3GPP TSG-RAN WG3 Meeting #114bis-e R3-221112

Online, 17 – 26 January 2022

**Agenda item: 21.2**

**Source: Nokia (moderator)**

**Title: Summary of offline: Propagation delay compensation enhancements**

**Document for: Discussion and Decision**

# 1 Introduction

This paper summarizes the following email discussion:

**CB: # NRIIOT2\_PDC**

**- Continue the open issues left over NG, Xn and F1 interfaces**

**- A time distribution indication and/or a Uu time synchronization error budget are introduced over F1 interfaces?**

**- Whether the Time Synchronization Assistance Information IE needs to be included in the PATH SWITCH REQUEST ACKNOWLEDGE message of the NG?**

**- The CU can determine to enable/disable the PDC?**

**- Whether the target gNB needs to provide the UE with configuration information for RTT measurement during the handover, and discuss the RTT PDC Measurement procedure**

**- 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, and Timestamp of last RTI…?**

**- Capture agreements and open issues**

**- TPs if agreeable**

(Nok - moderator)

Summary of offline disc [R3-221071](file:///C%3A%5CUsers%5Cx00300387%5CAppData%5CRoaming%5CeSpace_Desktop%5CUserData%5Cx00300387%5CReceiveFile%5CInbox%5CR3-221071.zip)

# 2 For the Chair’s Notes

## 2.1 From 2nd round (new)

**R3-221220 agreed (NGAP TP resolving FFS in Path Switch Request Acknowledge)**

## 2.2 From 1st round (already captured during online session)

**Introduce the Time Synchronisation Assistance Information IE as an optional UE-level parameter in PATH SWITCH REQUEST ACKNOWLEDGEMENT.**

**It is the gNB-CU that decides whether/how to perform PDC (Note: the PDC mechanisms to be specified in Rel-17, if any, are FFS pending RAN2).**

Further discussion needed on the following (open issues):

- usefulness of Uu Time Synchronisation Budget (cell level?) at the DU.

- whether/how the Uu Time Synchronisation Error Budget affects RTI delivery (e.g. periodicity).

Further discussion of gNB-based PDC is postponed to next meeting to allow further RAN2 progress. The following may need further discussion depending on RAN2 discussion outcome:

- For TA-based PDC at the gNB, it is FFS whether DU reports compensated RTI or the TA-value.

- For RTT-based PDC, DU may need to report gNB Rx-Tx time different to the CU (FFS)

# 3 Discussion (Round 1)

Please provide your Round 1 views (7 questions) by **12:00 UTC Tuesday January 18th**, so that comments may be taken into account during the online discussion that day.

## 3.1 Time synchronization: F1AP open issues

At RAN3#114e, it was discussed if the IEs of *Time Synchronization Assistance Information* (i.e., *Uu Time Synchronisation Error Budget* and *Time Distribution Indication*) must be known by the gNB-DU to decide the reference time distribution to the UEs, e.g., determine the periodicity of SIB9 and/or provide appropriate reference time accuracy. The following working assumption was captured in the Chair’s Minutes:

**WA: The Uu Time Synchronisation Error Budget IE is needed over F1AP, details FFS.**

Overview of RAN3 papers:

- ZTE [1][2]: For unicast delivery, the gNB-CU can send the minimum Uu time synchronization error budget (e.g. the most rigorous budget) of multiple UEs to the gNB-DU (in REFERENCE TIME INFORMATION REPORTING CONTROL), and gNB-DU reports the reference time with the minimum budget based on the gNB-CU request. For broadcast delivery, Uu time synchronization error budget can be decided in gNB-DU by OAM.

- Nokia [5]: For broadcast delivery, the gNB-CU provides a “Cell Level Uu Time Synchronisation Error Budget” to the gNB-DU (in SYSTEM INFORMATION DELIVERY COMMAND), since the gNB-DU is responsible for determining the SIB9 periodicity. For unicast, there is no need for gNB-DU to know the error budget since the gNB-CU controls both the delivery and encoding of the DL RRC messages. Also, the need for SIB9 broadcast may change over time and thus a mechanism is needed over F1AP to enable the gNB-CU to request to stop an ongoing SIB9 broadcast.

- Samsung [10]: The time synchronization error budget should be delivered to the gNB-DU over F1AP (in REFERENCE TIME INFORMATION REPORTING CONTROL), and with the error budget, the gNB-DU can determine the periodicity of the reference time distribution by using broadcast RRC message.

- Huawei [11]: No need to introduce the Uu Time Synchronisation Error Budget in F1.

- CATT [13][14]: Use non-UE associated signalling to carry the Uu Time Synchronisation Error Budget IE in F1AP. i.e. REFERENCE TIME INFORMATION REPORTING CONTROL.

Moderator’s Summary:

There appears to be general consensus that the *Uu Time Synchronisation Error Budget* should be provided to the gNB-DU using non-UE associated signalling, implying also that it is a “cell level” error budget derived by the gNB-CU based on the error budgets of individual UEs. We note that [11] does not see the need to introduce the error budget over F1, but the analysis seems to focus on a different use case (PDC rather than RTI delivery).

