**3GPP TSG RAN Meeting #93-e RP-21XXXX**

e-Meeting, September 13th – 17th, 2021

Agenda Item: 9.3.2.1

Title: Summary of email discussion [93e-17-IIoT-URLLC-Scope]

Source: Samsung (RAN1 Chair)

Document for: Discussion and Decision

# Introduction

As part of Rel-17 NR, there is an ongoing work item on *Enhanced Industrial Internet of Things (IoT) and ultra-reliable and low latency communication (URLLC) support for NR*. The work item is due for stage-3 completion by Q4 of 2021 in RAN1 and Q1 of 2022 in other working groups. For RAN1, there are only two WG meetings until the deadline of the stage-3 completion.

A number of companies have submitted contributions on how to move forward on multiple IIoT/eURLLC topics. A summary of the topics discussed in relevant contributions [1] ~ [6] is as follows:

* Intra-UE multiplexing and prioritization enhancements [1], [2], [3], [5]
* UE feedback enhancements for HARQ-ACK [2], [3]
* CSI feedback enhancements to allow for more accurate MCS selection [2], [3], [4]
* Enhancements for support of time synchronization [1], [2], [5], [6]
* Enhancements based on new QoS related parameters [1]

The purpose of the email thread [93e-17-IIoT-URLLC-Scope] is to collect company views and if possible, converge on a way forward on how to more efficiently progress the Rel-17 work on *Enhanced Industrial Internet of Things (IoT) and ultra-reliable and low latency communication (URLLC) support for NR*. For your reference, the detailed objectives in the WID [7] are provided below:

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| 1. Study, identify and specify if needed, required Physical Layer feedback enhancements for meeting URLLC requirements covering    * + UE feedback enhancements for HARQ-ACK [RAN1]      + CSI feedback enhancements to allow for more accurate MCS selection [RAN1]   Note: DMRS-based CSI feedback is not in scope of this WI   1. Uplink enhancements for URLLC in unlicensed controlled environments [RAN1, RAN2]:    1. Specify support for UE-initiated COT for FBE with minimum specification effort    2. Harmonizing UL configured-grant enhancements in NR-U and URLLC introduced in Rel-16 to be applicable for unlicensed spectrum 2. Intra-UE multiplexing and prioritization of traffic with different priority based on work done in Rel.16 [RAN1]: 3. Specify multiplexing behavior among HARQ-ACK/SR/CSI and PUSCH for traffic with different priorities, including the cases with UCI on PUCCH and UCI on PUSCH. 4. Specify PHY prioritization of overlapping dynamic grant PUSCH and configured grant PUSCH of different PHY priorities on a BWP of a serving cell including the related cancelation behavior for the PUSCH of lower PHY priority, taking the solution developed during Rel-16 as the baseline 5. Enhancements for support of time synchronization: 6. RAN impacts of SA2 work on uplink time synchronization for TSN, if any. [RAN2] 7. Propagation delay compensation enhancements (including mobility issues, if any). [RAN2, RAN1, RAN3, RAN4] 8. RAN enhancements based on new QoS related parameters if any, e.g. survival time, burst spread, decided in SA2. [RAN2, RAN3] |

# Initial phase

To kick off the initial discussions, the following sub-sections provide general questions for collecting views on the Rel-17 work item on Enhanced IIoT and URLLC. The views collected will be used to come up with moderator proposals to focus the follow up discussions in the next phase to more specific issues.

## Intra-UE multiplexing and prioritization enhancements

With only two RAN1 meetings left, intra-UE multiplexing and prioritization enhancements still has significant amount of work to be done. All four contributions to RAN#93-e discussing this topic propose a downscoping of the relevant work.

