced CSI computation time/complexity]
  + [CSI feedback for PDCCH]
  + Other CSI enhancement schemes that enable accurate MCS selection are not precluded
* Detailed assumptions of the proposed CSI enhancement schemes should be provided by the proponent, such as
  + Reporting values
  + Triggering conditions for the reporting
  + Associated measurement resource
  + Uplink resource to be used for the reporting
  + How to use the reported information at the gNB scheduler
  + CSI-RS overhead and CSI reporting frequency
  + CSI reporting latency/timeline
  + Etc.

Agreements:

* Consider Table 1 as baseline assumption for system level simulation for evaluating CSI enhancement schemes
  + The uses cases in Table 1 is for simulation purposes and it does not preclude a CSI enhancement scheme which is beneficial for the other URLLC use cases
* No baseline assumption is used for link level simulation
  + Companies are encouraged to use one of LLS assumption tables in Section A.3 in TR38.824 for any link level simulation

**Table 1. Baseline SLS assumption for CSI enhancement schemes in URLLC/IIoT**

|  |  |
| --- | --- |
| **Parameters** | **Values** |
| Performance metric | Option-1 (section 5.1 of TR 38.824)  Additional metrics (it is up to company to bring results with additional metric):   * MCS prediction error (e.g., difference of a scheduled MCS and an ideal MCS) * DL/UL signaling overhead * CCDF of latency samples from all UEs * BLER of 1st transmission * Resource utilization * Spectral efficiency |
| Use cases | Following two use cases can be considered for new triggering method and new reporting. Companies are encouraged to evaluate the following cases in descending priority:   * Rel-15 enabled use case (e.g. AR/VR) in TR 38.824   + Reliability: 99.999   + Latency: 4ms (200bytes)   + Traffic mode: FTP model 3 (100p/s) * Factory automation in TR 38.824   + Reliability: 99.9999   + Latency: 1ms (32bytes)   + Traffic mode: Periodic deterministic traffic model with arrival interval 2ms * Rel-15 enabled use case (e.g. AR/VR) in TR 38.824   + Reliability: 99.999   + Latency: 1ms (32bytes)   + Traffic mode: FTP model 3 (100p/s)   + Assumptions for eMBB and URLLC UEs sharing the same carrier is used (as in A2.5 of TR 38.824) |
| Simulation assumptions | Following simulation assumption is used based on the use case selected:   * Rel-15 enabled use case with UMa (Table A.2.4-1 in TR 38.824) * Factory automation at 4GHz (Table A.2.2-1 in TR38.824) with following update:   + Channel model is replaced with InF (InF-DH) in TR 38.901     - Companies can bring results with other InF scenarios additionally   + Layout is replaced with BS deployment in Table 7.8-7 in TR 38.901 |
| Transmission scheme | Multiple antenna ports Tx scheme   * Companies report the details of Tx scheme used |