However, company opinions diverge on which F1AP message to (re)use. This seems due to different understandings on the following points:

a) Is the Cell Level Uu Time Synchronisation Error Budget applicable for broadcast/SIB9 delivery (only), or unicast delivery (only), or both?

b) Does the Cell Level Uu Time Synchronisation Error Budget impact RTI delivery periodicity (only), the actual RTI content (only), or both?

Also, an issue is raised in [5] that accurate time synchronisation service can be actively enabled/disabled by the *Time Distribution Indication*, and therefore a mechanism may be needed to allow the gNB-CU to indicate to the gNB-DU that previously requested SIB9 broadcast is no longer needed.

Proposed way forward:

- WA: The gNB-CU determines a “Cell Level” Uu Time Synchronisation Error Budget value and provides it to the gNB-DU using non-UE associated signalling.

- Open Issue(s): Which F1AP message(s) to convey the Cell Level Uu Time Synchronisation Error Budget? Whether/how to enable the gNB-CU to stop ongoing broadcast/SIB9 delivery?

**Question 1: Can the following working assumption be agreed:**

WA: The gNB-CU determines a “Cell Level” Uu Time Synchronisation Error Budget value and provides it to the gNB-DU using non-UE associated signalling.

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| **Company** | **Comments** |
| Nokia | YES. |
| Huawei | No. We don’t see the need to signal the Uu time synchronization error budget (either cell level or the minimized value) to the DU since in our view, this budget is not relevant to the decision of the RTI delivery periodicity. This value in Rel-17 can be up to 900 ns only (as per SA1 requirement). This parameter can only be used for the PDC decided by the NG-RAN node, e.g, who performs PDC, which PDC algorithm is to be used, R16 PDC or R17 PDC mechanism etc. For example, * for a large value e.g.900ns, the gNB can decide do nothing;
* for a medium value, e.g., 400ns, the gNB can use the R16 PDC (based on UE implementation);
* for smaller value, e.g., 300 ns, the gNB can decide the R17 based PDC.

About the RTI periodicity, this can be decided by the UE assistance information, which is already known by the DU, or other implementation aspects at the DU.  |
| ZTE | Yes. |
| Qualcomm | Still FFS - right now it still seems unclear what exactly the gNB-DU does with this value. For example, don’t see how this impacts the broadcast reference time or uncertainty of this (DU-CU signalling) which is mentioned in some papers. Similarly for the scheduling periodicity. Would the error basically be used to decide whether to broadcast reference time at all? It would be good to shed some light on this.  |
| Ericsson | We do not see, how the UE error budget, which is sent per UE and based on the service requirement, is turned into a Cell Based parameter and used for broadcast.In our view, the “Error budget” is used for PDC, not direct related to “RTI” delivery periodicity for the whole Cell.The proposed WA needs further discussion. |
| CATT | Yes, we need further study the usage of this parameter |
| Samsung | Yes, but it seems unclear how the error budget is used. So further discussion is required when it turns into agreement. |
| Moderator Summary:* 7 companies responded.
* 4 companies agree with the proposal that gNB-CU determines a “Cell Level” Uu Time Synchronisation Error Budget value and provides it to the gNB-DU using non-UE associated signalling, although 2 of them believe further discussion is needed on how the DU uses the parameter.
* 3 companies are not yet convinced that the error budget needs to be signalled over F1.

Proposed conclusion: Further discussion needed on the usefulness of Uu Time Synchronisation Budget (cell level?) at the DU. |

**Question 2: Please provide your views on the following open issues related to RTI delivery:**

a) Is the Cell Level Uu Time Synchronisation Error Budget applicable for broadcast/SIB9 delivery (only), or unicast delivery (only), or both?

b) Does the Cell Level Uu Time Synchronisation Error Budget affect RTI delivery periodicity (only), the actual RTI content (only), or both?

c) Which F1AP message(s)?

d) Whether/how to enable the gNB-CU to stop ongoing broadcast/SIB9 delivery?