**Question/Request#1: Moderator would like to check company views on possible downscoping of intra-UE multiplexing and prioritization enhancements. Whether or not downscoping is necessary? And if so, which part of the objective should be downscoped?**

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| **Company** | **Views** |
| OPPO | We think down-scoping could help RAN1 to complete the WI in time.  Further, the following functionalities could be deprioritized first if any down-scoping should be considered on intra-UE multiplexing/prioritization:  - *Simultaneous Tx of PUCCH/PUSCH*: RAN1 agreed to support this for inter-band CA only. So its value in real deployment is lower than other features.  - *Overlapping between CG and DG PUSCH*: The RAN1 discussion on this part has been heavily dependent on corresponding Rel-16 maintenance discussion, so we expect it would be either controversial or with very limited time when the essential part of Rel-17 discussion starts. |
| Lenovo/Motorola Mobility | Considering the level of discussions, agreements, and amount of time RAN1 spent on multiplexing UCI of different priorities on PUCCH or PUSCH, we don’t think down-scoping is needed at this point. As having done for the HARQ-ACK feedback enhancement topic, RAN1 can make a bulk of agreements to complete the feature in next 2 meetings. |
| Qualcomm | We don’t think down-scoping is necessary but if some scope reduction needs to be agreed, we would prefer down-scoping only CG and DG PUSCH overlap handling. |
| Samsung | We think that after the August meeting, the status of URLLC is such that it does not need any down-scoping.  If any down-scoping is still desired, we would prefer to down-scope simultaneous PUCCH and PUSCH because, under the current framework, its usefulness will be limited. |
| Spreadtrum | We support down scoping.  Considering there are only two meeting left, and there are little agreements on overlapping between CG and DG PUSCH, we prefer to down scope this functionality from Rel-17 IIoT-URLLC. |
| Xiaomi | Downscoping is necessary. Since too many efforts has been put in UCI multiplexing, and it has already been extensively discussed in R16 URLLC, we support keep going on this topic and let go of others. And if still too much workload, UCI multiplexing on PUCCH can be prioritized and deprioritize UCI multiplexing on PUSCH |
| Apple | Down-scoping can help RAN1 to finish Rel-17 URLLC design on time:  The obvious candidate for downscoping is *“*PHY prioritization of overlapping dynamic grant PUSCH and configured grant PUSCH of different PHY priorities”*.*  Compared with Rel-16 URLLC design, the treatment on overlapping between CG and DG PUSCH may require the cancellation of an ongoing transmission. As revealed in the Rel-16 maintenance on UL skipping and L1/L2 priority, companies hold fundamentally different understandings on many issues. With the URLLC setup (e.g. L1/L2 priority, UL skipping, etc), it is unclear under what conditions PUSCHs will be generated, then it is questionable to define further behaviour concerning cancellation of one by another.  Simultaneous PUCCH/PUSCH Tx is another topic for downscoping. |
| DOCOMO | We don’t think down-scoping is necessary but if down-scoping is needed, we are OK to down-scope CG and DG PUSCH overlap handling. |

## UE feedback enhancements for HARQ-ACK

RAN1 made good progress on UE feedback enhancements for HARQ-ACK. However, there was one contentious issue with reference to PUCCH carrier switching: whether or not PUCCH carrier switching should include SUL and if so, which cases are supported.

**Question/Request#2: Moderator would like to check company views on SUL and PUCCH carrier switching with reference to HARQ-ACK feedback enhancements.**