# Appendix B: Discussion templates for each scheme

## B.1.1 Case 1-1: Statistical CSI/SINR

|  |  |
| --- | --- |
| **Statistical CSI/SINR [6][10][13]** | |
| New report quantity | Mean and variance CQI/SINR from a set of CSI-IM instances  (Subband or wideband) |
| Target/benefit | Scheduler gets worst-case CSI (without needing frequent CSI reports)  Scheduler gets information relevant to any TBS/BLER target (SINR) |
| Additional clarifications/details | [Mediatek] Are statistics measured only over frequency domain or over frequency and time domains?  [Nokia] we described the procedure for estimating SINR mean and std. Lot of details are [13], but mentioning (below) some details so you can refer quickly,  **Obtain frequency-domain SINR** samples by the CSI-RS measurement.  **Compute mean and std using the generated SINR samples**. Here, a further selection of SINR samples or using SINR samples when generating SINR distribution or any other method could be used for computing the mean and SINR.  **Report the SINR mean and std in the CSI report** (these are new quantities that reflect channel interference characteristics).  [QC] if the feedback is CQI statistics, why gNB can not derive it based on sub-band CQI feedback. If the feedback is SINR statistics, how can gNB use SINR information to adjust MCS, without knowing UE’s decoding performance, i.e., UE can decode which MCS at SNR X dB with 10^-5 BLER? Please notice that each UE could have different SINR <-> BLER performance depends on UE implementation. We don’t see reporting SINR can help base station. Reporting CQI statistics in theory could help because spec defined this CQI to MCS mapping table. But in practice, it is not needed neither, because 1) base station can derive CQI statistics based on sub-band CQI feedback. 2) UE could apply CQI backoff (based on CQI statistics observed at UE) via UE implementation and report more conservative CQI.  [Nokia2]  Addressing QC comment on SINR:  How can gNB use SINR information to adjust MCS, without knowing UE’s decoding performance, i.e., UE can decode which MCS at SNR X dB with 10^-5 BLER?  This is a bigger problem with CQI as it is not based on UE’s decoding performance at SNR X dB with a BLER target. At the gNB side, we use mapping of reported CQI, TB, target BLER to get accurate MCS (also w/wo OLLA). One example, when we support different TBS (256 vs 1024) the same MCS may require different SNR X values to reach 10-5 BLER, as you may know, different TBS (smaller sizes) are having different operating points, you may see Figure 4 in [13]. There are look-up tables we maintain to make things accurate as possible. However, accurate mapping is not feasible with the changing BLER targets, TB sizes, channel information not captured by CQI.  Selecting an MCS for different TBS, bler target becomes more accurate with the SINR details where we could use corresponding look-up tables to selects the best MCS without worrying too much on BLER target assumption at the UE and CQI mapping assumption of SINR operating point.  Please notice that each UE could have different SINR <-> BLER performance depends on UE implementation.  The issue you mentioned is also applicable for CQI reporting, which may be in a much worse due to the indirect nature of the report.  We agree that there will be differences between different UE vendors, between different UE models from the same vendor, and between individual devices of the same type/model. However, as we only focus on the mean and std, for a given UE, it is not difficult for gNB to derive the offset (mainly for SINR-ave. std is not changing much) the UE has from the actual SINR profile (for example, OLLA can determine such differences).  Then, UE reported SINR-ave (or adjusted), SINR-std, TB, and target BLER are used by the gNB to find the MCS accurately. The UE will not be impacted as most of these are handled by the network end.  Reporting CQI statistics in theory could help because spec defined this CQI to MCS mapping table.  CQI is not directly mapped to MCS in URLLC, and there is no use in having any table as we know. The comment is more applicable for eMBB. As we explained in an earlier time, CQI reporting assumes a TBS coming from CSI reference resource and only provided for 10-1 and 10-5 (please note this also finalized in a hurry during Rel-15, we spend a mid-night to take final decisions due to rush. Not a right solution). Many estimates are happening at the UE, where gNB interpreting the correct mapping table is not feasible. Such errors tend to make schedulers operate in a conservative manner, and performance is not good most of KPIs .  Few other points on legacy,  1) Using sub-band CQI feedback is sub-optimal because that feedback is subject to assumed TBS and assumed BLERtarget plus the UL reporting overhead is large.  2) UE should not apply any CQI backoff by itself, because UE cannot know what PHY layer BLERtarget base station applies to each TB. Note that for the same overall target BLER the PHY layer may differ between TBs e.g. because of differences in the remaining latency budget, i.e. base station may try better spectral efficiency and higher PHY layer BLERtarget if the latency budget allows retransmissions, but it must try low BLERtarget in cases where there is no time for retransmissions.  Apple: testability issues need to be addressed. |
| **Evaluation results** | |
| ZTE [3]  AR/VR | Mean + stdev of CQI: 31% satisfied UEs [50%], 2.9% RU [1.9%] |
| Ericsson [6]  AR/VR (mixed) | Mean + variance of SINR (wideband): 97.5% satisfied UEs [78.5%], 76% median RU [77%]  Mean + variance of SINR (subband): 97.2% satisfied UEs [78.5%], 60% median RU [77%]  Baseline uses fixed backoff of 20 dB |
| Intel [10]  AR/VR | Mean + stdev SINR: 99.20% [99.25%] UEs for 99.99% reliability |
| InterDigital [12]  AR/VR | Mean + stdev CQI: 90.0% satisfied UEs [85.7%], 2.9 PRBs RU [1.6] |
| InterDigital [12]  Factory | Mean + stdev CQI: 100% satisfied UEs [53.3%], 2.9 PRBs RU [1.6] |
| Nokia [13]  AR/VR | Mean + stdev SINR: 1 ms 99.9999%-pct latency [2 ms], 5% RU [3%] |
| Nokia [13]  Factory | Mean + stdev SINR: ~1 ms 99.999%-pct latency [1 ms] |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [QC] The baseline for comparison should be “UE apply CQI/SINR backoff (based on CQI/SINR statistics observed at UE) via UE implementation and report more conservative CQI”.  [Nokia] Meaningful benefit for statistical SINR report is shown in **R1-2008862** and **R1-2100835**. True URLLC QoS can be provided with very low overhead, which justifies the implementation/spec impact.  Suggest QC provide more information on what it means by more conservative CQI. Do you assume 38.214 defined CQI reporting method or doing extra on top of that. |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [QC] Yes. In our understanding, whatever algorithm base station use to adjust MCS based on CQI/SINR statistics report, UE can do similar things and reflect the adjustment in CQI report by UE implementation. On Base station side, base station can also derive CQI statistics based on sub-band CQI report.  [Company2] Views  [Nokia] UE cannot do the same thing that BS can since it doesn’t know what TBS and what PHY layer BLERtarget gNB is going to use for each TB.  R-15/16 WB CQI and SB CQI is not even close (see R1-2100835, fig 6). |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [QC] High impact on UE implementation. Please see the aspects mentioned in “specification impact”  [Nokia] Medium impact to UE implementation: SINR mean and std must be estimated from CSI-RS and CSI-IM. To estimate the interfered conditions, we have used the worst 8 PRBs (comparable to using worst 2 subbands). |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [QC] High impact to spec. Need specify the following: what CQI/SINR statistics to report. What is the report format? Quantize the report in how many bits? How does UE derive the report? Any enhancement on CSI-RS configuration to support this new report?  [Nokia] Low. Specification impact is only expected by adding new reporting of SINR-std and SINR-ave quantities in a CSI-report. Legacy CSI framework can be used with the same measurement, computation timelines, reporting modes, and other details. We can expect low impact compared to many other proposals. |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Company1] Views  [Nokia] Yes, in the specification, there should be details giving guidance on how the CSI quantity is calculated (this is valid for any CSI quantity). In SINR-stats, we have to define UE assumptions and some details (are provided in section 8.4 reply and also in **R1-2100835)**. As SINR is a direct metric, it may suit more for inter-operability than legacy CQI report (where specific estimate on BLER targets are assumed and different UEs may use different principles). For example, CQI determination is mentioned in 38.214 by assuming CSI reference resource, but how the UE assumes CQI for a given BLER target is not defined. |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [QC] Not mature yet. It is just a high level concept. Many details are missing. Please see the questions listed in spec impact.  [Nokia]: SINR is a well-known metric, compared to many others. Getting average and std should not be something fancy. Details are provided in R1-2100835. Design perspective NR framework is used as the legacy procedure. It is only a new CSI reporting quantity (same with all other options). We think this is not a big issue for all proposals. Disagree with QC. |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] Yes  [QC] No. Like we mentioned, this scheme can be achieved by UE/gNB implementation.  [Nokia] Yes,  We should take technical details into account than companies say No.  We explained the comments above, and it would be good to consider them. |

