3GPP TSG-RAN WG3 Meeting #114-e draft R3-215956

Online, 1 – 11 November 2021

**Agenda item: 21.2**

**Source: Nokia (moderator)**

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

**Document for: Discussion and Decision**

# 1 Introduction

This paper summarizes the following email discussion:

**CB: # NRIIOR1\_PDC**

**- The time synchronization assistance parameters (a time distribution indication and a Uu time synchronization error budget) are introduced over NG, Xn and F1 interfaces?**

**- During the handover, what kinds of time synchronization assistance information should the source gNB notify the target gNB, e.g., ReferenceTimeInfo (periodicity, clock source, and Timestamp of last RTI); TSN reference information (Uncertainty, Time Information Type, TSN distribution, Periodicity) …?**

**- the gNB-DU estimates and provides the compensated time reference value to the gNB-CU?**

**- Capture agreements and open issues**

**- TPs if agreeable**

(Nok - moderator)

Summary of offline disc [R3-215885](file:///C:\Users\llopes\OneDrive%20-%20Qualcomm\Documents\3%20RAN3\RAN3%20114\Inbox\Drafts\CB%20%23%20NRIIOR1_PDC\Inbox\R3-215885.zip)

# 2 For the Chair’s Notes

R3-214828 rev in R3-215953 (TP for NGAP) [FFS]

R3-215132 rev in R3-215954 (TP for XnAP) [FFS]

R3-214736 rev in R3-215955 (TP for F1AP) [FFS]

# 3 Discussion (Phase 1)

Please provide your Phase 1 views (8 questions) by **11:00 UTC Wednesday November 3rd**, so that they may be taken into account during the online session.

## 3.1 Time synchronisation information (NGAP)

Related papers from ZTE [1][2], Nokia [3], Qualcomm [5], Samsung [7], CATT [8], and Huawei [9].

SA2 has agreed that the TSCTSF can provide a **time distribution indication** and a **Uu time synchronisation error budget** to the NG-RAN via the PCF/AMF. The following proposals seem to represent a common denominator for almost all companies:

Proposal 1: Introduce a *Time Synchronisation Assistance Information* IE that includes a *Time Distribution Indication* IE and *Uu Time Synchronisation Error Budget* IE.

Proposal 2: The *Time Synchronisation Assistance Information* IE is a UE-level parameter that can be optionally included over NGAP in the following messages: INITIAL CONTEXT SETUP REQUEST, UE CONTEXT MODIFICATION REQUEST, HANDOVER REQUEST, and PATH SWITCH REQUEST ACKNOWLEDGEMENT.

Proposal 3: The *Time Distribution Indication* IE is encoded as ENUMERATED type having two codepoints (enabled, disabled).

Proposal 4: The *Uu Time Synchronisation Error Budget* IE is encoded as INTEGER type.

Note: The range and granularity of the *Uu Time Synchronisation Error Budget* IE is addressed separately.

**Question 1: Can proposals 1-4 be agreed?**

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| **Company** | **Comments** |
| Huawei | Agree |
| Nokia | Yes. |
| ZTE | Yes. |
| Qualcomm | Yes |
| Samsung | Agree |
| CATT | Yes |
| Ericsson | Question the need to include in “PATH SWITCH REQUEST ACKNOWLEDGEMENT.” |
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| Moderator Summary:   * There is consensus on proposals 1, 3, and 4. * For proposal 2, one company is unsure whether the *Time Synchronisation Assistance Information* IE is needed in the PATH SWITCH REQUEST ACKNOWLEDGEMENT. | |

Regarding the range and granularity of the *Uu Time Synchronisation Error Budget* IE, companies provided the following proposals:

a) range 250ns to 1ms with 50ns granularity [3]

b) range 0 to 1023ns with 1ns granularity [5]

c) range 10 to 900ns with 10ns granularity [7]

d) range 0 to 1000ns with 1ns granularity [9]

For the granularity, most companies prefer a value of 1ns or 10ns.

