3GPP TSG-RAN WG2 Meeting #115 Electronic R2-21xxxxx

9 – 27 August 2021

**Agenda item: x.x.x**

**Source: Intel (Rapporteur)**

**Title: Report of email discussion [Post114-e][512][URLLC/IIoT] T-synch open issues (Intel)**

**WID/SID: NR\_IIOT\_URLLC\_enh – Release 17**

**Document for: Discussion and Decision**

# 1 Contact Points

Respondents to the email discussion are kindly asked to fill in the following table.

|  |  |  |
| --- | --- | --- |
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# 2 Introduction

This document is the report of the following email discussion:

* [Post114-e][512][URLLC/IIoT] T-synch open issues (Intel)

**Scope:** Progress discussion on RAN2 related aspects to PDC (e.g. how PDC is triggered/activated, signaling, assistance information from UE, whether to support UE based compensation and/or gNB based compensation etc)?

**Intended outcome:** Report with agreeable proposals

**Deadline:** Long

# 3 Discussion

## 3.1 Network pre-compensation

In RAN2 #113e, the topic of propagation delay compensation was discussed and it was agreed that “*RAN2 to confirm which PDC option to choose is up-to RAN1 to decide.*”[1]. There has been discussion in RAN1 regarding methods of PDC which shall be supported in Release 17, however, final decision is yet to be made. On the topic of network pre-compensation, an LS was received from RAN3 on gNB-based propagation delay compensation, where RAN3 has requested *RAN1 and RAN2 to inform RAN3 if a decision is reached to support gNB-based PDC* [2]. In RAN1 meeting #104bis-e, it was concluded to “*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.*” [3]. It is therefore up to RAN2 to decide whether pre-compensation at the gNB should be supported in Release 17.

### 3.1.1 Network Pre-compensation for TA-based PDC method

In Rel-16, UE-side PDC is up to UE implementation and gNB does not perform pre-compensation, as from RAN2#109-e agreement “*In Rel-16, propagation delay compensation may be done by UE implementation*”, as well as field description of *time*: “The indicated time is referenced at the network, i.e., without compensating for RF propagation delay”.

In Rel-17, several companies discuss TA-based PDC in the contributions submitted to the last RAN2 meeting #114e [4][5][6][7][8][9][10][11][12][13][14][15]. Some companies consider that PDC may be conducted by the gNB or the UE [4] [6][7][8][12][13]. Companies in support of network precompensation have the view that for TA-based PDC method, network compensation can avoid error components in the propagation delay compensation arising due to TA estimation at the UE side [8][12][4] and it may require less resources if gNB can perform PDC for the unicast scenario [8], while some companies think it is unclear if pre-compensation can outperform [10]. It may however not be feasible for broadcast scenario since different UEs may have different propagation delays, therefore gNB cannot perform pre-compensation in the broadcast signalling [4][7][10]. Companies not in favour of supporting network pre-compensation have the view that since pre-compensation method can only work if all UEs have the same path delay or the reference time must only be delivered via dedicated signalling for all such UEs, it is unnecessary to support in addition to the legacy UE-side TA PDC method [5][10][15].

**Question 1a: Please indicate your company view on whether network pre-compensation is supported for TA-based method, in addition to legacy UE-based propagation delay compensation?**

