**3GPP TSG RAN WG1 Meeting #107-e R1-21xxxxx**

**E-meeting, November 11–19, 2021**

**Agenda Item: 8.3.4**

**Source: Moderator (Huawei)**

**Title: Feature lead summary on propagation delay compensation enhancements**

**Document for: Discussion and Decision**

# Introduction

The revised IIoT / URLLC work item description for Rel-17 [1] has enhancements for time synchronization as one of its main objectives:

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| 1. Enhancements for support of time synchronization: 2. RAN impacts of SA2 work on uplink time synchronization for TSN, if any. [RAN2] 3. Propagation delay compensation enhancements (including mobility issues, if any). [RAN2, RAN1, RAN3, RAN4] |

This document summarizes the key issues discussed under agenda item 8.3.4 based on the views in [3][4][5][6][7][8][9][10][11][12][13], and aims to discuss a set of issues in RAN1#107-e. The agreements in past meetings are captured in the Appendix.

# Potential enhancements for propagation delay compensation

In RAN1#102-e meeting, the following option 1 and option 2 are agreed for further study in RAN1.

* **Option 1**: TA-based propagation delay
  + **Option 1a**: Propagation delay estimation based on legacy Timing advance (potentially with enhanced TA indication granularity).
  + **Option 1b**: Propagation delay estimation based on timing advanced enhanced for time synchronization (as 1a but with updated RAN4 requirements to TA adjustment error and Te)
  + **Option 1c:** Propagation delay estimation based on a new dedicated signaling with finer delay compensation granularity (Separated signaling from TA so that TA procedure is not affected)
* **Option 2**: RTT based delay compensation:
  + Propagation delay estimation based on an RAN managed Rx-Tx procedure intended for time synchronization (FFS to expand or separate procedure/signaling to positioning).

## TA-based propagation delay compensation

The following agreement was achieved in RAN1#106-e:

**Agreement**

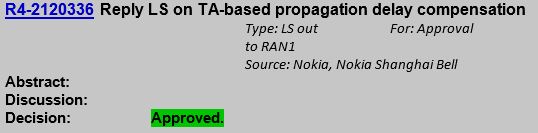
**Send LS to RAN4 to ask for feedback on the following questions:**

* **Question 1**: Is it feasible to support a smaller value than the current Te for the use of propagation delay compensation, assuming the existing conditions in TS 38.133 for Te requirement? If not, is it feasible under new conditions (e.g. using TRS instead of SSB)? If the answer is yes, please also provide feedback on how much it can be reduced **at most**.
* **Question 2**: Is it feasible to introduce enhanced TA command indication granularity? If the answer is yes, please also provide feedback on how much it can be reduced **at most (**e.g. reduced to (1/16)\* (16\*64\*Tc/2)**)** similar as the granularity for Rel-16 IAB based on the Timing Delta MAC CE **and related condition**.
* Note 1: The alternatives in the working assumption achieved in RAN1#104bis-e together with the examples in Table 4.2-2 will be included in the LS to give some background for RAN4
* Note 2: The agreement “both SCS 15 kHz and 30 kHz are assumed for both control-to-control and smart grid for evaluation of the time synchronization” achieved in RAN1#102-e will be included in the LS for RAN4 information also.
* Note 3: Inform RAN4 that the enhancements on Te and TA command indication granularity for propagation delay compensation may or may not have impact on normal TA related procedure, depending on which candidate option for TA-based PDC is adopted. Note that this is just for RAN4 information.
* Note 4: Whether RAN1 will introduce specification enhancements is still undetermined.

In the RAN#93-e meeting, the following was concluded.

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| conclusion: For the objective on enhancements for support of time synchronization, RAN should provide the following guidance:  - RAN4 to provide reply LS to RAN1 (e.g. in response to R1-2108635 on TA-based PDC and a potential RAN1 LS on RTT-based PDC) before the start of RAN1#107-e (Nov 11th) |

In RAN4#101-e meeting, the LS from RAN4 was agreed as below.



The key part of the LS R4-2120336 is copied below for your information.

