3GPP TSG-RAN WG3 Meeting #115-e R3-222453

Online, 21 February – 03 March 2022

**Agenda item: 21.2**

**Source: Nokia (moderator)**

**Title: Summary of offline: time synchronisation enhancements**

**Document for: Discussion and Decision**

# 1 Introduction

This paper summarizes the following email discussion:

**CB: # NRIIOT2\_PDC**

**- The Uu time synchronization error budget is introduced over F1 interfaces?**

**- Introduce a new Measurement and report procedure to support TA-based and/or RTT-based PDC?**

**- The UE-associated signalling is needed over F1AP to provide gNB Rx-Tx time difference measurement (RTT-based PDC) and/or TA measurement (TA-based PDC) from gNB-DU to gNB-C?**

**- Whether the gNB-CU needs to provide the TRS/PRS and SRS configuration information to gNB-DU in RTT measurement**

**- During the handover, what kinds of time synchronization assistance information should the source gNB notify the target gNB, e.g., Uncertainty, Time Information Type, TSN distribution, Periodicity…?**

**- Capture agreements and provide TPs if agreeable**

(Nok - moderator)

Summary of offline disc [R3-222453](file:///C:\Users\t00628561.CHINA\AppData\Roaming\eSpace_Desktop\UserData\t00628561\ReceiveFile\Inbox\R3-222453.zip)

# 2 For the Chair’s Notes

**For RTT-based PDC, PD pre-compensation is performed by the gNB-CU.**

**Introduce a new UE-associated class 1 procedure (CU-initiated) and a new UE-associated class 2 procedure (DU-initiated) to support both RTT-based PDC and TA-based PDC.**

**For RTT-based PDC, gNB-DU reports gNB Rx-Tx time difference to gNB-CU.**

**No need to signal any Uu Synchronization Error Budget over F1 in Release 17.**

**No need for any additional time synchronisation assistance information over Xn in Release 17.**

Online discussion needed on the following (open issues):

- For TA-based PDC, does gNB-DU report NR Timing Advance (meaning PD pre-compensation is performed by the gNB-CU) or compensated RTI (meaning PD pre-compensation is performed by the gNB-DU)?

# 3 Discussion (Round 1)

Please provide your Round 1 views (5 questions) by **11:00 UTC Wednesday February 23rd**, so that comments may be taken into account during the online discussion later that day.

## 3.1 Propagation Delay Compensation

RAN3 received an LS from RAN2 in [1], listing their agreements on Propagation Delay Compensation (PDC). In this 1st round of discussion, it is proposed to focus on the following RAN3 aspects:

a) Signalling framework over F1AP for RTT-based PDC and TA-based PDC

b) Whether PD pre-compensation is performed by the gNB-CU or by the gNB-DU

Also, it is proposed to first focus on unicast delivery of RTI without any ongoing NR positioning (e.g. E-CID positioning using “NR TADV” has not been initiated by the LMF). Potential specification impacts of broadcast delivery of pre-compensated RTI and of concurrent NR positioning procedures can be handled in 2nd round discussion.

Overview of related papers:

Company views on the high level PDC signalling framework are summarized in Table 1 below.

|  |  |  |
| --- | --- | --- |
| *Company* | *RTT-based PDC at gNB/UE* | *TA-based PDC at gNB* |
| Nokia [2] | New UE-associated Class 1 request (CU-initiated)  New UE-associated Class 2 report (DU-initiated) | Same as RTT-based PDC |
| ZTE [4][5] | New IE in UE Context Setup/Modification  New UE-associated Class 2 report (DU-initiated) | ? |
| Huawei [7][8] | New UE-associated Class 1 request (CU-initiated)  New UE-associated Class 2 report (DU-initiated) | New IE in RTI Reporting Control / RTI Report |
| Ericsson [10] | ? | New UE-associated Class 1 request (CU-initiated) |
| CATT [11] | New UE-associated Class 1 request (CU-initiated)  New UE-associated Class 2 report (DU-initiated) | Same as RTT-based PDC |

Table 1: Company views on PDC signalling framework

Company views on which node performs PD pre-compensation are summarized in Table 2 below.