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| --- | --- | --- |
| Company | Support/Don’t support | Comments |
| NTTDOCOMO | support | We see benefits of pre-compensation by gNB in case TA-based PDC is not supported by UE. |
| Ericsson | Don’t support | As TA commands would anyway be transmitted to the UE, there is no additional benefits in network pre-compensation method. Note that, this assumes that the TA-based method can meet the target sync accuracy level.  We share the view that it does not work with broadcast message transmitted in SIB9, and one additional RRC unicast message is needed.  Also, the spec is typically written from UE perspective, and not to discuss/mandate a gNB implementation. Assuming UE-based method is supported, what matters is UE knows whether it shall or shall not perform TA-based PDC. It does not need to know if the time is pre-compensated by the network or there is no need to perform PDC to reach the sync target. |
| Nokia / NSB | Don’t support | In general we prefer to support only UE-side PDC in Rel-17.  UE-side should be considered a mandatory feature for devices wanting accurate time synchronization. UE-side PDC is the obvious choice as PD is UE specific and works together with both SIB9 and RRC delivered referenceTimeInfo.  Network pre-compensation may have some benefits (e.g. when the UE-side PD estimation procedure is inaccurate). However, as the Rapporteur has nicely summarized, support for network pre-compensation will require a significant RAN3 standardization effort. We do not think the benefits outweighs the standardization effort to make it worth to pursue further in Release-17. |
| CATT | Don’t support | We agree with the arguments mentioned by the Rapporteur: a gNB-only pre-compensation method can only work if all UEs have the same path delay or the reference time must only be delivered via dedicated signaling for all such UEs, which sounds cumbersome. For simplicity, we suggest that only UE-based PDC is supported in Rel-17. |
| Samsung | Don’t support | As mentioned by other companies, UE-based compensation should be required for broadcast signaling, so it does not make sense that UE requiring accurate time info does not have compensation capability.  Regarding the accuracy, we think if information of the propagation delay, e.g. accurate TA, has sufficient granularity, then UE-based compensation will be able to be accurate. Also, the size of TA command/or PD command (?) is small, compared to *ReferenceTimeInfo*. |
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The reference timing becomes inaccurate if both the network and the UE apply the propagation delay compensation, or in other words double compensate. In [4][6][7][8][13], it has been proposed to introduce some measure to indicate to the UE when pre-compensation has been applied by the gNB to avoid double compensation of the propagation delay at both the UE and the network side.

**Question 1b: If network pre-compensation is supported for TA based method, do companies agree that network indicates to the UE (e.g. via a unicast RRC signalling) when pre-compensation has been performed by the gNB?**

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| --- | --- | --- |
| Company | Agree/Disagree | Comments |
| NTTDOCOMO | Agree |  |
| Ericsson | Disagree, but okay on principle to have an indication. | We agree that the network indicate to the UE whether it shall or shall not perform PDC with the signalled TA commands from the network. However, the format of the signalling (explicit, implicit, etc) and in which RRC message can be for further study.  It is not clear from the question, what UE should do if such an indication (i.e., pre-compensation has been performed by the gNB) is NOT transmitted by the network. Should UE compensate with TA or not? A clear and deterministic UE behaviour is preferred.  There can be cases in which the reference time is not compensated by the network and there is no need for UE to compensate by the received TA commands, e.g., a small cell or UE’s propagation delay to the gNB is smaller than the targeted time sync level, etc. In this case, network need to indicate explicitly to the UE to NOT to compensate with TA methods. Similarly, there are cases in which network need to indicate explicitly to compensate with TA methods. |
| Nokia / NSB | Agree/Disagree | We agree that an activation signal is needed for UE-based PDC.  When the UE is configured to do PDC it will not expect the gNB to have done any pre-compensation. However, when the UE is not configured for PDC, the UE is not expected to do PDC and it can be left for gNB implementation whether or not it has conducted pre-compensation.  Given the very limited time remaining in Rel-17, we would prefer that RAN WGs focus on acquiring the simplest PDC framework supported.. |
| CATT | Agree | There shouldn’t be any ambiguity on who (gNB or UE) performs PDC and both should not be enabled together. |
| Samsung | Agree but | The NW pre-compensation can be applicable only for unicast delivery of ReferenceTimeInfo. Thus, an indication bit can be included in ReferenceTimeInfo. |
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### 3.1.2 Network Pre-compensation for RTT-based PDC method

The RTT based compensation method makes use of the propagation delay measurements to determine the distance between the UE and the gNB [3]. There are two flavors of RTT-based PDC method:

* UE side compensation. A UE measures UE Rx-Tx time difference and receives the gNB Rx-Tx time difference from the gNB. The UE then calculates the propagation delay and compensates the received reference timing.
* gNB side pre-compensation. A UE measures UE Rx-Tx time difference and reports it to gNB. gNB measures the gNB Rx-Tx time difference and pre-compensates the reference timing information before providing to UE.