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| **Company** | **Comments** |
| Nokia | * In our understanding, the Uu Time Synchronisation Error Budget only affects RTI delivery periodicity (no effect on any of the content of the RTI).
* Since RTI delivery periodicity is determined by the DU only for the case of broadcast/SIB9 delivery, the error budget only needs to be signalled to the DU when the CU decides to initiate or modify SIB9 broadcast (therefore in the SYSTEM INFORMATION DELIVERY COMMAND).
* The error budget is not needed in the REFERENCE TIME INFORMATION REPORTING CONTROL unless RAN3 determines that the DU needs the error budget also for unicast delivery (e.g. error budget affects the actual RTI content).
* A mechanism is needed to enable the gNB-CU to indicate to the gNB-DU that previously requested SIB9 broadcast is no longer needed.
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| Huawei | For a), b), c), See our comments to Q1. For d), so far we don’t see the need, since the SIB9 is generated by the gNB-CU. Upon the “disable” time distribution for all UEs, the gNB-CU shall not include the RTI in SIB9, so that the gNB-DU will not broadcast the RTI.  |
| ZTE | * In our view, the cell-level UU time synchronization error budget is only applicable to unicast delivery. Because in the case of accurate time synchronization by broadcast, there is not cell level Uu time synchronization error budget request and gNB-DU can re-write the SIB9 (e.g. including reference time information), the Uu time synchronization error budget can be decided in gNB-DU by OAM.
* We think that the cell-level UU time synchronization error budget affects not only the RTI transmission cycle but also the actual RTI content (e.g. the *uncertainty*).
* Since non-UE associated signallings in F1AP are used to request/report the reference time, it is simple to carry the Uu time synchronization error budget in the non-UE associated signallings (e.g. REFERENCE TIME INFORMATION REPORTING CONTROL message).
* It is not necessary to use gNB-CU to stop the broadcast/SIB9 delivery in progress.
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| Qualcomm | This seems to be the key question, and so far it looks like the motivations are not consistent. It seems that the only clear use would be related to d) e.g. depending on the error budget for the cell, the gNB-DU may implicitly deprioritize scheduling of SIB9 even if it receives this from the gNB-CU (a sort of soft disabling). We really don’t see how the gNB-DU would change the content of the RTI depending on the error budget. |
| Ericsson | See Q1. In our view, the “Error budget” is not directly related to SIB9 or RTI.We also do not see the need that gNB-CU to “stop” the SIB 9 delivery. This is to break the Rel 16 legacy? |
| Samsung | a) We think both. But the unicast delivery can be controlled by the gN-CU.b) By now, we haven’t seen clear use cases yet in other WG discussion. But it seems to be able to be used for the RTI delivery periodicity.c) Assuming the error budget is used for determination of the RTI delivery periodicity.We don’t have strong preference on F1AP message, but slightly prefer the GNB-CU CONFIGURATION UPDATE REQUEST message. The SYSTEM INFORMATION DELIVER COMMAND message is used for other sage and includes some mandatory IEs. So it may not be proper to update only the error budget. And if only broadcast/SIB9 delivery is used, the REFERENCE TIME INFORMATION REPORTING CONTROL message would not be used.d) It is not necessary. |
| Moderator Summary:* 6 companies responded.
* 3 companies believe that the Uu Time Synchronisation Error Budget affects the frequency (periodicity) of RTI delivery, while 1 of those companies believes it also affects the actual RTI content (e.g. the *uncertainty*)
* 3 companies are not yet convinced that the Uu Time Synchronisation Error Budget affects RTI delivery.

Conclusion: Further discussion needed on whether/how the Uu Time Synchronisation Error Budget affects RTI delivery (e.g. periodicity). |

## 3.2 Time synchronization: NGAP open issues

The following agreement was previously captured in the Chair’s minutes:

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

**- NGAP (INITIAL CONTEXT SETUP REQUEST, UE CONTEXT MODIFICATION REQUEST, HANDOVER REQUEST, and PATH SWITCH REQUEST ACKNOWLEDGEMENT [FFS]),**

Nokia [5] and CATT [13] propose to drop the above FFS to allow the *Time Synchronisation Assistance Information* IE to be included also in the PATH SWITCH REQUEST ACKNOWLEDGEMENT.

**Question 3: Can the following be agreed (i.e. dropping FFS):**

**Introduce the Time Synchronisation Assistance Information IE as an optional UE-level parameter in PATH SWITCH REQUEST ACKNOWLEDGEMENT.**

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| **Company** | **Comments** |
| Nokia | YES. |
| Huawei | YES |
| ZTE | Yes. |
| Qualcomm | Yes |
| Ericsson | This is to cover the case that the parameter is changed at the Xn Handover procedure. Given the Path Switch Req Ack is the last message ( i.e. no response), how to handle if there will be a failure? On the other hand, if we do not consider the failure case, it would be ok, just to use this message to inform the new set of parameters. Prefer that we could discuss first. |
| CATT | Yes |
| Samsung | Yes |
| Moderator Summary:* 7 companies responded.
* 6 companies agree to introduce the *Time Synchronisation Assistance Information* IE as an optional UE-level parameter in PATH SWITCH REQUEST ACKNOWLEDGEMENT (i.e. remove current FFS).
* 1 company prefers further discussion.

Proposed conclusion: Agree to the proposal. Further questions (if any) can be asked during online session. |

## 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.**

This is a continuation of discussion from previous meetings, where two use cases were identified for passing additional assistance information from source to target:

**Use Case #1**: Assist the target gNB in deciding the RTI delivery configuration.

**Use Case #2**: Assist the target gNB in determining the level of urgency/reliability to deliver the first RTI following handover.

Overview of RAN3 papers:

- Ericsson [3][4]: 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.

- Nokia [6]: To support target gNB in determining the level of urgency/reliability to deliver the first RTI following handover, source gNB provides the timestamp when, at the latest, the next RTI needs to be delivered to the UE in the HANDOVER REQUEST.

- Huawei [11][12]: The RTI configuration in the source can be used by the target gNB to determine the suitable time sync deliver mode and deliver period after the handover completion. Therefore, the source gNB sends the RTI delivery periodicity for UE to the target gNB during handover.

Moderator’s Summary:

For Use Case #1, the following information is proposed:

- Uncertainty [4]

- Time Information type [4]

- TSN distribution (i.e. broadcast or unicast) [4]

- Periodicity of RTI delivery [4][12]

For Use Case #2, the following information is proposed:

 - Timestamp when, at the latest, the next RTI needs to be delivered to the UE [6]

Proposed way forward:

- RAN3 to further discuss whether use cases are acknowledged, and if so, what (if any) additional information is needed during handover.