**Question 2: For the granularity of the *Uu Time Synchronisation Error Budget* IE, please indicate your preference between 1ns, 10ns, either (i.e. no strong preference), or other (please specify)?**

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| **Company** | **Comments** |
| Huawei | No strong view. But slightly prefer 1ns granularity considering that the maximum value is not so big. |
| Nokia | 10ns granularity seems sufficient (preferable), but 1ns can also be agreeable. |
| ZTE | We think either 1ns or 10ns is fine. Or wait for the conclusion of SA2. |
| Qualcomm | 1ns seems fine – no big impact on IE size |
| Samsung | We think 10ns seems sufficient because 5G system time reference information to the UE is signalled with a granularity of 10 ns. |
| CATT | Both 1ns and 10ns are fine |
| Ericsson | 1ns or 10ns |
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| Moderator Summary: Companies seem fine with either 1ns or 10ns, with no strong preference. | |

For the maximum value, most companies propose values motivated by TS 22.204 Table 5.6.2-1 for the control-to-control (900ns) and smart grid (1000ns) use cases. One company suggests a larger maximum value taking into account other use cases in TS 22.204 Table 5.6.2-1 such as telesurgery (50us) and Rel-18 use cases in TS 22.261 Table 7.8-2 such as trading (1ms) to be more futureproof.

**Question 3: For the maximum value of the *Uu Time Synchronisation Error Budget* IE, please indicate your preference between 1000ns, 1ms, either (i.e. no strong preference), or other (please specify)?**

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| **Company** | **Comments** |
| Huawei | In general we agree for future proof reason, the maximum value could be set larger than 1000ns. But 50us/1ms value seems not needed.  Note that for R16, the error budget maximum value over Uu is around 550 ns (evaluated by RAN1). Lager value seems not needed. So 1000 ns is preferred. |
| Nokia | Maximum value of 1ms is preferred, since it can already be foreseen that 1000ns is too small for several use cases. |
| ZTE | For vertical application and future proof, we prefer maximum value with 1ms. Or wait for the conclusion of SA2. |
| Qualcomm | Tend to agree with Huawei on immediate need, but also agree future proofness may be an issue. One option is to add two IEs e.g. optional 0-999ns, and optional 0-1000us, where the requirement is the sum, so right now we might not need the second one in practice (but then maybe keep the second FFS). |
| Samsung | We don’t have strong position, but prefer 1000ns. We also think too large value seems not be necessary. |
| CATT | We prefer to set the maximum value to 1ms for future proof. |
| Ericsson | 1 ms, or open for other better values |
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| Moderator Summary:   * Six companies indicate that we should try to select a value that is future proof. * A majority (four companies) prefer 1ms. * One company prefers 1000ns but also indicates no strong position * One company indicates that the value could be set larger than 1000ns, but 50us/1ms value seems not needed. * One company indicates that values larger than 1000ns could be FFS for now. | |

For the minimum value, it is the moderator’s view that a 0 value does not make sense. One option is to choose the minimum value to be the same as the granularity (i.e. minimum value 1ns if granularity is 1ns, or minimum value 10ns if granularity is 10ns, etc.).

**Question 4: For the minimum value of the *Uu Time Synchronisation Error Budget* IE, can the same value as the granularity be agreed? If not, please propose an alternative.**

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| **Company** | **Comments** |
| Huawei | Agree |
| Nokia | Yes. |
| ZTE | Yes. |
| Qualcomm | Yes, it may be good to avoid this possibility upfront. Of course other smaller values may also not make sense in any particular system, but 0 should never be used. |
| Samsung | Yes |
| CATT | Yes |
| Ericsson | Fine |
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| Moderator Summary: There is consensus that the minimum value of the Uu Time Synchronisation Error Budget IE can be the same as the granularity. | |

## 3.2 Time synchronisation information (F1AP)

Related papers from ZTE [1] and Samsung [7].