While details of measurement framework are FFS in RAN1 [3], these measurements may likely be exchanged between the UE and the gNB e.g through unicast signalling [4] regardless of whether compensation is done at UE or at gNB. Therefore, for RTT based method, some companies think that pre-compensation at the gNB may be relatively easier to implement from perspective of the overall signaling exchange [4][14], where gNB can perform PDC if UE can report UE Rx-Tx time difference to NW [7][9][14], e.g as part of *MeasurementReport* [4][14]. Companies opposing pre-compensation for RTT based PDC suggest that if the design philosophy of Timing Delta MAC CE from IAB can be reused, then UE-side PDC seems simple in this case [9]. One company suggests that whether the Timing Delta MAC-CE should be a DL MAC-CE or re-designed as an UL MAC-CE on Uu needs to be discussed in RAN2 [14].

**Question 2: For RTT-based PDC method, which of the following option(s) do companies support?**

* Option 1: Support UE-side PDC only for RTT based method.
* Option 2: Support gNB-side pre-compensation only for RTT method
* Option 3: Support both UE-side PDC and gNB-side pre-compensation for RTT based method

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| Company | Option supported | Comments |
| NTTDOCOMO | option3 |  |
| Ericsson | Option 1 | Firstly, we assume either UE-side or gNB-side PDC can meet the target sync accuracy level.  We slightly prefer the option 1, due to the following concerns (related with spec change efforts) in the option 2:   * It has RAN3 impacts. There is a need to account for CU-DU time difference, because RRC signal is generated at the CU while reference signals for time sync and measurement are at the DU. * It has an “additional” information flow in the UL to report UE Rx-Tx time difference. It is unclear when/how to trigger UE report. Additionally, it is not clear how to make this report as close in time proximity as possible to when the network plans to deliver a 5G reference time. This requires a lot of discussions.   For the option 1, we prefer RRC signalling since the reference time is provided in RRC and one can re-use IE of gNB Rx-Tx time difference from the positioning specs, e.g., 9.2.40 gNB Rx-Tx Time Difference in TS 38.455.  Lastly, we don’t see any benefits to support both option 1 and option 2. |
| Nokia / NSB | Option 1 | For similar reasons as provided in Question 1a, we prefer UE-side PDC. |
| CATT | Option 1 | We don’t see the need to differentiate RTT-based and TA-based PDC methods and prefer a common solution. |
| Samsung | Option 1 | We prefer a simple option. |
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## 3.2 Propagation Delay Compensation Activation/Deactivation

Companies discuss in the contributions submitted to the last RAN2 meeting #114e whether the gNB can enable/disable UE side PDC [5][6][8][9][11][13]. The gNB may, for instance, disable UE-side PDC if network pre-compensation is applied or in the case of short path delay or stringent synchronicity requirements [5][6][9][11][14][19] to avoid double compensation [4][6][7][8][13] and avoid unnecessary path estimation errors, respectively [5][6].

### 3.2.1 UE-side PDC activation/deactivation for TA-based method

Some options are identified as below for companies to choose from, where the gNB explicitly signals to the UE whether to enable and/or disable PDC. Similar options were also identified in the email discussion [17], however, PDC activation/deactivation issue could not be discussed during the RAN2#112e meeting due to limited time. From signalling perspective Option 1 below and Question 1b earlier propose similar unicast RRC signalling, however, the context for network behaviour is different for both cases. There are companies who do not indicate support for network pre-compensation, however, still think that UE-side PDC may be activated/deactivated based on the scenario and synchronization requirement [5][9]. Therefore, we discuss the issue of PDC activation/deactivation separately here. Option 2 below is valid for the case when not all UEs in a cell need PDC e.g due to different distances from the gNB, or being in different scenarios (control to control, smart grid etc) with different synchronization requirements [8][9][17].