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| 1. **Overall Description:**   RAN4 thanks RAN1 for the LS R1-2108635 about TA-based propagation delay compensation.  RAN4 has discussed the questions in R1-2108635 and RAN4 provides the following answers:    **Question 1**: Is it feasible to support a smaller value than the current Te for the use of propagation delay compensation, assuming the existing conditions in TS 38.133 for Te requirement? If not, is it feasible under new conditions (e.g. using TRS instead of SSB)? If the answer is yes, please also provide feedback on how much it can be reduced **at most**.  **Answer:**   * There is no consensus in RAN4 whether it is feasible to support a smaller value than the current Te assuming the existing conditions in TS 38.133 for Te requirement. * RAN4 considers that it is feasible to support a smaller Te value than the current Te for the use of propagation delay compensation under the assumption of using TRS (or other RS used for Te estimation) instead of SSB.   + Asmaller Te can be achieved when TRS (or other RS) bandwidth is larger than SSB bandwidth.   + A Smaller Te can be achieved for UE is operating in RRC\_CONNECTED mode. * There is no consensus in RAN4 about how much Te value can be reduced at most or the related conditions, which RAN4 will discuss further. * Support of Smaller Te can be defined as an optional Rel-17 capability and should not apply to all UEs. * From RAN4 view it is still being studied whether a smaller Te can be achieved for the first transmission in the DRX cycle and would like to ask RAN1 the following:   + If the presence of TRS (or other RS) can be guaranteed during the DRX OFF?   **Question 2**: Is it feasible to introduce enhanced TA command indication granularity? If the answer is yes, please also provide feedback on how much it can be reduced **at most (**e.g. reduced to (1/16)\* (16\*64\*Tc/2μ),similar to the granularity for Rel-16 IAB based on the Timing Delta MAC CE) **and related condition**.  **Answer:**   * It is feasible to introduce enhanced TA command indication granularity. * It is RAN4 understanding that:   + Enhanced granularity will apply for UE supporting PDC   + This agreement does not impact UL timing accuracy requirement * TA command indication granularity can be reduced to 64Tc for both 15 kHz SCS and 30 kHz SCS.   + RAN4 will further discuss whether there are any specific conditions to use improved TA command indication granularity  1. **Actions:**   **To RAN 1 group:** RAN4 respectfully asks RAN1 to take the above information into consideration. |

**Feature lead:** based on the feedback from RAN4 above, it is feasible to support a smaller Te value than the current Te for the use of propagation delay compensation under the assumption of using TRS (or other RS used for Te estimation) instead of SSB. But there is no consensus in RAN4 about how much Te value can be reduced at most or the related conditions, and RAN4 will discuss further. And TA command indication granularity can be reduced to 64Tc for both 15 kHz SCS and 30 kHz SCS.

### Evaluation on the achievable time synchronization accuracy for enhanced TA-based PDC

Based on inputs from companies in RAN1#107-e meeting, the total error results are summarized below. Note that the evaluation for the existing TA-based PDC, i.e. no any enhancements on Te and/or TA command indication granularity, is not included in the table, since we are mainly looking at the potential performance for enhanced TA-based PDC.

Table 1 Overall synchronization error summary for RTT-based PDC

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| Source | overall synchronization error | | Note |
| 15 kHz | 30 kHz |
| Nokia  (R1-2111141) | 297 ns | 255 ns | 50 MHz (i.e.270 RB) bandwidth for DL RS for 15 kHz;  100 MHz (i.e.273 RB) bandwidth for DL RS for 30 kHz;  = 100 ns;  = 10 ns for 15 kHz, 5 ns for 30 kHz;  Te = 262 ns for 15 kHz, Te = 196 ns for 30 kHz;  (1/16)\*existing TA granularity; |
| OPPO  (R1-2111344) | >275 |  | 24 RB bandwidth for DL RS for 15 kHz;  24 RB bandwidth for DL RS for 30 kHz; |
|  |  | 106 RB bandwidth for DL RS for 15 kHz;  51 RB bandwidth for DL RS for 30 kHz; |
| ZTE  (R1-2110917) | 242 ns | 211 ns | 106 PRB bandwidth for RS for 15 kHz;  51 PRB bandwidth for RS for 30 kHz;  32 Tc for TA command indication granularity;  Te: 195 ns for 15 kHz, 130 ns for 30 kHz; |
| Intel  (R1-2111492) | 246 ns | 246 ns |  |
| Samsung  （R1-2111733） | ~265 ns | 117ns | 132 PRB/176 PRB for DL/UL reference signal  (1/4 )\* Te, (1/16)\*TA granularity |
| Huawei  (R1-2111926) |  |  | 24RB for DL RS, 44 RB for UL RS, 15 kHz;  24RB for DL RS, 48 RB for UL RS, 30 kHz;  (1/16)\*TA granularity |
|  |  | 104RB for DL RS, 176 RB for UL RS, 15 kHz;  132B for DL RS, 176 RB for UL RS, 30 kHz;  (1/16)\*TA granularity |
| Feature lead |  |  | 50 MHz (i.e.270 RB) bandwidth for DL RS for 15 kHz;  100 MHz (i.e.273 RB) bandwidth for DL RS for 30 kHz;  = 100 ns (i.e. no special enh. for UL RS);  = 10 ns for 15 kHz, 5 ns for 30 kHz;  (1/16)\*existing TA granularity = 64 Tc; |
| Feature lead |  |  | 50 MHz (i.e.270 RB) bandwidth for DL RS for 15 kHz;  88 RB bandwidth for UL RS for 15 kHz;  100 MHz (i.e.273 RB) bandwidth for DL RS for 30 kHz;  88 RB bandwidth for DL RS for 30 kHz;  = 0.5/(N\_PRB\_DL\_RS\*12\*SCS;  (1/16)\*existing TA granularity; |
| Feature lead |  |  | 50 MHz (i.e.270 RB) for DL RS for 15 kHz;  176 RB bandwidth for UL RS for 15 kHz;  100 MHz (i.e.273 RB) for DL RS for 30 kHz;  64 MHz (i.e.176 RB) for DL RS for 30 kHz;  = 0.5/(N\_PRB\_DL\_RS\*12\*SCS;  (1/16)\*existing TA granularity = 64 Tc; |
| Note: | | | |