Regarding potential F1AP impacts, it is proposed in [1] and [7] that the Uu Time Synchronisation Error Budget 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. Therefore, the *Time Synchronisation Assistance Information* IE needs to be delivered over the F1 interface.

**Question 5: Should the *Time Synchronisation Assistance Information* IE be provided to the gNB-DU over F1 interface?**

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| **Company** | **Comments** |
| Huawei | Two parameters are included in the assistance information.  Not sure whether the *Time Distribution Indication IE* is needed by the DU, since the CU will generate the time reference SIB9 which will be updated by DU accordingly. So it seems no strong need for the DU to be aware of the  *Time Distribution Indication IE.*  But we agree the error budget parameter is needed so that the DU can determine the synchronization enhancement configurations (being discussed in RAN1/RAN2). |
| Nokia | Agree that the *Uu Time Synchronisation Error Budget* IE could be useful to signal over F1 to the DU. The *Time Distribution Indication* IE may also be useful to signal over F1, depending on the signalling design, since it can be used to disable the accurate reference time distribution. |
| ZTE | Yes.  In the case of accurate time synchronization by unicast, gNB-CU needs to inform gNB-DU of the Uu time synchronization error budget by the *REFERENCE TIME INFORMATION REPORTING CONTROL* message, so that gNB-DU can provide appropriate reference time accuracy.  And in the In the case of accurate time synchronization by broadcast, gNB-CU also needs to inform gNB-DU of the Uu time synchronization error budget (FFS how to design the signalling), so that gNB-DU can re-encode the SIB9 with appropriate reference time accuracy. |
| Qualcomm | Similar view to Huawei and Nokia, perhaps the *Time Distribution Indication* IE could be marked FFS for now. |
| Samsung | Similar as Huawei and Nokia, we think the *Uu Time Synchronisation Error Budget* IE is required for the DU to determine the synchronization enhancement configuration.  Whether to include the *Time Distribution Indication IE* needs more clarification for the usage. (FFS at this time) |
| CATT | Agree with HW, put the FFS on the *Time Distribution Indication IE* |
| Ericsson | We need discussion on what is needed |
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| Moderator Summary: There appears to be consensus to include the *Uu Time Synchronisation Error Budget* IE over F1AP, while the *Time Distribution* IE can be marked as FFS. | |

## 3.3 Time synchronisation information (XnAP)

Related papers from ZTE [1], Nokia [4], Qualcomm [5], Samsung [7], CATT [8], Huawei [9][10], and Ericsson [11][12][13].

It seems that all companies that propose to include the **time distribution indication** and a **Uu time synchronisation error budget** (i.e. *Time Synchronisation Assistance Information* IE) over NGAP also propose that the same information be passed over XnAP.

Proposal 5: Introduce the *Time Synchronisation Assistance Information* IE (same as NGAP) as an optional UE-level parameter in the following XnAP messages: HANDOVER REQUEST and RETRIEVE UE CONTEXT RESPONSE.

**Question 6: Can proposal 5 be agreed?**

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| **Company** | **Comments** |
| Huawei | Agree |
| Nokia | Yes. |
| ZTE | Yes. |
| Qualcomm | Yes |
| Samsung | Yes |
| CATT | Yes |
| Ericsson | Fine |
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| Moderator Summary: There is consensus on proposal 5. | |

Then, there are companies proposing that some additional information about the *ReferenceTimeInfo* (RTI) configuration at the source gNB can be passed to the target gNB over XnAP:

1) Periodicity of RTI delivery [9][11]

2) Time Information Type (i.e. *timeInfoType* field of the RTI) [4][11]

3) Uncertainty (i.e. *uncertainty* field of the RTI) [11]

4) TSN distribution (i.e. broadcast or unicast) [11]

**Question 7: Please provide feedback on why the above parameters should or should not be passed from source gNB to target gNB over XnAP.**