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| **Company** | **Views** |
| CMCC | RAN1#106-e was trying to clarify/discuss the scenarios for PUCCH carrier switching, specifically the following 4 cases were under discussion:  **Case 1: PUCCH carrier switching among different cells not being configured with SUL**  **Case 2-1: PUCCH carrier switching among different cells where at least one cell is configured with SUL. For the cells having SUL configured, PUCCH is only configured either for NUL or SUL.**  **Case 2-2: PUCCH carrier switching among different cells where at least one cell is configured with SUL. For cells having SUL configured, PUCCH may be configured for NUL carrier, SUL carrier or both**  **Case 3: PUCCH carrier switching for a single cell configured with SUL and having PUCCH configured for NUL and SUL**  Based on the discussion in RAN1, it seems some companies have concern on the cases involving SUL. ***From our perspective, both CA case and SUL related cases should be supported for PUCCH carrier switching***. From CMCC perspective, both CA and SUL are important features and deployment scenarios, therefore we should do the enhancements for both, especially when there might be only very minor additional specification effort to support all the cases. Therefore, we proposal the following:  **For PUCCH carrier switching, the following switching scenarios are supported in Rel-17:**  **Case 1: PUCCH carrier switching among different cells not being configured with SUL**  **Case 2-1: PUCCH carrier switching among different cells where at least one cell is configured with SUL. For the cells having SUL configured, PUCCH is only configured either for NUL or SUL.**  **Case 2-2: PUCCH carrier switching among different cells where at least one cell is configured with SUL. For cells having SUL configured, PUCCH may be configured for NUL carrier, SUL carrier or both**  **Case 3: PUCCH carrier switching for a single cell configured with SUL and having PUCCH configured for NUL and SUL** |
| Lenovo/Motorola Mobility | This can be discussed in RAN WG1 level. We don’t think it is necessary to discuss this topic in RAN-P. |
| Qualcomm | Consistent with our previous comments, Case 1 and Case 2.1 are in scope. Cases 2-2 and 3 are not in scope. This is the direct consequence of the RAN1 agreements we had up to now. |
| Samsung | We are OK to include SUL for PUCCH carrier switching.  However, in general, that should be under the requirement of minimum specification impact as agreed and as justified by the limited applicability of the feature. |
| Xiaomi | We support to include the SUL in PUCCH carrier switching. On the one hand, SUL is already supported in preceding specification. On the other hand, switching among different carriers within one cell is an important case too, which should not be precluded. |
| Apple | We are open to the study on supporting SUL under PUCCH carrier switching, but prefer to make the decision at the working group level. |
| DOCOMO | We are fine to include SUL for PUCCH carrier switching. |

## CSI feedback enhancements to allow for more accurate MCS selection

RAN1 made the following conclusion on delta-MCS in RAN1#106-e after discussing the topic in GTW sessions and over emails.

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| **Conclusion**  There is no consensus in RAN1 on the support of delta-MCS in Rel-17. |

Given the conclusion, no further discussions on delta-MCS will take place in RAN1 unless RAN decides otherwise.

During the RAN1 discussions in RAN1#106-e (August), the general thinking among all interested companies was that if delta-MCS needs to be supported in Rel-17, the decision would have to be made in RAN1#106-e in order to secure enough time for follow up specification details on delta-MCS (only two more RAN1 meetings left).

In RAN#93-e, Qualcomm, DOCOMO, Sony, CATT, ZTE, and Ericsson submitted RP-212107 [4] which proposes to re-open the discussions on delta-MCS in RAN1.