## B.1.2 Case 1-2: CSI prediction

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| --- | --- |
| **CSI prediction [21]** | |
| New report quantity | CSI for a set of future instances |
| Target/benefit | Scheduler gets CSI closer to actual CSI for the PDSCH scheduling instance |
| Additional clarifications/details | [CompanyX] |
| **Evaluation results** | |
| (Not available) |  |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company1] Views  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Samsung] gNB implementation based approaches exist  [QC] gNB does not know interference information so gNB implementation based prediction does not work well. |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [Samsung] Does not appear specifiable  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Samsung] Does not appear testable  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [Company1] Views  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] No  [QC] Yes  [Nokia] no discussion or details above to study this further. |

## B.1.3 Case 1-3: Interference statistics

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| --- | --- |
| **Interference statistics [2]** | |
| New report quantity | Mean/variance/max of interference-to-noise ratio |
| Target/benefit | Scheduler gets worst-case CSI (without needing frequent CSI reports)  (Scheduler can decide how aggressive MCS setting can be) |
| Additional clarifications/details | [CompanyX] |
| **Evaluation results** | |
| (Not available) |  |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company1] Views  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Company1] Views  [Company2] Views |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [Samsung]  [QC] high. Please see the spec impact |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [QC] high spec impact. Need define: what intf statistics quantity to report? How to derive the report? Any new CSI-IM resource needed? Bit width and quantization for the report.  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Samsung] “Statistical CSI/SINR” has clearer testability.  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [Samsung] “Statistical CSI/SINR” is better defined.  [QC] This is a high level idea only. It is not mature yet. Many details are missing. |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] No  [QC] Yes. This is different from CQI/SINR statistics where base station can derive. Base station can not derive UE interference info. So this can be further studied. |