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| --- | --- | --- |
| *Company* | *RTT-based PDC at gNB/UE* | *TA-based PDC at gNB* |
| Nokia [2] | CU performs PD pre-compensation | CU performs PD pre-compensation |
| ZTE [4][5] | CU performs PD pre-compensation | ? |
| Docomo [6] | CU performs PD pre-compensation | CU performs PD pre-compensation (unicast)  DU performs PD pre-compensation (broadcast/SIB9) |
| Huawei [7][8] | CU performs PD pre-compensation | DU performs PD pre-compensation |
| Ericsson [10] | ? | CU performs PD pre-compensation |
| CATT [11] | CU performs PD pre-compensation | DU performs PD pre-compensation (slight preference) |

Table 2: Company views on node that performs PD pre-compensation

Moderator’s observations for RTT-based PDC:

- 5 of 5 companies propose that CU performs PD pre-compensation.

- 4 of 4 companies propose to introduce a new UE-associated Class 2 procedure to enable DU to report gNB Rx-Tx time difference to CU.

- 3 of 4 companies propose to also introduce a new UE-associated Class 1 procedure to enable CU to request (either “on-demand” or “periodic”) gNB Rx-Tx time difference from DU. The remaining 1 company proposes to reuse the UE Context Setup/Modification procedure for the same purpose.

Based on the above observations, it seems there is (near-)consensus on the following:

**Proposal #1:** For RTT-based PDC, PD pre-compensation is performed by CU.

**Proposal #2:** To support RTT-based PDC, introduce a new UE-associated class 1 procedure (CU-initiated) and a new UE-associated class 2 procedure (DU-initiated) to enable reporting of gNB Rx-Tx time difference from DU to CU.

**Question 1: Can Proposals #1 & #2 be agreed for RTT-based PDC?**

NOTE: If proposal 2 is agreeable, then details of the new procedures can be discussed in the 2nd round.

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| **Company** | **Comments** |
| Huawei | Agree the two proposals.  And another reason why a new UE-associated procedure is needed instead of reusing the positioning message or E-CID measurement, is that the POSITIONING MEASUREMENT REQUEST/ RESPONSE carrying the gNB Rx-Tx Time Diff are non-UE associated messages and E-CID measurement will also be involved with LMF besides the UE and gNB. |
| ZTE | Yes for proposal 1  For proposal #2, similar as that in UU interface that RRCReconfiguration includes the measurement configuration and the measurement results are included in a UE specific message MeasurementReport, we prefer in F1AP to introduce a new IE in existing signalling(UE Context Setup /Modification Request) to configure the measurement control information, and a new UE-associated class 2 procedure (DU-initiated) to enable reporting of gNB Rx-Tx time difference from DU to CU. In this manner, a DL message can be saved and can decrease the measurement configuration delay. |
| CATT | Agree to the two proposals. Use the new message is more clear. |
| Samsung | We support two proposals. |
| Nokia | Yes, for both proposals. |
| Ericsson | Proposal 1 is fine.  Proposal 2, about the DU to CU reporting, we could also consider to report a group of UEs in one message. |
| Qualcomm | Yes for both |
| Moderator Summary:   * 7 companies responded * For Proposal 1, all 7 companies agree. * For Proposal 2, 6 companies agree to introduce a new UE-associated class 1 procedure and 6 companies agree to introduce a new UE-associated class 2 procedure. However, 1 company prefers to reuse the UE Context Setup/Modification procedure rather than a new class 1 procedure, while another company proposes to consider a new non-UE associated class 2 procedure (which would be needed “to report a group of UEs in one message”?) rather than a new class 2 procedure   Proposed conclusion:   * Agree to Proposal 1 (consensus). * Agree to Proposal 2, since 6 of 7 companies agree to introduce a new UE-associated class 1 procedure (CU-initiated), and 6 of 7 companies agree to introduce a new UE-associated class 2 procedure (DU-initiated). | |

Moderator’s observations for TA-based PDC:

- 3 of 5 companies propose that CU performs PD pre-compensation, while the remaining 2 companies propose that DU performs PD pre-compensation.

- 3 of 4 companies propose to introduce a new UE-associated Class 1 procedure to enable CU to request (either “on-demand” or “periodic”) TA-based PDC information from DU. The remaining 1 company proposes to enhance the existing non-UE associated Reference Time Information Reporting Control and Reference Time Information Report procedures to carry UE-specific information.

- 2 companies additionally indicate that common procedures can be used for both TA-based and RTT-based PDC.