**Question/Request#3: Moderator would like to check company views on re-opening the discussions on delta-MCS in RAN1.**

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| **Company** | **Views** |
| CMCC | We do not think it is a good idea to re-open the discussion on delta-MCS in RAN plenary meeting, especially considering that some companies observed the benefit brought by the it is not significant, and cannot justify the related enhancement. |
| OPPO | We are supportive to the principle as proposed in RP-212107 to re-open RAN1 discussion on delta-MCS. Meanwhile, we do not think plenary discussion should go to a detailed level as in RAN1 discussion; for example, the number of bits in delta-MCS report should be discussed and determined in RAN1. The guidance from RANP should be just on high-level. |
| Futurewei | We also don’t agree to re-open the discussion on delta-MCS in RAN plenary meeting. The benefit of the scheme is not justified and there will be a lot of open questions and work. As stated in the SR of this WI, the progress is behind schedule. If any RAN plenary intervention is needed, it should be to down-scoping instead of re-opening issues. |
| Lenovo/Motorola Mobility | We prefer not to re-open the discussion, as argument to support or to oppose the scheme will most likely be repeated including the discussions on the performance, and applicability to new transmissions in different frequency resources. |
| Qualcomm | We are supportive of this proposal. As mentioned before, if some agreement can be reached on how to select among the alternatives, e.g. as in the following  ▪ Alt. 1: Delta-MCS is reported in same resource as HARQ-ACK without additional time on top of the Rel-15 PDSCH-to-HARQ delay  ~~▪ Alt. 2: Delta-MCS is reported in resource separate from HARQ-ACK~~  ~~▪ Alt. 3: RRC configures between Alt. 1 and Alt. 2~~  then the remaining time is sufficient in RAN1 to work out the rest of the details.  We are open to other selection among the alternatives as well, but preferably it should conclude the selection in RAN#93e. |
| Samsung | We have technical concerns on the proposal from RP-212107 and in particular, on:  (a) not allowing additional UE processing time subject to UE capability (we do not even know yet the best metrics or a processing time required to obtain them), and  (b) having 1 bit for delta-MCS (1 bit does not provide any information for the general case that BLER can vary among transmissions).  We also believe that re-opening the discussion again is not likely to lead to a consensus on a design and will be counter-productive to the completion of Rel-17 IIoT. |
| Spreadtrum | We prefer not to reopen CSI enhancement, especially, there is still no analysis of impaction to PDSCH processing time. It is too urgent to conclude that when Delta-MCS is in the same PUCCH resource with HARQ-ACK, there is no additional time on Rel-15 timeline.  We are open for further study if timeline issue can be included in the scope, and majority views support it. |
| Apple | RAN1 has already drawn a conclusion, which should be respected. In addition, Delta-MCS is quite different from conventional HARQ/CSI feedback (so its specification is no small thing), which should be carefully studied and then specified if necessary. We are not sure now there is enough time to do that, given there are only two meetings left. We prefer to focusing on work on the rest of URLLC topics. |
| DOCOMO | We are supportive for the proposal. Regarding the potential workload issue, if we could achieve decisions on the necessity of additional timeline and resource for delta-MCS reporting as in RP-212107, the remaining time would be sufficient for the work item completion. |

## Enhancements for support of time synchronization

Enhancements for support of time synchronization was discussed in RAN#92-e for possible RAN guidance but without any outcome. While some progress has been made in the working groups in Q3, there is still no formal decision on which scheme(s) is to be supported in Rel-17. Given the limited time left until the completion of Rel-17, the rapporteur for Rel-17 IIoT and URLLC has proposed the following compromise in [1]:

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| **Proposal 2: For propagation delay compensation enhancements, RAN to agree the following compromise proposal:**   * **Support for baseline TA-based propagation delay compensation based on the Rel-15 / 16 timing advance procedure (i.e. Alt. 1) in Rel-17 without changes on existing TA requirements.** * **Support for Rx-Tx measurement based propagation delay compensation as the (main) Rel-17 PDC enhancement.** |

The above proposal is also made in [2]. From moderator’s point of view, the above proposal seems to be a reasonable way forward to ensure that Rel-17 has proper support of time synchronization for the envisioned use cases.

**Question/Request#4: Are there any strong concerns on the above proposal from the work item rapporteur on enhancements for support of time synchronization?**