## B.1.4 Case 1-4: Interference covariance matrix

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| --- | --- |
| **Interference covariance matrix [5]** | |
| New report quantity | Interference covariance matrix |
| Target/benefit | Reducing CSI processing time because only interference is updated.  Scheduler gets CSI closer to actual CSI for the PDSCH scheduling instance.  Support of SU-MIMO and better MU-MIMO support. |
| Additional clarifications/details | [CompanyX] |
| **Evaluation results** | |
| Huawei [5]  Factory (non-baseline) | 160 supported UEs [100], 38% RU [100%] |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Samsung] MU-MIMO is challenging even for eMBB, not appropriate for sparse ultra-reliable traffic. Feedback overhead and required accuracy inappropriate for URLLC.  [QC] Feedback overhead is too large. |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Company1] Views  [Company2] Views |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [QC] high  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Company1] Views  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [QC] this is just a high level idea. Many details are still missing.  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] No  [QC] No |

## B.1.5 Case 1-5: CSI based on worst IMR occasion

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| --- | --- |
| **CSI based on worst IMR occasion [3]** | |
| New report quantity | CQI from the CSI-IM occasion with maximum interference within a set of CSI-IM occasions. |
| Target/benefit | Scheduler gets worst-case CSI (without needing frequent CSI reports) |
| Additional clarifications/details | [CompanyX] |
| **Evaluation results** | |
| ZTE [3]  AR/VR | 58% satisfied UEs [50%], 2.3% RU [1.9%] |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Samsung] gNB can do conservative scheduling if so prefers based on average and more accurate CQI reports.  [QC] Yes, gNB can do scheduling more conservatively.  . |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [Samsung] Feasibility is unclear as interference needs to be filtered for accuracy  [Company2] Impact to UE implementation maybe medium/low. UE need to measure multiple IMR and use the worst one. |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [QC] Need specify how to define worst IMR. |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Nokia] Yes. We do not see any concern on the testability of the proposal.  [Company1] Views  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [QC] Relatively simply scheme, looks mature.  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] No  [QC] Yes, it seems this scheme falls into same category as 1-6 and 1-7. They can be studied together  [Nokia] Yes. |

## B.1.6 Case 1-6: Worst-M CQI

|  |  |
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| **Worst-M CQI [13]** | |
| New report quantity | CQI corresponding to transmission over Worst-M subbands |
| Target/benefit | Scheduler gets worst-case CSI (without needing frequent CSI reports) |
| Additional clarifications/details | [Samsung] Why can’t the scheduler just use the best subband?  [Nokia] The idea is to report CQI associated with the worst-M sub-bands for the defined target BLER, in addition to the wideband CQI. In our observation, there is high variation on the sub-bands interference levels with time and knowing best sub-bands are not fully allowing to schedule the UE on those as in the next instance you may get bad interference on those sub-bands. The idea is to get worse-M CQI to understand how bad interferences can be and somewhat use random scheduling across full band with a MCS selected based on worst-M CQI. We tried out different scheduler considerations on how to use different CQI types and did not find that best-M or reporting best\_M subbands are that useful. We would say this can be due to the randomness of interferences across all sub-bands. |
| **Evaluation results** | |
| Nokia [13]  AR/VR | Worst-2 CQI: 1 ms 99.9999%-pct latency [2 ms], 5% RU [3%] |
| Nokia [13]  Factory | Worst-2 CQI: ~1 ms 99.999%-pct latency [1 ms] |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Nokia] Meaningful benefit for worst-M CQI report is shown in R1-2008862 and R1-2100835. True URLLC QoS can be provided with very low overhead, which justifies the implementation/spec impact.  [Company1] Views  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Company1] Views  [Company2] Views  [Nokia] No. See R1-2100835. |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [QC] implementation impact is low/medium  [Nokia] Low. |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [QC] spec impact is low/medium  [Nokia] Low. |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Nokia] No issues are visible on Testability.  [Company1] Views  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [QC] This seems a relatively simple scheme. It is mature enough  [Nokia] No sub-options. Clear proposal. |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [QC] it seems this scheme falls into same category as 1-5 and 1-7. They can be studied together  [Nokia] Yes |

## B.1.7 Case 1-7: Worst-best criteria for subband CQI report

|  |  |
| --- | --- |
| **Worst-best criteria for subband CQI report [21]** | |
| New report quantity | CQI for each of K worst subbands. CQI for each subband is best across CSI-RS resources |
| Target/benefit | Scheduler gets worst-case CSI (without needing frequent CSI reports) |
| Additional clarifications/details | [Samsung] Why can’t the scheduler just use the best subband? |
| **Evaluation results** | |
| (Not available) |  |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company1] Views  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Company1] Views  [Company2] Views |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [QC] low/medium  [Company2] Views |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [QC] low/medium  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Company1] Views  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [QC] This is a relative simple scheme. It is mature enough.  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [QC] it seems this scheme falls into same category as 1-5 and 1-6. They can be studied together  [Company2] Yes/No |