Based on the above observations, companies are split whether PD pre-compensation is performed by CU or DU, i.e. whether DU reports NR Timing Advance or compensated RTI. Regardless of this, all but one company proposes to introduce new UE-associated procedures for TA-based PDC, while the one company that proposes to reuse non-UE associated procedures indicated at last RAN3 meeting that new UE-associated F1AP procedure is acceptable (see [13] question #6).

Therefore, the following is proposed:

**Proposal #3:** To support TA-based PDC, introduce a new UE-associated class 1 procedure (CU-initiated) and a new UE-associated class 2 procedure (DU-initiated) to enable reporting of “TA-based PDC information” (details FFS).

**Issue-1:** Further discuss whether the “TA-based PDC information” is:

a) NR Timing Advance (meaning PD pre-compensation is performed by CU) or

b) compensated RTI (meaning PD pre-compensation is performed by DU).

**Question 2: Can Proposal #3 be agreed for TA-based PDC? If so, can TA-based PDC and RTT-based PDC use common procedures (i.e. the new procedures of Proposal #2 and #3 can be the same)?**

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| **Company** | **Comments** |
| Huawei | We agree this proposal 3 under conditions that we don’t intend to combine the new TA-based PDC with the existing non-UE associated Reference Time Information Reporting Control procedure.  For example, we don’t want to specify that the CP has to calculate the final PDC value after acquiring the node level Time Reference Information from the REFERENCE TIME INFORMATION REPORT message, and acquiring the UE level TA-based PDC value from another new procedure.  If this can be met, we are also fine to have a common UE-associated procedure for TA-based and RTT-based PDC. |
| ZTE | Yes, we agree with Proposal 3. But based on the comments of Q1, we do not agree that the new procedures of Proposal2 and Proposal3 are the same. |
| CATT | Agree the proposal 3. The new message can be used for both TA and RTT |
| Samsung | Yes, we agree with Proposal 3. And we prefer common procedure for TA-based PDC and RTT-based PDC. |
| Nokia | Yes, for proposal 3. We prefer common F1AP procedures for TA-based and RTT-based PDC. |
| Ericsson | Ok with Proposal 3.  In addition, we think the existing E-CID, which is UE based, can also be considered, if such has started. |
| Qualcomm | Ok with proposal 3. In addition, we don’t see a strong reason not to attempt common procedure(s) for TA and RTT. |
| Moderator Summary:   * 7 companies responded. * 6 companies agree with Proposal 3, while 1 company can agree with Proposal 3 with a caveat that we don’t combine the new TA-based PDC with the existing non-UE associated Reference Time Information Reporting Control procedure.   Proposed conclusion:   * Agree to proposal 3. The caveat from Huawei can be taken into account during the 2nd round when discussing further details of the new procedures. | |

**Question 3: For TA-based PDC, what does the gNB-DU report to the gNB-CU: (a) NR Timing Advance or (b) compensated RTI?**

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| **Company** | **Comments** |
| Huawei | We think the key problem is not which node (CU/DU) performs the PDC. For unicast message, anyway, it is the **CU** that generates compensated Reference Time Information to the UE, based on the information sent from the DU.  So the key problem is about the exact information and its granularity of the information from the DU to CU.   * For a), as discussed in R3-221967, the TA indicating granularity is , (about 520ns) which may cause an additional sync error. * For b), the granularity is in terms of 10ns (by referring to the Reference Time broadcast in SIB9 in RRC specification), which is more accurate.   So b) is our preference. |
| ZTE | We think PD pre-compensation in gNB can only be performed by CU for unicast case, and RRC signalling is encoded in CU, so (a) is a good choice. |
| CATT | We prefer b). Share with Huawei. |
| Samsung | We’re fine with (a) to be aligned with RTT-based PDC, i.e. CU performs PD pre-compensation. |
| Nokia | We prefer (a).  Regarding whether there is any difference in accuracy/granularity between (a) and (b), the comments from Huawei assume that TA would be signalled over F1AP with same granularity as the signalling over Uu (i.e. granularity of 521ns, 260ns, 130ns, 65ns, 33ns for µ = 0, 1, 2, 3 and SCS 15kHz, 30kHz, 60kHz and 120kHz respectively).  However, we believe that TA with finer granularity than could be signalled over F1AP. For example, Rx-Tx measurement report with k=5 gives 32ns (64Tc) resolution for TA, so the Rx-Tx granularity could be allowed for reporting TA over F1AP. Then, there would be no meaningful difference in accuracy between (a) and (b). For example:  **INTEGER (0..62500) in units of 64Tc**  (where max value is roughly aligned with NTA range) |
| Ericsson | a). It is more logical for CU to perform compensation. |
| Qualcomm | Prefer a). Also Nokia’s suggestion should be considered. |
| Moderator Summary:   * 7 companies responded * 5 companies prefer (a) while 2 companies prefer (b).   Proposed conclusion:   * Further discuss online. Most companies prefer (a), and perhaps the suggested encoding to use units of 64Tc might address the concerns of the 2 companies the prefer (b)? | |