**Feature lead:**

Based on the inputs in Table 1, although RAN4 didn’t provide the enhanced Te, it can be expected that enhanced TA-based PDC with 30 kHz is able to meet the upper bound of the synchronicity budget for control-to-control scenario, since there is sufficient room to cover the error due to Te. However, the case of 15 kHz would depend on the condition, e.g. the bandwidth of the RS.

To evaluate the best performance that enhanced TA-based PDC can be achieved, feature lead provides the potential overall synchronization error as shown in the last three rows in Table 1 above, assuming maximum bandwidth for DL RS, i.e. 50 MHz (i.e.270 RB) bandwidth for DL RS for 15 kHz and 100 MHz (i.e.273 RB) bandwidth for DL RS for 30 kHz. Note that it is assumed that TA command indication granularity can be reduced to 1/16.

According to the RAN4 discussions, it seems 262 ns for 15 kHz and 196 ns for 30 kHz corresponding to the maximum RS bandwidth is what RAN4 was considering, however in the end no consensus achieved, which means there is no any value sent from RAN4 to RAN1 on reduced Te. Note that 262 ns for 15 kHz and 196 ns for 30 kHz corresponding to the maximum RS bandwidth are also discussed in Nokia R1-2111141, which looks reasonable and we can use it for have some rough idea on the potential performance of enhanced TA-based PDC.

From RAN1 perspective, seems not much we can do without the enhanced Te value from RAN4, but at least we can try to see check the potential best performance that TA-based PDC can achieve, in order to compare with RTT-based PDC. Initial observations as shown in section 2.1.1.1.

#### First round email discussion

Based on the inputs and analysis above, the following observations and/or conclusions are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals before providing your views here.

**Proposed observation 2.1.1.1-1: enhanced TA-based PDC under 30 kHz can meet the upper bound (i.e. ±275 ns) of Uu interface synchronicity error budget for control-to-control scenario, at least when the bandwidth for DL RS is the maximum bandwidth (i.e. 273 PRB).**

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**Proposed observation 2.1.1.1-2: enhanced TA-based PDC under 15 kHz can meet the upper bound (i.e. ±275 ns) of Uu interface synchronicity error budget for control-to-control scenario, at least when the bandwidth for DL RS is the maximum bandwidth (i.e. 270 PRB) and the bandwidth for UL RS is larger than 44 RBs.**

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**Proposed observation 2.1.1.1-3: If the bandwidth for DL RS is smaller than the maximum bandwidth (i.e. 270 PRB), enhanced TA-based PDC may or may not meet the upper bound (i.e. ±275 ns) of Uu interface synchronicity error budget for control-to-control scenario.**

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### Whether/how to configure UL signal for enhanced TA-based PDC

In the RAN1#106bie-e meeting, the following was agreed with an FFS whether/how to configure UL signal for enhanced TA-based PDC.

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| **Agreement**  If enhanced TA-based PDC with reduced Te based on TRS is supported in Rel-17, one CSI-RS for tracking (TRS) configuration is configured for enhanced TA-based PDC.   * FFS whether/how to configure UL signal for enhanced TA-based PDC |

In this meeting, companies share their views as below.