## B.1.8 Case 1-8: 3-bits differential subband CQI or 4-bit full subband CQI

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| --- | --- |
| **3-bit differential subband CQI or 4-bit full subband CQI [5][9][13]** | |
| New report quantity | Differential subband CQI with 3 bits or full 4-bit subband CQI |
| Target/benefit | Reduced MCS prediction error from quantization  More accurate subband information |
| Additional clarifications/details | [CompanyX] |
| **Evaluation results** | |
| Mediatek [9]  Factory | 3-bit D-subband CQI: 0.4% of incorrect MCS [22%]. Baseline uses 2-bit D-CQI |
| Nokia [13]  Factory | 4-bit subband CQI: 1 ms 99.9999%-pct latency [2 ms], 6% RU [3%] |
| Intel [10]  AR/VR | 4-bit subband CQI: 99.05% [99.25%] UEs for 99.99% reliability |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Samsung] Some benefits are shown  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Company1] Views  [Company2] Views |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Company1] Views  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [Samsung] Scheme is well defined and easy to simulate  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] Yes  [Company2] Views |

## B.1.9 Case 1-9: Reference wideband CQI excludes worst subbands

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| --- | --- |
| **Reference wideband CQI excludes worst subbands [9]** | |
| New report quantity | Existing 2-bits D-subband CQI formats or 3-bits D-subband CQI format |
| Target/benefit | Reduced MCS prediction error from quantization |
| Additional clarifications/details | [CompanyX] |
| **Evaluation results** | |
| Mediatek [9]  Factory | Reported enhanced wideband CQI better than baseline wideband CQI 62% of time |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company1] Views  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Company1] Views  [Company2] Views |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Company1] Views  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [Company1] Views  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Company1] Yes/No  [Company2] Yes/No |

## B.1.10 Case 1-10: CSI expiration time

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| --- | --- |
| **CSI expiration time [21]** | |
| New report quantity | Delay after which auto-correlation of CQI falls below threshold |
| Target/benefit | Scheduler gets correct sampling time for CSI reports |
| Additional clarifications/details | [CompanyX] |
| **Evaluation results** | |
| (Not available) |  |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company1] Views  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Samsung] For TDD bands, channel prediction can be supported by gNB implementation using SRS.  [QC] gNB estimation based on SRS has a lot drawbacks:   1. To use SRS for Doppler tracking, we need something similar to TRS with multiple “looks” in time domain (e.g. 4 symbol gap or repetition across two slots). This can't be made as it requires S+U slots back-to-back, exhaust UL resources. And UE can't keep phase coherent across slots, which will make Doppler estimation does not work at gNB. 2. UL Tx power is much smaller than gNB DL power. So SRS estimation quality is poor for gNB. (UL link budget is worse than DL). 3. Nokia paper in HST [R1-2101009] confirmed that that gNB’s capability to estimate Doppler from SRS is limited. |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [QC] medium. UE need to derive expiration time.  [Company2] Views |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [Samsung] How to specify is unclear  [QC] low spec impact. UE estimate CSI expiration time based on UE implementation. This part does not need to be specified. What needs to be specified is a mapping table between a X bits value and a time (which can be in terms of slots). So the spec impact is low. |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Samsung] Testability is unclear  [QC] A test case can be defined with channels with different coherence time. Test equipment then check the value of reported expiration time. And the reported value need to satisfy certain error tolerance level. |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [QC] We will provide more details in next meeting  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] No  [QC] YES. Without this feedback, gNB does not know how to set/adjust CSI feedback periodicity. For eMBB service, gNB may be able to slowly fine-tuning the periodicity to correct value. But for URLLC, due to fast channel/interference variation, the slow fine-turning does not work. UE feedback could help gNB in this scenario. |