**Question 4: Please provide your views on the following open issues:**

a) Is use case #1 acknowledged (yes/no)? If so, what additional information (if any) is needed during handover (e.g. uncertainty, time information type, TSN distribution, and/or periodicity)?

b) Is use case #2 acknowledged (yes/no)? If so, what additional information (if any) is needed during handover (e.g. timestamp)?

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| **Company** | **Comments** |
| Nokia | Use Case #1: Yes, but no additional info needed. When time synchronisation service is first initiated, the gNB determines the RTI delivery configuration based on the Time Synchronisation Assistance Information (i.e. Uu Time Synchronisation Error Budget) received from the CN over NGAP. Since RAN3 has already agreed that Time Synchronisation Assistance Information is passed from source to target during HO, the target gNB can determine the RTI delivery configuration on its own using the same information that was available at the source.Use Case #2: Yes. The target gNB must always assume RTI must be delivered immediately and with high reliability after HO, unless source gNB provides timestamp when (at the latest) the next RTI needs to be delivered to the UE. |
| Huawei | Use case#1: Yes. We think at least the periodicity is needed. The periodicity at the source node has been decided based on the UE assistance information, or other factors (not relevant to the Uu time synchronization error budget). This periodicity is useful as reference for the target node to determine the RTI delivery configuration. Use case#2: not very necessary. E.g. the target RAN can send the first RTI by DCCH after the HO complete. Even if the target RAN does not send it to UE, based on RAN2 common understanding, UE can maintain the referencetime based on the elapsing slots. |
| ZTE | Both no for Use Case #1 and Use Case #2. Use Case #1: No. Since RAN3 has already agreed that Time Synchronisation Assistance Information is passed from source to target during HO, and 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.Use Case #2: No. It can be based on the gNB implementation, e.g. the target gNB can always deliver the RTI immediately after HO. Furthermore, RAN2 has not agreed to introduce RTI periodicity, the timestamp is useless to decide the next RTI occasion.  |
| Qualcomm | Somewhat neutral on both, but happy to explore the justifications.Use case #1: as mentioned by both ZTE and Nokia, the Time Synchronisation Assistance Information is passed from source to target during handover, and so the open issue is whether there is any benefit in having the source configuration. This seems to do no harm, but it seems also not essential.Use case#2: this seems also beneficial but perhaps not absolutely essential. We assume the intention is to signal to the target the time by when the RTI delivery would have been performed in the absence of handover, rather than the time by which it shall be delivered (periodicity may change at target, or even target just immediately deliver). So with some clarification of meaning and purpose, this could be ok. |
| Ericsson | Use Case #1. At least “TSN distribution” and “Periodicity of RTI delivery”. It is to help the target NG-RAN node to obtain accurate the RTI information.  |
| CATT | Share with Qualcomm.  |
| Samsung | Use Case #1: Further clarification of usage is required. As Nokia mentioned, the Time Synchronization Assistance Information is passed from the source to the target during HO and the target would determine the configuration based on the information. Use Case #2: We think it’s not essential. The time synchronization needs to be performed after the handover based on the configuration in the target. |
| Moderator Summary:* 7 companies responded.
* For use case #1, 2 companies believe it is useful to signal the periodicity during handover, while 1 of those companies also believes it is useful to signal the TSN distribution (unicast or broadcast). Other 5 companies do not see the benefit of the additional parameters.
* For use case #2, 1 company believes it is useful to signal the timestamp when, at the latest, the next RTI needs to be delivered to the UE. Other 6 companies believe it is not needed or not essential.

Proposed conclusion: There is no consensus yet that any additional parameters are needed during handover. The current FFS still exists (**It is FFS on whether assistance information (e.g., UE TSN timing reference, referenceTimeInfo delivery periodicity, timestamp) should be delivered during HO**), and proponents can further try to convince companies on the benefits. |

## 3.4 gNB-based PDC (network pre-compensation)

The latest progress in other groups is captured in [11] as follows (extracting the most relevant parts):

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| R1#107-e **Conclusion:** Leave it to RAN2 to decide whether to support UE based compensation and/or gNB based compensation for any propagation delay compensation method RAN1 may adopt for Rel-17, if applicable.For Rel-17 * Support RTT-based PDC method
* Support PDC method based on legacy TA-based mechanism
	+ No RAN1/RAN4 specification impact expected

For RTT-based propagation delay compensation, the Rx-Tx time difference is reported via RRC signaling. |
| R2#115e1 RAN2 assumes that gNB can perform pre-compensation. RAN2 agrees to introduce signalling to enable/disable UE-side PDC. R2#116e1 The gNB can enable/disable UE-side PDC via unicast and broadcast RRC signalling.2 A new RRC parameter can be introduced to explicitly enable/disable UE-side PDC |

Overview of RAN3 papers:

- ZTE [1]: During the handover process, the RTT measurement cannot be performed immediately because the relevant resource of the target gNB is not configured. In order to meet the handover time requirements of some services, RAN3 should consider whether the target gNB needs to provide the UE with the configuration information for RTT measurement during the handover.

- Ericsson [7]: For the case where E-CID measurements with “NR Timing Advance” have been started by the LMF, the gNB-CU can make use of the existing E-CID measurement when computing TA for PDC. However, for other cases a new F1AP procedure (e.g. “RTT PDC Measurement Initiation” procedure) is needed to enable the gNB-CU to trigger reporting of NR Timing Advance measurements.