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| **Company** | **Views** |
| CMCC | **For propagation delay compensation enhancements**  Since current LMF-based RTT method involves CN, RAN and UE which costs long delay, it is not suitable for IIOT, which requires ultra-low delay. Hence, the design of enhanced RTT-based method only involved gNB and UE is needed. This means that the current NAS signaling for positioning needs to be adapted into AS signaling for the TSC PDC, which will require significant discussion for details. From our perspective, RTT-based PDC method is not so simple that can reduce the work load of the WID.  Additionally, RAN1 has sent LS to RAN4 and RAN4 is involved in the discussion. Therefore, we prefer not to so rush to preclude the TA-based PDC solution in RAN plenary and continue the evaluation and discussion in RAN1/4/2. Maybe, a joint session of RAN1, RAN2 and RAN4 for this topic can be added into the slot. |
| OPPO | Yes, we do have the concern. As mentioned in GTW, RAN1 has not yet completed the analysis for RTT-based PDC to confirm its capability to meet RAN2 Uu interface error budget. On the other hand, thanks to focused efforts in RAN1 #106e, now RTT-based PDC becomes the PDC candidate having the largest spec impacts (examples including configuring/defining PRS outside of positioning protocol from RAN2, defining new CSI-RS-based timing sync performance requirements in RAN4, copying gNB Rx-Tx time difference report from wired link between gNb and positioning server to wireless link between gNB and UE, and etc). Therefore, if RTT-based PDC is selected now, the risk is either RAN1 finds out later it cannot meet RAN2 error budget even with feasible RAN4 performance requirement improvement, or RAN1 confirms RTT-based PDC can meet RAN2 error budget but RAN1/RAN2/RAN4 have hard time to complete all spec work in Rel-17 time frame.  [1] mentions a “deadlock” between companies supporting RTT-based PDC and companies supporting TA-based PDC. We have different view on this statement. In our view, the real “deadlock” comes from the fact that RAN1 has three error models for TA-based PDC and another three error models for RTT-based PDC, so RAN1 cannot even agree upon a numerical comparison between the two error performances for RTT-based PDC and TA-based PDC respectively. Such “deadlock” is technical and should be solved in RAN1, for example, to narrow down to one single error analysis formula for each PDC candidate.  Our preference is to continue the discussion in RAN1, e.g. to determine the error performance formula for all PDC solutions currently on the table (RAN1 may need to do this anyway in the end for the chosen PDC solution).  If RANP intervention is indeed desired, we think RANP could give the following guidance   * to make RTT-based PDC thinner, e.g., by picking just one DL-RS between PRS and CSI-RS, in order to make RAN2/RAN4 load lighter if RTT-based PDC is finally chosen by RAN1. * whether to allow the capability of meeting RAN2 error budget being SINR dependent (So far there is argument that the one-way propagation delay estimation performance can be made better in RTT-based PDC by utilizing specific DL-RS but such improved performance in error budget calculation has to be SINR dependent [per RAN4 outcome]; in contrast, other PDC solutions such as TA-based PDC still stay with SINR-independent error budget calculation -- so the comparison among PDC solutions in this way does not seem to be applet-to-apple, due to different SINR conditions for timing error upper-bounds).   Finally, we would like to remind the group: OPPO provided a solution called implicit PDC in the past RAN1/RAN2 meetings since April, also mentioned in the last RANP. We showed this solution can have no impacts to RAN1/RAN4; RAN2 signaling modification could be sufficiently make it to meet RAN2 error budget. If the major interest here in RANP is to find a solution that can simply ensure timely completion of WI objective on PDC, we do not see a reason why this solution has been put out of consideration. |
| Lenovo/Motorola Mobility | In our view, this should be concluded or agreed in RAN WG1 level. |
| Qualcomm | We agree with the moderator’s input proposal. The main PDC method should be RTT-based. In addition, TA-based method can be further supported as long as it is done without any TA procedure change/enhancement. |
| Samsung | The progress in previous RAN 1 was good. We think technical discussions and decision can be made in working group. On the other hand, we can understand rapporteur’s concern. If this proposal is acceptable for most of companies, we can live with the proposal. |
| Xiaomi | We prefer a single solution for PDC, considering the limited time remaining in Rel-17 and the standard work required in both RAN1 and RAN2. As both TA-based PDC and RTT-based PDC are targeting at resolving the same issue, the extra complexity of specifying two solutions is not necessary. |

## Enhancements based on new QoS related parameters

The work item rapporteur made the following proposal in [1] to ensure timely completion of the enhancements based on new QoS related parameters.