## B.1.11 Case 1-11: Partial information update

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| **Partial information update [5][8][10]** | |
| New report quantity | CQI updated more frequently than RI/PMI |
| Target/benefit | Reduce CSI processing requirement  Scheduler gets CSI closer to actual CSI for the PDSCH scheduling instance  Allows better tracking of channel/interference |
| Additional clarifications/details | [Samsung]: Difference between this and “CSI/SINR statistics”?  [Moderator]: Difference with “CSI/SINR statistics” is that there is no reporting of CQI for every CSI-IM instance for CSI/SINR statistics. |
| **Evaluation results** | |
| Vivo [8]  AR/VR | Full CSI every 40 ms, update CQI only based on IMR every 10 ms:  71% satisfied UEs [67%, period 40 ms]/[98%, period 10 ms]  56% RU [77%, period 40 ms]/[48%, period 10 ms]  Full CSI every 40 ms, update CQI based on CSI-RS and IMR every 10 ms:  89% satisfied UEs [67%, period 40 ms]/[98%, period 10 ms]  52% RU [77%, period 40 ms]/[48%, period 10 ms]  Baseline uses full CSI recalculation |
| Huawei [5]  Factory (non-baseline) | Update CQI every 1 ms: 100 supported UEs [70]  Baseline uses full CSI recalculation every 3 ms |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company1] Views  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Company1] Views  [Company2] Views |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Company1] Views  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [Company1] Views  [Company2] Views |
| Other | [Samsung] LTE operated in similar manner, this was changed in NR to avoid error propagation issues (when CRC protection is not possible) |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] Yes  [Company2] Yes/No |

## B.2.1 Case 2-1: Decoding margin

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| --- | --- |
| **Decoding margin [6][12]** | |
| New report quantity | Indication of whether decoded PDSCH pass (fail) with high margin or low margin.  May be reported for each occasion or aggregated for multiple occasions (“slow”) |
| Target/benefit | Successful PDSCH: Reduce BLER of 1st transmission (assists OLLA)  Failed PDSCH: Scheduler knows appropriate parameter (MCS) for retransmission |
| Additional clarifications/details | [Qualcomm]: What decoding information is used to derive the report quantity? How is the report quantity derived? Does the derivation method uniformly work for all modulation orders? How to quantize the report quantity?  [Samsung]: UE procedure to obtain the metrics needs to be described together with the quantization levels (e.g. corresponding to steps of 1 dB, or 2 dB, …, or the MCS equivalent steps). This is important because the whole BLER curve (e.g. between a hard ACK at 10-5 and a soft NACK at BLER=10-1, is only ~5 dB). If there is to be any robustness to interference variations, only one quantization level seems possible. Whether and how information from multiple decoding results is averaged/combined into a single report needs to be described. Further, the gNB can also perform such “deltas” in link adaptation and obtain new OLLA statistics. Need to define gNB action.  [Nokia] Need clarification on how thresholds depend on TBS and MCS (ref R1-2100269 observation 5). Need clarification on how thresholds depend on channel’s fading profile (SINR-distribution in f-domain). How does OLLA converge to different BLERtargets [say 1e-7, 1e-5, 1e-3] with this approach? |
| **Evaluation results** | |
| InterDigital [12]  AR/VR | Soft-ACK (slow): 93.8% satisfied UEs [85.7%], 7.8 PRBs RU [6.7] |
| InterDigital [12]  Factory | Soft-ACK (slow): 100% satisfied UEs [53.3%], 2.4 PRBs RU [1.6] |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company1] Views  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Company1] Views  [Company2] Views |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Company1] Views  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [Company1] Views  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Company1] Yes/No  [Nokia] Yes |