- Samsung [8][9]: For the network pre-compensation for the PDC, the gNB should provide UE-specific time reference information because the pre-compensated time reference value would be different on UE’s time synchronization capability and location. Therefore, new UE-associated F1AP procedures (e.g. “Compensated Reference Time Information Reporting Control” and “Compensated Reference Time Information Report” procedures) are needed to enable reporting of network pre-compensated RTI.

- Huawei [11]: The gNB-CU determines to enable/disable gNB-based pre-compensation. For TA-based PDC, add a list of UEs in the REFERENCE TIME INFORMATION REPORTING CONTROL message, and then the REFERENCE TIME INFORMATION REPORT message can include the TA-based compensated reference time information for these UEs. For RTT-based PDC, the gNB-CU must request the gNB-DU to report the UL Rx-Tx time difference. Then depending on whether the pre-compensation is performed at UE or gNB, the gNB-CU sends to the UE the UL Rx-Tx time difference or the pre-compensated RTI, respectively, via unicast RRC message.

Moderator’s Summary:

Since this is the first meeting to discuss details of gNB-based PDC, the moderator would like to recommend that RAN3 first focus on F1AP impacts and postpone discussion of possible XnAP (handover) impacts to next meeting.

It is proposed in [11] that the gNB-CU determines to enable/disable gNB-based pre-compensation, which seems potentially agreeable.

Also, there seems to be consensus that new F1AP procedure(s) are needed to support network pre-compensation. However, there are different proposals for what the procedure(s) should actually do.

In case of TA-based PDC:

a) gNB-DU reports UE-specific TA value (i.e. pre-compensation is performed by the gNB-CU) using new UE-associated procedure(s) [7]

b) gNB-DU reports UE-specific pre-compensated RTI (i.e. pre-compensation is performed by the gNB-DU) using new UE-associated procedure(s) [8][9]

c) gNB-DU reports UE-specific pre-compensated RTI re-using non-UE associated Reference Time Information Reporting Control and Reference Time Information Reporting procedure(s) [11]

In case of RTT-based PDC:

d) gNB-DU reports UE-specific UL Rx-Tx time difference using new UE-associated procedure(s) [11]

Three companies propose new UE-associated procedures, while one company proposes to re-use existing non-UE associated procedures to carry UE-specific information. It seems more appropriate that UE-specific information is carried in UE-associated signalling which is also the majority view, so perhaps this can be taken as a working assumption with further details to be discussed.

Proposed way forward:

- It is the gNB-CU that decides to enable/disable gNB-based pre-compensation.

- WA: Introduce new UE-associated F1AP procedure(s) to support gNB-based pre-compensation. Details FFS.

- Open Issue(s): What information is reported by the gNB-DU to the gNB-CU?

**Question 5: Can the following be agreed:**

**It is the gNB-CU that decides to enable/disable gNB-based pre-compensation.**

**WA: Introduce new UE-associated F1AP procedure(s) to support gNB-based pre-compensation. Details FFS.**

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| **Company** | **Comments** |
| Nokia | YES. |
| Huawei | Since there are two PDC mechanisms: TA based and RTT based. We understand the question 5 is only for **TA based or both**? We may suggest gNB-based RTT PDC is pending RAN2. On this basis, we agree that “**It is the gNB-CU that decides to enable/disable gNB-based pre-compensation**” |
| ZTE | No, it depends on the RAN2 decision on whether gNB based pre-compensation or UE based compensation is used and the what signalling(e.g. RRC signalling or MAC CE) is used for the RTT measurement results delivery to UE. RAN3 should postpone this discussion to wait for the RAN2 agreement. |
| Qualcomm | In principle this seems reasonable but we wonder if RAN3 should send a quick LS to RAN2 to trigger them to send a clear statement of the mechanisms to be supported (assuming reply to be received before RAN3#115) – though perhaps they will send it anyway. |
| Ericsson | Propose to capture as “**It is the gNB-CU that decides to use TA or RTT / gNB based pre-** **compensation or UE based compensation.”**For WA, our view is that we do not need to agree now. It would be more clear after further discussion and clarification. |
| CATT | Yes |
| Samsung | Yes |
| Moderator Summary:* 7 companies responded.
* 6 companies agree to capture that gNB-CU decides to enable/disable gNB-based pre-compensation, although alternate formulations were also suggested.
* 1 company believes that RAN3 should postpone this discussion to wait for RAN2 agreements.

Proposed Conclusion: It is the moderator’s understanding that RAN2 has clearly agreed that “gNB can perform PDC”. However, the mechanisms have not yet been decided by RAN2 (including whether they are specified or left to vendor implementation). To capture the progress of this question, it is proposed to agree to the following working assumption which seems “solution neutral”:It is the gNB-CU that decides whether/how to perform PDC (Note: the PDC mechanisms to be specified in Rel-17, if any, are FFS pending RAN2). |

**Question 6: For TA-based PDC at the gNB, should the pre-compensation be performed by the**

**a) gNB-DU**, e.g., DU reports compensated RTI via a new UE-associated F1AP procedure; or

**b) gNB-CU**, e.g., DU reports TA value via a new UE-associated F1AP procedure, and (uncompensated) RTI via the legacy Reference Time Information Reporting procedure?, or