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| **Company** | **Comments** |
| Huawei | One of Proponents of periodicity value.  The source node configures the periodicity based on the multiple rounds of the UE assistance information. While during handover, the target gNB has no idea of the Reference Time Information configuration at the source node (e.g., the synchronisation time period broadcast/unicast mode). We consider these configuration in source gNB is useful for the synchronisation time configuration reference by the target RAN. i.e., it can help the target gNB to determine the suitable time sync deliver mode, and deliver period after the handover completion.  We are also fine with 4). |
| Nokia | For (1), in our understanding the gNB determines the periodicity of RTI delivery on its own based on the *Time Synchronisation Assistance Information* IE (received from the CN over NGAP or the source/old gNB over XnAP) and the holdover capability of the UE.  For (3) and (4), it is not clear what relevance this information has at the target gNB, i.e. how it would influence the target gNB’s decision on the RTI delivery configuration.  For (2), it may be useful if the target gNB uses a different clock type than the source gNB so we are fine to signal Time Information Type. |
| ZTE | There is no need to provide additional parameters (1,2,3, and 4).  Based on the RAN2 specification, only *referenceTimeInfoPreference* is provided from UE to gNB, only the *referenceTimeInfoPreference* should be delivered to target gNB during HO, it can already be delivered to target gNB by RRC Container.  And for the above assistance information(1,2,3, and 4), they are producedby the source gNB based on the *referenceTimeInfoPreference* and/or *Time Synchronisation Assistance Information*. For the target gNB, it can make an appropriate decision according to the reference time preference of the UE (*referenceTimeInfoPreference*) and/or *Time Synchronisation Assistance Information* from AMF.  So, we think it is enough to deliver the reference time preference of the UE (*referenceTimeInfoPreference*) and/or *Time Synchronisation Assistance Information* to the target gNB during HO. |
| Qualcomm | So far, it is not clear that anything breaks if any of these parameters is not passed to the target. At best , it seems that these could be seen as “informational” i.e. configuration at source. But open to discuss further. |
| Samsung | We have the similar view as ZTE.  The UE provides only the *referenceTimeInfoPreference* to the gNB and it is delivered to the target gNB. And the AMF provides the time synchronization assistance information to the target gNB. We still have question on why these information are not enough during HO. |
| CATT | We agree with ZTE and QC, it not clear to have this information transferring to target node. We need further discuss it |
| Ericsson | For (4), the target RAN could prepare the reference time in the split architecture, particularly when unicast is used. |
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| Moderator Summary: There is no consensus at this time for any of the four parameters (periodicity, time information type, uncertainty, or TSN distribution). | |

## 3.4 gNB-based PDC

Related papers from Samsung [6] and Huawei [9].

Two companies propose that RAN3 initiate discussion on gNB-based propagation delay compensation (PDC), citing further progress in RAN2 based on the following agreement at RAN2#115-e:

1. RAN2 assumes that gNB can perform pre-compensation. RAN2 agrees to introduce signalling to enable/disable UE-side PDC.
2. The gNB can enable/disable UE-side PDC via unicast-RRC signalling for Rel-17
3. RAN2 shall wait for RAN1 to decide the measurement framework for RTT based PDC method and does not preclude UE-side PDC or gNB based pre-compensation at this point. RAN2 is expecting guidance from RAN1 on what is needed.

RAN3 briefly discussed gNB-based PDC at the beginning of Rel-17, and an LS was sent to RAN1 and RAN2 which stated that RAN3 will not further discuss gNB-based PDC unless support for the functionality is first confirmed by RAN1/RAN2 [14]. The following agreement was captured in the RAN3#111-e Chair’s Minutes:

**Wait for reply LS from RAN1 and RAN2, before further discussing gNB-based PDC.**

Therefore, it should first be confirmed that companies are willing to reopen RAN3 discussion on gNB-based PDC to perform a RAN3 impact analysis (but still with the understanding that support for gNB-based PDC is up to RAN1 and RAN2 decisions [14]).