* **Option 1:** The gNB enables/disables UE-side PDC via unicast-RRC signalling for TA based method
* **Option 2:** The gNB enables/disables UE-side PDC via indication in SIB for TA-based method
* **Option 3** Other

**Question 3a: Please indicate which option(s) do companies support for UE-side PDC activation/deactivation for TA based method.**

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| Company | Option supported | Comments |
| NTTDOCOMO | Option 3 | UE conduct PDC or not based on a pre-configured threshold.  This question should be decoupled with if gNB pre-compensation is supported or not to avoid duplicated compensation issue. If only UE-side PDC is supported, for stationary UEs (e.g. smart grid sensors), we do not see necessity to (de)activate the PDC, since once the UE is placed far from the base station where it needs delay compensation, it should always conduct the PDC (i.e. always activated). While for mobile UEs (e.g. AGV in smart factory), since they are moving around in the factory, when it is far from the base station, it needs to perform PDC, otherwise not. UE knows whether it needs to perform PDC based on TA value and a pre-configured threshold, unicasting RRC signalling of (de)activating PDC consume lots of dedicated radio resource, which is not desirable in case of high density of UEs in the cell. As such, we believe a pre-configured threshold method (i.e. UE conduct PDC if the TA is larger than the threshold, otherwise not) is more efficient with low cost of signalling. |
| Ericsson | Option 1 | For TA-based method, UE-side PDC may be needed to reach the sync target. Depending on the distance from the UE to the gNB, only some but not all UEs need PDC. Thus, the option 1 should be supported. With the similar arguments, it is not clear the use case/benefits of the option 2. |
| Nokia / NSB | Option 1 | For similar reasons as provided in Question 1a, we prefer to support only UE-side PDC in Rel-17.  We support unicast PD activation/deactivation. We do not see any significant gains in supporting broadcast option, and as PD is a UE specific, it is natural to specify on a UE basis. |
| CATT | Option 1 | UE-side PDC activation/deactivation is UE specific, the option1 is the best choice to achieve it. |
| Samsung | No need | We assume Q3a is not about NW’s pre-compensation but about other cases.  In case that UE does not require any PDC due to 1) short distance to gNB or 2) UE’s required accuracy is low. Then, NW can just use Rel-16 compensation mechanism, i.e. leave it up to UE implementation. UE will just do its best by using its own way or do nothing. Rel-16 compensation shall be configured for backward compatibility. Thus, no additional indication is needed. |
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**Question 3b: For companies who support Option 1 in Question 3a and agree that network indicates to the UE when pre-compensation has been performed by the gNB in Question 1b, please indicate your company view on whether the signalling can be same for both cases.**

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| Company | Same/Different/Other | Comments |
| Ericsson | Same | The same for both cases, i.e., the network indicates to the UE whether it shall or shall not perform PDC with the signalled TA commands from the network. |
| Nokia / NSB | Same | We do not see a reason to specify two different PDC activation mechanisms (one for UE-side PDC and one for NW-side PDC). For UE-side PDC, the gNB should be able to instruct the UE on which PD method (TA or RTT-based) it should use for PDC. |
| CATT | Different | We think the below scenario is reasonable: neither of gNB and UE does PDC(Neither of them does PDC) , so we don’t think the signalling can be same for both cases. |
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### 3.2.2 UE-side PDC activation/deactivation for RTT based method

The signalling flow and framework is yet to be finalized in RAN1 for RTT based method. Activation/deactivation of UE-side PDC can be part of the signalling flow e.g. for UE-side PDC, if UE starts to measure UE Rx-Tx difference only after receiving gNB Rx-Tx time difference from the network, then lack of such information from the gNB could implicitly disable UE-side PDC. Therefore, it might be better to wait for RAN1 progress before discussing how UE-side PDC is activated/deactivated for RTT based method.

**Question 4: Do companies agree that RAN2 waits for RAN1 to decide the signalling framework/flow of RTT based method before discussing the issue of UE-side PDC activation/deactivation for RTT based method?**