**c) gNB-DU**, e.g., DU reports compensated RTI for a list of UEs via the non-UE-associated F1AP procedure (REFERENCE TIME INFORMATION REPORT)

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| **Company** | **Comments** |
| Nokia | (b) has the benefit of enabling the gNB-CU to know whether TA value has changed, and whether multiple UEs have TA value in common. This could allow more accurate and efficient updating of the RTI. For example, if TA is being reported periodically and the TA value changes, it could trigger gNB-CU to provide immediate update of RTI to the UE. Or if multiple UEs have same TA value, then the broadcast RTI can be compensated by this value while unicast RTI is sent only to small number of UEs having different TA value. |
| Huawei | c) is preferred. a) is also acceptable to us.For b). the CU need to associate the UE-associated, and the non-UE associated signalling, to acquire the timing, which is complicated. Also it is not clear whether the reported “TA value” granularity is accurate enough.  |
| ZTE | It depends on RAN2 agreement on whether TA-based PDC at the gNB will be supported. RAN3 should postpone this discussion to wait for the RAN2 agreement. |
| Ericsson | Our view is (b). We can reuse the E-CID. Also in our view, it is gNB-CU who decides if to use TA-based PDC at gNB. |
| CATT | We prefer b). the gNB-CU may control the PDC with the information from DU and itself |
| Samsung | Slightly prefer a).As in Huawei’s comment, b) requires the association of the UE-associated and the non-UE associated signalling. And we don’t see the big difference between two approaches, and only the difference is whether the gNB-DU or the gNB-CU performs the compensation. |
| Moderator Summary:* 6 companies responded.
* Companies are split whether DU reports compensated RTI or the TA-value.
* 1 company believes that RAN3 should postpone this discussion to wait for RAN2 agreements.

Proposed Conclusion: Capture the following FFS but postpone further discussion until next RAN3 meeting to wait for RAN2 decisions.* For TA-based PDC at the gNB, it is FFS whether DU reports compensated RTI or the TA-value.
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**Question 7: For RTT-based PDC (at either the UE or gNB), do you agree that gNB-DU reports gNB Rx-Tx time difference to gNB-CU (yes/no)? Any other impacts?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | Yes. Other impacts (if any) can be discussed after further progress in RAN2 (e.g. whether RTT-based PDC is supported at gNB).  |
| Huawei | Yes. It seems even if the UE performs RTT based PDC, still the gNB-DU reports the gNB Rx-Tx time difference to gNB-CU. But we can further discuss the details with new RAN2 agreements (whether the gNB performs pre-compensation for RTT-based PDC). |
| ZTE | It depends on the RAN2 decision on whether gNB based pre-compensation or UE based compensation is used and the what signalling(e.g. RRC signalling or MAC CE) is used for the gNB Rx-Tx time measurement results delivery to UE. RAN3 should postpone this discussion to wait for the RAN2 agreement. |
| Ericsson | Yes to gNB-DU reports gNB Rx Time diff.  |
| CATT | Yes |
| Samsung | Yes. Details can be discussed further progress in RAN2. |
| Moderator Summary:* 6 companies responded.
* 5 companies believe that RTT-based PDC requires DU to report gNB Rx-Tx time different to the CU.
* 1 company believes that RAN3 should postpone this discussion to wait for RAN2 agreements.

Proposed conclusion: Capture the following FFS but postpone further discussion until next RAN3 meeting to wait for RAN2 decisions.* For RTT-based PDC, DU may need to report gNB Rx-Tx time different to the CU (FFS)
 |

# 4 Discussion (Round 2)

Please provide your Round 2 views (3 questions) by **13:00 UTC Monday January 24th**.

As captured during the online session, further discussion is needed on the following (open issues) in 2nd round:

- whether/how the Uu Time Synchronisation Error Budget affects RTI delivery (e.g. periodicity).

- further collect companies’ view on gNB-based PDC, check RAN2 progress if any.

## 4.1 Error budget impacts on RTI delivery

In the 1st round, 3 companies indicated that the Uu Time Synchronisation Error Budget affects RTI delivery. The following explanation is provided (based on [15]).

Periodic delivery of RTI to the UE is needed to ensure clock alignment at the UE with the 5G clock, in the presence of UE clock drift and mobility. The relationship between these factors is shown in the figure below.



The accuracy of the device clock depends on implementation and other factors (e.g. environmental). As an example, the gNB could assume that the UE has a local clock with 0.1 to 0.3 PPM clock accuracy. This corresponds to a drift of 10 to 30ns per 100ms. The UE mobility directly towards or away from the gNB can cause additional drift. To show how the budget can affect the needed RTI periodicity, let’s look at the following example:

- UE local clock is assumed by gNB implementation to have 0.1PPM accuracy, and there is no UE mobility.

- Minimum bound (MB) is 250ns

- The Uu Synchronisation Error Budget is 300ns, 450ns or 900ns (taking Huawei’s example from Question #1 for small/medium/large budget values).

In this case, the RTI periodicity necessary to maintain the UE’s timing synchronisation requirement (budget) is shown in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| *Budget (B)* | *“Margin” (B – MB)* | *Max RTI interval (unicast)* | *Max SIB9 periodicity* |
| 300ns | 50ns | 500ms | 320ms |
| 450ns | 200ns | 2 sec | 1.28sec |
| 900ns | 650ns | 6.5 sec | 5.12sec |

**Observation 1**: *The Uu Synchronisation Error Budget can affect the needed interval/periodicity of RTI delivery, i.e., smaller budget may require more frequent RTI updates than a larger budget*.