Proposal 6: Further discuss the RAN3 impacts of gNB-based PDC, with the understanding (as agreed by RAN3 in [14]) that support for gNB-based PDC is up to RAN1 and RAN2 decisions.

**Question 8: Can proposal 6 be agreed?**

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| **Company** | **Comments** |
| Huawei | Agree.  Meanwhile we in-principle agree with the proposal in R3-215081. Maybe it can be discussed here.   * *The gNB-CU decides whether to use the UE-based PDC or the gNB-based PDC, and the gNB-DU estimates and provides the compensated time reference value to the gNB-CU. So the new UE-associated F1AP procedure and messages are introduced to support gNB-based PDC* |
| Nokia | Yes. |
| ZTE | Yes. |
| Qualcomm | Depends on timing. Our understanding is that the situation in other groups is not fully clear, so it seems safer not to re-initiate discussions at this meeting. We would be ok (for safety) to open discussions in January if situation is still unclear (or of course if there a definite go-ahead). |
| Samsung | Yes.  We haven’t found the discussion for the LS reply in RAN1 and RAN2 even though RAN1 and RAN2 have made some progress. It could be open in this meeting or in the next meeting. |
| CATT | Yes, but looks we don’t have enough TU on this study |
| Ericsson | As agreed by RAN3 |
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| Moderator Summary: There appears to be consensus that RAN3 can further discuss the RAN3 impacts of gNB-based PDC from the next meeting, with the understanding that support for gNB-based PDC is up to RAN1/RAN2. | |

# 4 Discussion (Phase 2)

Please provide your Phase 2 views (2 questions) by **12:00 UTC Monday November 8th**, so that there is sufficient time to prepare and review the F1AP TP (if needed) prior to the come-back sessions.

## 4.1 Time synchronisation information (F1AP)

In the phase 1 discussion, there appeared to be consensus to include the *Uu Time Synchronisation Error Budget* IE over F1AP, while the *Time Distribution* IE can be marked as FFS over F1AP (see section 3.2).

However, during the online session different views were expressed whether the IE(s) should be carried in a UE-associated or non-UE associated procedure. A summary of the arguments is provided below:

- **UE-associated**: The parameters are carried in UE-associated procedures over NGAP and XnAP, and are UE-level parameters.

- **non-UE associated**: The accurate reference time information is delivered to the UE via RRC signaling initiated by the gNB-CU. The RRC signaling may be UE-specific (dedicated signaling) or non-UE specific (SIB9). But regardless, the accurate reference time information that the gNB-CU retrieves from the gNB-DU to build the RRC message(s) is not UE-specific.

**Question 2-1: Is the *Uu Time Synchronisation Error Budget* IE needed by the DU (YES or NO). If YES, should it be carried in UE-associated or non-UE associated signalling over F1AP?**

Please also feel free to add to (or rebut) the arguments above.

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| **Company** | **Comments** |
| Huawei | Yes, this should be carried in UE-associated signalling. |
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| Moderator Summary: | |

**Question 2-2: If your answer to Q2-1 is YES, is the *Time Distribution Indication* IE also needed by the DU?**

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| **Company** | **Comments** |
| Huawei | This could be marked as FFS. Since the reason we put above:   * The CU, based on the time distribution indication, determines to 5G accurate timing broadcasting, then generate the time reference SIB9 which will be updated by DU accordingly. |
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| Moderator Summary: | |

# 5 Conclusions, Recommendations

**Phase 2**:

TBD

**Phase 1**:

Proposals 1-4 can be agreed, but with PATH SWITCH REQUEST ACKNOWLEDGEMENT marked as FFS.

For minimum value (and granularity) of the *Uu Time Synchronisation Error Budget* IE, companies seem fine with either 1ns or 10ns with slight preference towards 1ns. Therefore, it is proposed to go with 1ns.