## B.2.2 Case 2-2: Block error probability

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| --- | --- |
| **Block error probability [9][13]** | |
| New report quantity | Indication of (log) of estimated block error probability (BLEP) of PDSCH, or delta from a reference (log) BLEP |
| Target/benefit | Successful PDSCH: Reduce BLER of 1st transmission (assists OLLA)  Failed PDSCH: Scheduler knows appropriate parameter (MCS) for retransmission |
| Additional clarifications/details | [Qualcomm]: What decoding information is used to derive the report quantity? How is the report quantity derived? Does the derivation method uniformly work for all modulation orders? How to quantize the report quantity?  [Samsung]: UE procedure to obtain the metrics needs to be described together with the quantization levels (e.g. corresponding to steps of 1 dB, or 2 dB, …, or the MCS equivalent steps). This is important because the whole BLER curve (e.g. between a hard ACK at 10-5 and a soft NACK at BLER=10-1, is only ~5 dB). If there is to be any robustness to interference variations, only one quantization level seems possible. Whether and how information from multiple decoding results is averaged/combined into a single report needs to be described. Further, the gNB can also perform such “deltas” in link adaptation and obtain new OLLA statistics. Need to define gNB action.  [Nokia] See “Implementation complexity”. |
| **Evaluation results** | |
| InterDigital [12]  AR/VR | 90.9% satisfied UEs [85.7%], 7.1 PRBs RU [6.7] |
| InterDigital [12]  Factory | 96.1% satisfied UEs [53.3%], 2.2 PRBs RU [1.6] |
| Nokia [13]  AR/VR | EP only: 5 ms 99.9999%-pct latency [2 ms], 20% RU [3%]  EP + mean + stdev SINR: 1 ms 99.9999%-pct latency [2 ms], 6% RU [3%] |
| Nokia [13]  Factory | EP only: ~1 ms 99.999%-pct latency [1 ms]  EP + mean + stdev SINR: ~1 ms 99.999%-pct latency [1 ms] |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company1] Views  [Nokia] Results show that (a) desired performance level can be achieved with (b) different CQI/MCS-selection schemes (c) in different scenarios. |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Company1] Views  [Nokia] No. Different companies have indicated their agreement that HARQ-ACK/NACK based OLLA is not feasible with low BLERtargets / URLLC – OLLA does not converge due to the absence of NACKs. |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [Company1] Views  [Nokia] Medium complexity.   1. Derive mutual information from post-combined SINR or app LLR, i.e: MI=f(LLR) or MI=f(SINR(RE(k)))   where k goes through REs occupied by the TB, and   1. BLEP=f(MI). 2. Report quantity: round( -log10( BLEP ))   When MI is computed from SINR samples, then mean MI per bit (if used) depends on the modulation order (see ref [9] given in R1-2100835).  For report quantity quantization, we think 3 bits can be mapped to 1e-1, 1e-2, …,1e-8.  Treatment of HARQ-codebook changes and multiple decoding results is to be defined. |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [Company1] Views  [Nokia] Medium impact due to new report quantity. |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Company1] Views  [Nokia] At least higher BLERs/EPs can be tested quickly. For lower BLERs a relative test could be perhaps considered i.e. make sure that UE reports monotonically decreasing BLEP when channel conditions improve. |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [Company1] Views  [Nokia] UE side is vendor/implementation specific (may depend on receiver/decoder architecture). |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Company1] Yes/No  [Nokia] Yes. |

## B.2.3 Case 2-3: (Delta) CQI/MCS/SINR

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| --- | --- |
| **(Delta) CQI/MCS/SINR [3][4][7][21]** | |
| New report quantity | Indication of transmission parameter (in units of CQI/MCS/SINR) that indicates the difference between the actual MCS/SINR for the PDSCH and the required MCS/SINR to achieve a specific BLER target |
| Target/benefit | Successful PDSCH: Reduce BLER of 1st transmission (assists OLLA)  Failed PDSCH: Scheduler knows appropriate parameter (MCS) for retransmission |
| Additional clarifications/details | [Qualcomm]: The measurement source is PDSCH decoding LLRs. We will provide details in next meeting.  [vivo]: What measurement resource is used?  [Samsung]: UE procedure to obtain the metrics needs to be described together with the quantization levels (e.g. corresponding to steps of 1 dB, or 2 dB, …, or the MCS equivalent steps). This is important because the whole BLER curve (e.g. between a hard ACK at 10-5 and a soft NACK at BLER=10-1, is only ~5 dB). If there is to be any robustness to interference variations, only one quantization level seems possible. Whether and how information from multiple decoding results is averaged/combined into a single report needs to be described. Further, the gNB can also perform such “deltas” in link adaptation and obtain new OLLA statistics. Need to define gNB action (delta\_MCS seems well-defined).  [Nokia]  Successful PDSCH: How is OLLA adjusted when BLERtargets are specific to each TB? (e.g. different 1st transmissions have BLERtarget 1e-1, 1e-3, 1e-5, 1e-3,…) |
| **Evaluation results** | |
| ZTE [3]  AR/VR | Delta SINR (ACK): 61% satisfied UEs [50%], 2.3% RU [1.9%]  Delta SINR (NACK): 94% satisfied Ues [50%], 33% RU [1.9%]  Delta MCS (NACK): 60% satisfied Ues [50%], 1.9% RU [1.9%] |
| InterDigital [12]  AR/VR | Delta SINR (ACK): 99.6% satisfied Ues [85.7%], 16.2 PRBs RU [6.7] |
| InterDigital [12]  Factory | Delta SINR (ACK): 100% satisfied Ues [53.3%], 3.0 PRBs RU [1.6] |
| Intel [10]  AR/VR | CSI: 99.35% [99.25%] Ues for 99.99% reliability |
| Qualcomm [21]  AR/VR mixed  (20 URLLC UEs) | CQI/MCS: 100% satisfied Ues [100%], 3471 RBs for 2nd Tx [5255] |
| Qualcomm [21]  AR/VR mixed  (100 URLLC UEs) | CQI/MCS: 100% satisfied Ues [100%], 5878 RBs for 2nd Tx [7545] |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company1] Views  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [QC] NO. R16 cannot provide delta MCS feedback to improve OLLA at gNB.  [Company2] Views |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [QC] UE need to implement LLR -> (delta) MCS mapping  [Company2] Views |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [QC] low. Only a table to capture a X bit -> (delta) MCS is needed.  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Samsung] delta\_MCS is easiest to test among this (and decoding margin, EP)  [QC] agree with Samsung (delta) MCS is easiest to test |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [Company1] Views  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] Yes  [QC] YES |