**Question 2.1: Please provide your views on Observation 1.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | We agree with Observation 1. The consequences of observation 1 can be further discussed at next meeting. |
| Huawei | When further checking the RAN2#114-e meeting Chairman notes (May, 2021), to reply SA2 question (S2-2103023), Ran2 made the following agreements relating to benefits of having the Uu time synchronization error budget at the NG-RAN:=> RAN2 sees some benefits to having this information. => email discussion to finetune to converge on what to respond to SA2 The final reply LS is in R2-2106560. But the exact benefits are not listed. So our understanding is that the main benefit of the Uu synchronization error budget is still to assist the NG-RAN node decision of the PDC. The RTI delivery periodicity is not helpful from the error budget. |
| Ericsson | We do not agree with the argument leading to observation 1. Our view is the UE Error Budget is to be used for the dedicated UE. For that UE, the RTI may needs to be more frequently obtained by gNB-CU, but it does not mean that the Cell Level RTI delivery periodicity from gNB-DU to gNB-CU needs to be impacted.Simply, when the TA or RTT Rx-Tx time diff is delivered to gNB-CU, gNB-DU could provide, for this dedicated UE, the current RTI. |
| CATT | We buy in the observation. |
| Samsung | We’re ok with Observation 1 and think the error budget could be used for RTI delivery. However, we’re not sure whether Observation 1 is common understanding in RAN2.  |
| ZTE | Agree with Huawei. In our view, the Uu synchronization error budget is mainly used to decide the RTI contents(e.g. uncertainty field) and the propagation delay compensation accuracy(e.g. decide the propagation delay compensation periodicity and decide whether high-accuracy propagation delay compensation is used).By now, there are two kinds of propagation delay compensation accuracy: TA-based PDC and gNB Rx-Tx time based PDC, which will be used is decided by gNB-CU.As for the RTI periodicity, if the propagation delay compensation has not been performed by gNB for the RTI and UE receives the RTI once, UE can always deduce the gNB’s RTI value of a radio frame boundary when the UE keeps synchronization with the gNB, it does not matter what the RTI delivery periodicity is. If the propagation delay compensation has not been performed by gNB for the RTI, we agree that Uu synchronization error budget will be used to decide the RTI delivery periodicity. |
| Moderator Summary:* 6 companies provided their views. Companies are split (3/3) whether the Uu Synchronisation Error Budget can affect the needed interval/periodicity of RTI delivery.
* Most companies believe that the error budget can assist the gNB-CU to decide whether/how to perform PDC.

Proposed conclusion:* No agreements. Discussion to continue next meeting based on the open issues captured in the 1st round discussion.
 |

In the 1st round, 1 company indicated that the Uu Time Synchronisation Error Budget may affect the *uncertainty* field of the RTI.

**Observation 2**: *The Uu Synchronisation Error Budget can affect the uncertainty field of the RTI*.

**Question 2.2: Please provide your views on Observation 2.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | In our understanding, the error budget is intended to assist the configuration of RTI delivery and PDC decision. It does not impact the RTI fields themselves. For *uncertainty*, it is up to gNB to set it but it primarily reflects e.g. determined errors in the synchronization path inside and outside of the gNB architecture towards the synchronisation source. |
| Huawei | Seems not affect.  |
| Ericsson | Seems no effect, but can discuss further. |
| CATT | Seems not affect. |
| Samsung | Seems not affect. |
| ZTE | Refer to our comments for Question 2.1, the Uu synchronization error budget will be used for RTI contents decision (e.g. uncertainty field). gNB can provide RTI with accuracy from 10ns to 1ms. Usually, the higher Uu synchronization error budget accuracy is, the higher RTI accuracy need to be provided. And the higher RTI accuracy is provided, the higher gNB crystal oscillator accuracy and the more gNB power consumption will be need. gNB only need to provide the RTI with accuracy that is necessary. |
| Moderator Summary:* 6 companies provided their views.
* Most companies do not see any impact of the Uu Synchronisation Error Budget on the RTI contents. One company believes that it can affect the uncertainty field of the RTI.

Proposed Conclusion:* No agreements.
 |

## 4.2 gNB-based PDC (network pre-compensation)

During the 1st round, it was captured that the following may need further discussion in RAN3 depending on RAN2 discussion outcome:

- For TA-based PDC at the gNB, it is FFS whether DU reports compensated RTI or the TA-value.