For the maximum value of the *Uu Time Synchronisation Error Budget* IE, most companies prefer 1ms, while remaining companies indicated a preference for 1000ns (or more to be future proof, without indicated an exact value). Therefore, it is proposed to go with 1ms, but it can be discussed online whether this is agreeable or should be kept FFS.

For F1AP, the *Uu Time Synchronisation Error Budget* IE is needed while the *Time Distribution* IE can be marked as FFS. Which F1AP message was not covered by the question, but to make progress on TPs the moderator would like to propose that the information is added to the REFERENCE TIME INFORMATION REPORTING CONTROL message as proposed in [2].

For XnAP, proposal 5 can be agreed. There is no consensus at this time for any additional parameters to pass from source gNB to target gNB over XnAP. Discussion can continue on the additional parameters at next meeting, this is already captured as an agreement from RAN3#113e in the Chair Minutes.

For gNB-based PDC, companies seem fine to further discuss it from the next meeting but keeping the understanding that support for gNB-based PDC is up to RAN1/RAN2 decision.

Based on the above, it is proposed to capture the following in the Chair’s Notes:

**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]),**

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

**The *Time Synchronisation Assistance Information* IE includes two sub-IEs:**

**- *Time Distribution Indication* IE, encoded as ENUMERATED type with two codepoints (enabled, disabled).**

**- *Uu Time Synchronisation Error Budget* IE encoded as INTEGER type having range 1ns to 1ms, and 1ns granularity.**

**Introduce the *Uu Time Synchronisation Error Budget* IE and *Time Distribution Indication* IE (FFS) over F1AP in the REFERENCE TIME INFORMATION REPORTING CONTROL message.**

**Further discuss RAN3 impacts of gNB-based PDC, but decision whether it is supported in Rel-17 is up to RAN1/RAN2.**

Short online discussion whether maximum value of the *Uu Time Synchronisation Error Budget* IE (1ms) is agreeable or should be marked FFS.

Round 2 of the CB is needed to capture the above agreements as TPs:

R3-214828 rev in R3-21xxxa (TP for NGAP)

R3-215132 rev in R3-21xxxb (TP for XnAP)

R3-214736 rev in R3-21xxxc (TP for F1AP)

# References

1. R3-214735, (TP for Introduction of Enhanced IIoT support over NG and Xn) Further discussion on Time Synchronization enhancements (ZTE)
2. R3-214736, (TP for Introduction of Enhanced IIoT support over F1)Time Synchronization enhancements (ZTE)
3. R3-214828, (TP for NR\_IIOT\_URLLC\_enh BL CR for TS 38.413) Time synchronisation assistance information (Nokia, Nokia Shanghai Bell)
4. R3-214829, (TP for NR\_IIOT\_URLLC\_enh BL CR for TS 38.423) Impact of handover on time synchronization (Nokia, Nokia Shanghai Bell)
5. R3-214903, (TP for BL CR for 38.413 IIOT) AS Time Distribution (Qualcomm Incorporated)
6. R3-215081, Discussion on supporting the gNB-based Packet Delay Compensation (Samsung)
7. R3-215082, (TP for NR\_IIOT\_URLLC\_enh BL CR for TS 38.413) Discussion on supporting the time synchronization error budget (Samsung)
8. R3-215122, TP for BLCR for 38.413 on Propagation Delay Compensation Enhancements (CATT)
9. R3-215131, (TP for eIIOT BLCR for TS 38.413) Supporting propagation delay compensation enhancements (Huawei)
10. R3-215132, (TP for eIIOT BLCR for TS 38.423) Supporting propagation delay compensation enhancements (Huawei)
11. R3-215154, Discussion on Further enhanced NR-IIoT: Enhancements for support of time synchronization (Ericsson)
12. R3-215155, Enhancements for support of time synchronization (Ericsson)
13. R3-215156, Enhancements for support of time synchronization (Ericsson)
14. R3-211136, LS on gNB-based propagation delay compensation (RAN3)