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| --- | --- | --- |
| Company | Agree/Disagree | Comments |
| NTTDOCOMO | Agree |  |
| Ericsson | Disagree | No strong view but tend to disagree. We are fine to wait for and align with RAN1, if this is the majority view.  Some principles can already be discussed, and we wonder if RAN1 would ever discuss the signalling framework/flow (which is the RAN2 scope). For example, RAN1 has already left the decision on UE-side PDC or gNB-side PDC to RAN2, and maybe the intention is already clear that there is no interest for RAN1 to discuss when UE should start to measure UE Rx-Tx (as the example described above). Nevertheless, it is okay to wait and confirm. |
| Nokia / NSB | Agree/Disagree | We propose that RAN2 discussed the overall PDC signalling framework.  The details of the RTT method requires a RAN1 decision (e.g. reference signal configuration, measurement definitions, measurement reports), but whether the Rx-Tx measurement report is delivered from the gNB to the UE or vice-versa can still be discussed. So can the need to support multiple reference signal configurations and whether these are aperiodic or periodic (and if so periodicities). |
| CATT | Agree | In order to avoid invalid discussion, we prefer to wait for RAN1’s decision. |
| Samsung | Agree |  |
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## 3.3 Other methods for PDC Triggering and Assistance Information from UE

Companies also discussed other methods for UE-side PDC in RAN2 meeting #112e as summarized in email discussion summary [17]. Few companies think that in some cases, the UE may indicate to the gNB (in e.g. UEAssistanceInformation) when it believes that a PD update is needed [7][9][13], or an implicit activation based on pre-configured threshold may be used for activation of UE-side PDC [12]. On the other hand some companies think that UE assistance or threshold configuration may not be beneficial [11], since the threshold-based mechanism is only beneficial when the network is required to frequently change indication to the UE e.g when UE is sufficiently close to the gNB [13].

**Question 5: Do companies support assistance information from the UE which could for example be used by gNB to active PDC?**

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| Company | Yes/No | Comments |
| NTTDOCOMO | ? | For RRC\_CONNECTED, gNB knows how far UE is away in the cell, there is no need to inform gNB of activating PDC using assistance info from UE.  While assistance information which includes UE’s preferable periodicity of referenceTimeInfo update is helpful for network for configuration, since the periodicity could be related to UE’s clock accuracy. Is this also relative to rapporteur’s question? |
| Ericsson | No | The benefits are unclear.  It was agreed in RAN2#110-e that:   * UE can calculate/predict the reference timing based on DL timing information after receiving the referenceTimeInfo from gNB once. (No spec impact)   In RAN2#113, it was further confirmed that:   * There is no UE clock drift issue to be addressed   The rationale is that RAN4 specifies in TS 38.101 that UE clock is locked to DL frequency with at least ±0.1 PPM precision. This means +/- 1ns timing drift over 10ms, and a refresh time of 1s is sufficient to remain within the 1 µs accuracy.  After UE receiving one 5G reference time corrected by PDC, UE tracks the time with an internal oscillator corrected by a frequency locking to the gNB clock. Another PDC might be needed together with another reference time delivery by gNB, but gNB is aware of when that would happen. |
| Nokia / NSB | Yes/No | We do support UE assistance information for the sake of PDC and time synchronization services, but we also acknowledge that the timeframe in Rel-17 is be too short to properly discuss these. |
| CATT | No | There is no need for any assistance information to activate PDC. Network can derive it by itself by tracking the UE’s distance to gNB from available UL measurements (e.g. SRS). |
| Samsung | No |  |
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**Question 6: Do companies support that UE-side PDC may be implicitly activated when a pre-configured threshold is met? FFS how such threshold is pre-configured.**

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| Company | Yes/No | Comments |
| NTTDOCOMO | Yes | UE knows whether it should compensate propagation delay based on TA and the pre-configured threshold. The threshold can be pre-configured by dedicated RRC signalling. Assume the robots are moving around in the smart factory, when UE is far from the base station where it exceeds a pre-configured threshold, UE needs to perform PDC, otherwise not. Especially, in case of high density of UEs in the cell, this method save lots of dedicated RRC signalling of (de)activating PDC. For pingpong issue, it’ a rare case, and if UE move back and forth around the place where it is a threshold for PDC, network is also confused whether to activate or deactivate the PDC for it. |
| Ericsson | No | See above |
| Nokia / NSB | No | We do not support an implicit PDC trigger e.g. based on a threshold.  Specifying a threshold is not straight forward and the benefits of such procedure is expected to be very small as it is not expected that PDC needs to be frequently activated/deactivated. |
| CATT | No | UE-side PDC should be in gNB’s control. For the pre-configured threshold, we are not sure about the use scenario and fail to see how to configure it in practice. |
| Samsung | No |  |
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There are also other proposals whether a new trigger for TA update can be introduced e.g if TA estimation error exceeds several times TA granularity (not applicable to SCS > 60KHz) [8], or if UE can trigger random access or RACH procedure and proactively acquire PD estimation if it does not have valid TA e.g for UEs in RRC\_IDLE or RRC\_INACTIVE state [7][12][14][16]. RAN2 in the last meeting #114e indicated in LS to SA2 [18] that it is beneficial for NG-RAN to receive time synchronization error budget available for Uu interface. Having this information regarding time synchronization budget, it is rapporteur’s understanding that in RRC\_CONNECTED the gNB may send MAC CE for timing update whenever required and UE may not need to trigger a TA update.