- For RTT-based PDC, DU may need to report gNB Rx-Tx time different to the CU (FFS)

**Question 2.3: Please provide any additional views on gNB-based PDC, e.g. to facilitate common understandings and progress.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei | For TA based PDC, we understand it is already agreed in RAN2 that the gNB-based pre-compensation is supported. Our view is that the compensated RTI is more accurate, compared with the TA-value (in terms of Ts). If this is common understanding or WA, then we are fine to introduce a new UE-associated signalling, or reuse the existing non-UE-associated Reference Time Information procedure, even at this meeting. For RTT-based PDC, we think the DU needs to report gNB Rx-Tx time different to the CU, even for UE-based RTT PDC. We may suggest to agree it at this meeting. .  |
| Ericsson | We think gNB-DU provides TA value to gNB-CU.TA-value has been standardized for positioning. It would be good to re-use.If gNB-CU needs to estimate and re-write the message, then there is no accuracy gain for compensated RTI.Agree on that regardless of UE-based or gNB-based RTT PDC, there is a need to transmit gNB Rx-Tx time diff from gNB-DU to gNB-CU. |
| Samsung | For TA based PDC, we have the similar view as Huawei. The compensated RTI delivery seems to be more accurate.And we want to decouple the positioning and the TA-based PDC. For RTT-based PDC, the reporting the gNB Rx-Tx time difference from the gNB-DU to the gNB-CU would be required, but details can be discussed in the next meeting. |
| ZTE | Although we think that DU needs to report the TA-value and gNB Rx-Tx time different to CU, it relies on RAN2 decision. Therefore, RAN3 should postpone this discussion to wait for the RAN2 agreement. |
| Moderator Summary:* 4 companies provided their views.
* For TA-based PDC, 2 companies believe the DU should provide the compensated RTI while 2 companies believe the DU should instead provide the TA value.
* For gNB Rx-Tx time difference, all companies appear to agree that it should be reported by the DU to the CU, but there are different views on F1AP signalling procedures (e.g. reuse positioning procedures or create new procedures).

Proposed Conclusion:* No agreements. Discussion to continue next meeting based on the open issues captured in the 1st round discussion and on latest RAN2 decisions.
 |

# 5 Conclusions, Recommendations

Conclusions/recommendations from Round 1 discussion:

1. Further discussion needed on the usefulness of Uu Time Synchronisation Budget (cell level?) at the DU.

2. Further discussion needed on whether/how the Uu Time Synchronisation Error Budget affects RTI delivery (e.g. periodicity).

3. Agree to introduce the *Time Synchronisation Assistance Information* IE as an optional UE-level parameter in PATH SWITCH REQUEST ACKNOWLEDGEMENT (i.e. remove current FFS). Further questions (if any) can be asked during online session.

4. There is no consensus yet that any additional parameters are needed during handover. The current FFS still exists (It is FFS on whether assistance information (e.g., UE TSN timing reference, referenceTimeInfo delivery periodicity, timestamp) should be delivered during HO), and proponents can further try to convince companies on the benefits.

5. It is the moderator’s understanding that RAN2 has clearly agreed that “gNB can perform PDC”. However, the mechanisms have not yet been decided by RAN2 (including whether they are specified or left to vendor implementation). To capture the progress of this question, it is proposed to agree to the following working assumption which seems “solution neutral”: It is the gNB-CU that decides whether/how to perform PDC (Note: the PDC mechanisms to be specified in Rel-17, if any, are FFS pending RAN2).

6. Capture the following FFS but postpone further discussion until next RAN3 meeting to wait for RAN2 decisions: “For TA-based PDC at the gNB, it is FFS whether DU reports compensated RTI or the TA-value.”

7. Capture the following FFS but postpone further discussion until next RAN3 meeting to wait for RAN2 decisions: “For RTT-based PDC, DU may need to report gNB Rx-Tx time different to the CU (FFS).”

Conclusions/recommendations from Round 2 discussion: None.

# References

1. R3-220227, Remaining issues on Time Synchronization enhancements (ZTE)
2. R3-220228, (TP for Introduction of Enhanced IIoT support over F1) Time Synchronization enhancements (ZTE)
3. R3-220337, Discussion on Further enhanced NR-IIoT: Enhancements for support of time synchronization (Ericsson)
4. R3-220338, Enhancements for support of time synchronization (Ericsson)
5. R3-220367, (TP for NR\_IIOT\_URLLC\_enh BL CR for TS 38.473) Time synchronization open issues (Nokia, Nokia Shanghai Bell)
6. R3-220368, (TP for NR\_IIOT\_URLLC\_enh BL CR for TS 38.423) Time synchronization and handover (Nokia, Nokia Shanghai Bell)
7. R3-220616, Discussion on PDC TA based and E-CID measurement (Ericsson)
8. R3-220646, (TP for NR\_IIOT\_URLLC\_enh BL CR for TS 38.473) Discussion on supporting the network pre-compensated PDC (Samsung)
9. R3-220647, (TP for NR\_IIOT\_URLLC\_enh BL CR for TS 38.470) Supporting the network pre-compensated PDC (Samsung)
10. R3-220648, (TP for NR\_IIOT\_URLLC\_enh BL CR for TS 38.473) Discussion on the time synchronization error budget over F1AP (Samsung)
11. R3-220652, (TP for eIIOT BLCR for TS 38.473) Supporting propagation delay compensation enhancements (Huawei)
12. R3-220653, (TP for eIIOT BLCR for TS 38.423) Supporting propagation delay compensation enhancements (Huawei)
13. R3-220940, Discussion on Propagation Delay Compensation Enhancements (CATT)
14. R3-220941, TP for BLCR for 38.473 on Propagation Delay Compensation Enhancements (CATT)R3-220094, LS on updated Rel-17 LTE and NR higher-layers parameter list (RAN1)
15. R3-213449, Impact of handover on time synchronization (Nokia, Nokia Shanghai Bell)