## 3.2 Uu time synchronisation error budget over F1

Overview of related papers:

- 2 companies (ZTE in [4][5] and CATT in [12]) propose to introduce a “cell level” Uu Time Synchronisation Error Budget over F1AP in the REFERENCE TIME INFORMATION REPORTING CONTROL message. The “cell level” value is e.g. the most stringent value among the UE-specific values provided over NGAP from the CN.

- 1 company (Nokia in [2]) believes that a “cell level” Uu Time Synchronisation Error Budget is useful for the DU to derive SIB9 periodicity for broadcast-based RTI delivery due to UE clock drift. However, it may be sufficient in Rel-17 to assume that DU is configured via OAM with an appropriate SIB9 periodicity value.

- 1 company (Huawei in [8]) believes that Uu Time Synchronisation Error Budget is only useful for PDC decision by the CU, and therefore is not needed by the DU.

Moderator’s Summary:

Companies are split whether DU needs to know the Uu Time Synchronisation Error Budget. Among companies who do see the need, there are differing views on why (e.g. accuracy of unicast RTI delivery or periodicity of broadcast RTI delivery).

**Issue-2:** Further discuss whether:

a) CU provides a “cell level” Uu Time Synchronisation Error Budget (e.g. the most stringent value among the UE-specific values provided over NGAP from the CN) in the REFERENCE TIME INFORMATION REPORTING CONTROL message; or

b) No need to signal any Uu Synchronization Error Budget over F1 in Release 17.

**Question 4: Should Uu Time Synchronisation Error Budget (cell level, e.g.** **most stringent value among the UE-specific values provided over NGAP from the CN) be included in the REFERENCE TIME INFORMATION REPORTING CONTROL message?**

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| **Company** | **Comments** |
| Huawei | We don’t see the need, as discussed in R3-221968 |
| ZTE | Yes. |
| CATT | If the DU perform the PDC, this information is needed in DU |
| Samsung | We’re fine with b) in Rel.17. |
| Nokia | We can accept (b). |
| Ericsson | b) would be fine in order to conclude at this meeting. |
| Qualcomm | The use cases still seem marginal, so prefer b). In any case if it is a clear omission, and a very clear new argument can be made, this can always be revisited either as a correction or in rel-18. |
| Moderator Summary:   * 7 companies responded * 2 companies support including the Uu Synchronization Error Budget in REFERENCE TIME INFORMATION REPORTING CONTROL message, while 5 companies indicate that there is no need to signal any Uu Synchronization Error Budget over F1 in Release 17.   Proposed conclusion:   * No consensus to include the Uu Synchronization Error Budget over F1 in Release 17. | |

## 3.3 Time synchronization: XnAP open issues

The following are the relevant agreements / open issues already captured in the Chair’s minutes:

**Introduce the Time Synchronisation Assistance Information IE as an optional UE-level parameter in**

**- XnAP (HANDOVER REQUEST and RETRIEVE UE CONTEXT RESPONSE)**

**It is FFS on whether assistance information (e.g., UE TSN timing reference, referenceTimeInfo delivery periodicity, timestamp) should be delivered during HO.**

Overview of RAN3 papers:

- Nokia [3]: The *Time Synchronization Assistance Information* IE already agreed to be exchanged over XnAP is enough for the target gNB to determine the delivery configuration of RTI to the UE in the new cell. Therefore, no additional time synchronisation assistance information is needed over XnAP in Release 17.

- Huawei [7]: The RTI configuration in the source gNB can be used by the target gNB to determine the suitable time sync delivery mode and delivery period after the handover completion. At least the RTI periodicity is needed.

- Ericsson [9]: It is beneficial for the target gNB to know the UE’s TSN time reference information used in the source gNB as early as possible during NG and Xn handover. Therefore, the TSN Time Reference Information (Uncertainty, Time Information Type, TSN distribution, and Periodicity) should be included in the HANDOVER REQUEST message.