**Question 7: Do companies support that a UE may trigger a TA update or RACH procedure for PDC?**

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| --- | --- | --- |
| Company | Yes/No | Comments |
| NTTDOCOMO | No | Same understanding with rapporteur. |
| Ericsson | No | The benefits are unclear.  Reference time delivery is used to time stamp a gPTP message and subsequently sync with an external clock. There are ongoing data transmissions and there is no need to consider RRC\_IDLE/RRC\_INACTIVE state. In addition, since the PDC is used together with a reference time delivery by gNB, gNB can initiate a PDCCH order to update TA. |
| Nokia / NSB | No | We do see the potential in a UE-side PDC update trigger, but it can be down-prioritized in Rel-17. There is no benefits of a UE side PDC update via RACH due to low time accuracy of the RACH preamble detection.  The benefits of a UE side PDC trigger procedure comes when the gNB can trust in the UE DL frame tracking capabilities, and then can relax its PDC configuration. The current performance requirements to the UE leaves little room for benefits of such procedure. We would like this to be properly studied and hence it is better to leave the such enhancements for Rel-18. |
| CATT | Yes | For legacy procedure, the RACH procedure is used to acquire initial synchronization and MAC CE for timing update if needed. Some enhancement can be considered in the current release to further balance, otherwise, we lose the chance to further improvement. |
| Samsung | No |  |
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# 4 Conclusion

TBD.

# 5 References

[1] R2-2101954 Report for Rel-17 Small data and URLLC/IIoT and Rel-16 NR-U, Power Savings, and 2step RACH, 3GPP TSG-RAN WG2 Meeting #113 electronic

[2] R2-2104720 LS on gNB-based propagation delay compensation (R3-211136; contact: Nokia)

[3] R1-2104151 Final Report of 3GPP TSG RAN WG1 #104bis-e v1.0.0

[4] R2-2104886 Pre-compensation at the gNB for RTT and TA based PDC Intel Corporation

[5] R2-2104898 Design for Time Synchronization in Rel-17 CATT

[6] R2-2104901 Propagation Delay Compensation for TSN Qualcomm Incorporated

[7] R2-2105289 Discussion on the propagation delay compensation vivo

[8] R2-2105307 Further discussion on time synchronization and PDC ZTE Corporation, Sanechips, China Southern Power Grid Co., Ltd

[9] R2-2105565 Consideration on the support of time synchronization enhancement OPPO

[10] R2-2105766 Synchronization and Error Budget Samsung

[11] R2-2105825 Discussion on enabling UE side propagation delay compensation Lenovo, Motorola

[12] R2-2105844 Propagation Delay Compensation Signaling CANON Research Centre France

[13] R2-2105868 Time Synchronization Signalling Analysis Nokia, Nokia Shanghai Bell

[14] R2-2106249 Support of time synchronization for TSN based on RAN1 progress CMCC

[15] R2-2106433 Discussion on enhancements for support of time synchronization LG Electronics Deutschland

[16] R2-2106324 Timing synchronization for UE in RRC\_INACTIVE state and RRC\_IDLE state TCL Communication Ltd.

[17] R2-2009755 Summary of E-mail discussion: [Post111-e][924][R17 URLLC/IIoT] Propagation delay for TSN (Nokia)

[18] R2-2106560 Reply LS on Time Synchronization assistance parameters

[19] R2-2106323 Discussion on Propagation Delay Compensation (PDC) III