## B.2.4 Case 2-4: HARQ redundancy version sequence

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| --- | --- |
| **HARQ redundancy version sequence [20]** | |
| New report quantity | Indication of recommended HARQ redundancy version sequence |
| Target/benefit | Scheduler knows the best HARQ redundancy version sequence to use |
| Additional clarifications/details | [Qualcomm]: What decoding information is used to derive the report quantity? How is the report quantity derived? Does the derivation method uniformly work for all modulation orders? How to quantize the report quantity? |
| **Evaluation results** | |
| (Not available) |  |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Samsung] We do not think there is any benefit for the UE to indicate preferred RV sequence (because at low BLERs or for small TBs, the RV sequence has negligible impact).  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Company1] Views  [Apple] No |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [Company1] Views  [Apple] UE makes request and gNB honors the request. |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Company1] Views  [Apple] testability of the scheme is guaranteed |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [Company1] Views  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] No  [Apple] Yes |

## B.2.5 Case 2-5: Reason for NACK

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| --- | --- |
| **Reason for NACK [14][21]** | |
| New report quantity | Indication of whether NACK is due to radio propagation or strong spike in interference |
| Target/benefit | Scheduler knows whether to switch beam or change other transmission parameters. Scheduler can also decide on the SNR step size used in an OLLA, e.g. if a NACK is caused by spike in interference, then a smaller reduction in SNR step size is used compared to when the NACK is caused by poor radio condition. |
| Additional clarifications/details | [QC] UE via a combination of measurements on CSI RS and DMRS to identify PDSCH decoding failure is due to which of the following 1) Beam blocking; 2) Other cell interference; 3)Frequency selective fading; 4) coverage hole. UE then report the reason (with recommended operations) to base station to help base station take actions accordingly. |
| **Evaluation results** | |
| (Not available) |  |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company1] Views  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [QC] No  [Company2] Views |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [Company1] Views  [Company2] Views |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [Samsung] Practically impossible to define.  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [Samsung] Practically impossible to test.  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [QC] We will provide details in next meeting  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] No  [QC] Yes |

## B.2.6 Case 2-6: Number of NACK values

|  |  |
| --- | --- |
| **Number of NACK values [19]** | |
| New report quantity | Indication of the number of NACK values among NACK/DTX values |
| Target/benefit | Scheduler knows whether to adapt PDSCH (in OLLA) or PDCCH. Enables conventional OLLA. |
| Additional clarifications/details | [CompanyX] |
| **Evaluation results** | |
| (Not available) |  |
| **Company views for each criterion (not necessarily by order of importance)** | |
| Performance | *Do evaluation results and metrics show a meaningful benefit for an agreed scenario?*  *Does the gain justify the cost in terms of resource utilization, UL overhead, implementation/spec impact?*  [Company1] Views  [Company2] Views |
| Existing R16 solution available? | *Is it possible to achieve the targeted benefit by UE/gNB implementation in R16?*  [Samsung] No. Unless number of HARQ-ACK bits is only 1-2, reported state is NACK/DTX.  [QC] No. |
| Implementation complexity | *What is the impact on UE/gNB implementation complexity? (e.g. low/medium/high, please explain)*  [QC] low. UE just count # true NACKs and feedback a number.  [Company2] Views |
| Specification impact | *What is the impact on specifications? (e.g. low/medium/high, please explain)*  [QC] low. Just append # true NACK at the end of the HARQ-ACK codebook  [Company2] Views |
| Testability/inter-operability | *Is it possible to test the new report such that inter-operability is achieved?*  [QC] YES.  [Company2] Views |
| Maturity | *How mature is the proposal from design perspective? Are there many options/sub-options to investigate down the road?*  [QC] relatively simply idea. Mature enough.  [Company2] Views |
| Other |  |
| Continue study? | *Do you think RAN1 should continue study of this scheme for R17 IIoT/URLLC?*  [Samsung] Yes  [QC] Yes |