Moderator’s Summary:

To assist the target gNB in deciding the RTI delivery configuration, two companies believe it is useful for the source gNB to provide the RTI Periodicity in the HANDOVER REQUEST message. In addition, one company believes that RTI Uncertainty, Time Information Type, and TSN Distribution are also useful.

This topic has been discussed for several meetings without any change to company opinions. Since this is the last meeting of the work item, the moderator suggests to first focus on RTI periodicity which has support from at least 2 companies.

**Issue-3:** Further discuss whether to enable source gNB to provide RTI periodicity to the target gNB in the HANDOVER REQUEST message.

**Question 5: In case of handover, should RTI periodicity be included in the HANDOVER REQUEST message?**

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| **Company** | **Comments** |
| Huawei | Yes.  This can help the target gNB to determine the delivery period after the handover completion, based on the information from the source gNB. This can be seen as reference information to be considered by the target gNB. |
| ZTE | No.  Based on the RAN2 specification, the UE provides only the *referenceTimeInfoPreference* to the gNB and it can already be delivered to the target gNB. The target gNB can obtain all the RTI related info. urthermore, RAN2 has not agreed to introduce RTI periodicity. |
| CATT | No |
| Samsung | No. We have the similar view as Nokia in [3]. |
| Nokia | No. |
| Ericsson | Yes. Other information like uncertainty, time type, which is not part of the *Time Synchronization Assistance Information,* might be useful to have. |
| Qualcomm | Neutral. Use cases are quite slim but would not oppose this if it helped to move forward. However that does not seem to be the case. |
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| Moderator Summary:   * 7 companies responded. * 2 companies support including RTI periodicity in HANDOVER REQUEST, while 5 companies do not. * 1 company additionally supports including other information like uncertainty and time type.   Proposed conclusion:   * No consensus to include RTI periodicity (or any other additional assistance information) in the HANDOVER REQUEST message. | |

# 4 Discussion (Round 2)

TBD

# 5 Conclusions, Recommendations

Conclusions/recommendations from Round 1 discussion:

1. **For RTT-based PDC, PD pre-compensation is performed by the gNB-CU.**

2. **Introduce a new UE-associated class 1 procedure (CU-initiated) and a new UE-associated class 2 procedure (DU-initiated) to support both RTT-based PDC and TA-based PDC.**

3. **For RTT-based PDC, gNB-DU reports gNB Rx-Tx time difference to gNB-CU.**

4. **No need to signal any Uu Synchronization Error Budget over F1 in Release 17.**

5. **No need for any additional time synchronisation assistance information over Xn in Release 17.**

6. For TA-based PDC, further discuss whether DU reports NR Timing Advance (meaning PD pre-compensation is performed by the gNB-CU) or compensated RTI (meaning PD pre-compensation is performed by the gNB-DU).

# References

1. R3-221666, LS on PDC for Time Synchronization (RAN2)
2. R3-221874, (TP for NR\_IIOT\_URLLC\_enh BL CR for TS 38.473) Time synchronization: resolution of F1AP open issues (Nokia, Nokia Shanghai Bell)
3. R3-221875, Time synchronization: resolution of mobility open issues (Nokia, Nokia Shanghai Bell)
4. R3-221877, Discussion on Time Synchronization enhancements (ZTE)
5. R3-221878, (TP for Introduction of Enhanced IIoT support over F1) Time Synchronization enhancements (ZTE)
6. R3-221951, Propagation Delay Compensation for TSN time synchronization (NTT DOCOMO INC.)
7. R3-221967, (TP for eIIOT BLCR for TS 38.473 and TS 38.423) Supporting PDC enhancements: TA-based PDC and mobility (Huawei)
8. R3-221968, (TP for eIIOT BLCR for TS 38.473) Supporting PDC enhancements: RTT based PDC (Huawei)
9. R3-222037, Discussion on Further enhanced NR-IIoT: Enhancements for support of time synchronization (Ericsson)
10. R3-222038, Discussion on PDC TA based and E-CID measurement (Ericsson)
11. R3-222212, Discussion on Propagation Delay Compensation Enhancements (CATT)
12. R3-222213, TP for BLCR for 38.473 on Propagation Delay Compensation Enhancements (CATT)
13. R3-221112, Summary of offline: Propagation delay compensation enhancements (Nokia)