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| **Proposal 3: For the objective on New QoS parameter, RAN should provide the following guidance to RAN2:**   * **Sharpen the focus and concentrate on the specification work for survival time solution based on “HARQ NACK” that RAN2 has agreed to work/study.** * **Other options should be dropped for the time being.** * **If no consensus can be reached by the end of Rel-17, RAN2 should postpone the discussion to future releases.** |

**Question/Request#5: Companies are requested to provide their views on the above proposal for RAN guidance to RAN2 on enhancements based on new QoS related parameters.**

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| **Company** | **Views** |
| CMCC | We support this proposal and prefer that RAN2 only focus on the fast feedback mechanism, i.e. HARQ NACK or UL retransmission triggering the adjustment of resource usage, e.g. PDCP duplication triggering. |
| OPPO | We are generally fine with the first two bullets. But wonder why the last bullet is needed. To our best knowledge, there is a chance that Rel-18 does not have URLLC item. So the last bullet provides almost nothing but some confusion because it is a rare practice to promise a “postponed feature” to show up by a delay of more than one release.  If the intention is just to say “**If no consensus can be reached by the end of Rel-17, the objective on new QoS parameter should be removed from WID**”, this can be discussed in December RANP. Anyhow “No consensus, no support in the release” is a common practice in 3GPP. |
| Lenovo/Motorola Mobility | We are supportive of the proposed RAN guidance to RAN2. |
| Qualcomm | Our view is similar to Oppo’s. We agree with the first two bullets.  The last bullet seems unnecessary as it is not really actionable. What will be discussed in future releases is up to future SI/WI scope(s). We cannot make decisions about that now. The only thing we can decide now is what is in and what is out of Rel-17. I’m sure the rapporteur intended to say the same, but the proposed bullet could be interpreted differently. |
| Samsung | RAN2 discussion on QoS related scheduling has been well-organized so far and on-time completion is still possible. We think whether to drop other solutions can be decided in WG2, after technical discussions in the next quarter. |
| Xiaomi | We support the proposal, as this can reduce the work load in RAN2 and facilitate the QoS discussion in Rel-17. |
| Apple | While we are fine to concentrate on the HARQ NACK as initial/first approach, the exact solution is rather not yet settled. There is also an option to combine the HARQ NACK with a TX-side timer and as Nokia pointed out in the discussion paper, many details are yet to be established. We think the solution options should be a RAN2 WG decision.  Plus, it seems a bit premature to drop other options currently. In particular, the second bullet should be removed from proposal 3. Bullet 1 reflects the direction that RAN2 has agreed, maybe there is no need “to sharpen the focus”. Further, other methods to enhance reliability during survival time have not quite been discussed. Rather than removing enhancement options we think the discussion can be continued in Rel-18 to allow for proper evaluation of those items. |
| DOCOMO | We are fine with the proposal to facilitate the discussion. |

# Intermediate phase

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# Fine tuning phase

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# Conclusion

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# References

[1] RP-211939 Rapporteur views on status of Rel-17 URLLC/IIoT WI Nokia, Nokia Shanghai Bell

[2] RP-212002 Discussion on progress in Rel-17 URLLC/IIOT Intel Corporation

[3] RP-212024 Scope discussion on Rel-17 IIOT/URLLC vivo

[4] RP-212107 Views on RAN1 scope for URLLC/IIOT Qualcomm, DOCOMO, Sony, CATT, ZTE, Ericsson

[5] RP-212235 Progress and scope of Rel-17 enhanced IIoT and URLLC CATT

[6] RP-212349 Propagation Delay Compensation for URLLC/IIoT Ericsson

[7] RP-210854 Revised WID: Enhanced Industrial Internet of Things (IoT) and ultra-reliable and low latency communication (URLLC) support for NR Nokia, Nokia Shanghai Bell