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| *Nokia (R1-2111141)*  Also, in the previous meeting it was discussed whether an UL signal, such as SRS, would need to be configured for the UE so that the enhanced Te requirement would only apply for the configured TRS/SRS pair. In our view, imposing such UL signal configuration for enhanced TA based PDC by default should not be needed. After detecting the TRS, the UE should transmit at least one uplink signal complying with the enhanced Te requirement, while should be up to gNB implementation to schedule/configure the UL transmission.  However, in case the Te margin reduction is concluded to be unfeasible in RAN4, the impact of UL reception error would need to be reduced for meeting the control-to-control budget with an enhanced TA. In that case, the configuration of a higher bandwidth SRS would be needed for reducing the gNB UL reception error. That means, instead of an UL reception error based on minimum UL bandwidth, such error component would need to be reduced by at least 44ns. So, UL reception gets to , which corresponds to an UL signal of 0.5/56ns=8,9MHz or 50RBs in 15kHz.  **Observation 2.1.2: For enhanced TA based PDC to meet the synchronicity budget of control-to-control in 15kHz, if a maximum bandwidth TRS is used for reducing Te while the Te margin for implementation is not changed, an UL signal of at least 8.9 MHz is needed in order to reduce the**  **Proposal 2.1.1: If enhanced TA-based PDC is supported, the configuration of an UL signal (e.g. SRS) for enhanced TA should only be considered in case the Te margin component of Te cannot be reduced (depending on RAN4 input).** |

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| ZTE (R1-2110917)  During the TA procedure in NR, SRS can be used for the network to perform measurement and adjust the UE TA in addition to PRACH. Therefore, it is straightforward to use SRS for TA-based PDC in Rel-17.  ***Proposal 1:*** *If enhanced TA-based PDC with reduced Te is supported in Rel-17, one SRS configuration can be configured for TA-based PDC.* |

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| *vivo (R1- 2111008)*    For improving uplink receiving accuracy at gNB, it is unnecessary to restrict a specific UL signal/channel for enhanced TA-based PDC. Actually, any UL channel(s)/signalling(s) can be used for the enhanced TA-based PDC with reduced Te, e.g., SRS/PUSCH. After transmitting TRS, gNB can schedule aperiodic SRS or A-CSI or PUSCH for UE to transmit for the enhanced error detection. The detailed requirement needs RAN4 input e.g., the bandwidth and density of UL channel or signalling.  ***Proposal 1: If enhanced TA-based PDC with reduced Te*** ***based on TRS is supported in Rel-17, UL signal for enhanced TA-based PDC is up to implementation.*** |

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| *OPPO (R1- 2111344)*   * gNB configures a list of SRS signals in *SRS-Config* (contained in *BWP-UplinkDedicated*), and uses any subsets of the received SRS to check alignment of UL-Rx timing. Whether there is certain SRS specifically for PDC purpose could be transparent to UE. * gNB configures one or more TRS signals, one in each *NZP-CSI-RS-ResourceSet*, in IE of *CSI-MeasConfig* contained in *ServingCellConfig*. It is up to UE implementation to use the TRS with the largest configured bandwidth, or the CSI-RS (but not TRS) with the largest configured bandwidth, or the combination of both plus even additionally the other configured CSI-RS and/or any other DL-RS (if transmitted in the same radio frame) to detect the DL-Rx timing. The gNB does not need to assign a specific TRS that UE should exclusively use for TA-based PDC purpose. Some of those DL-RS may even be transmitted in the same radio frame as SIB9 that carries ReferenceTimeInfo to improve the SFN timing detection accuracy, without introducing additional specification changes (at least in RAN1/RAN2).   ***Observation 3: The existing specification does not prevent gNB and UE from using the CSI-RS/TRS and any other DL-RS to improve the DL-Rx timing detection accuracy.***   * ***There is no need to have PDC-specific DL/UL RS configuration for TA-based PDC.*** * ***The error performance of TA-based PDC can leave existing Te requirement unchanged, since Te is an upper-bound used by spec for “TA control” purpose and does not prevent UE from performing better by using DL-RS in “TA measurement”. Therefore, RAN4’s response on potential Te enhancement is not relevant to RAN1’s evaluation that uses DL-RS to improve TA interval measurement.*** |

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| *Samsung (R1-2111733)*  **Proposal #2: If TA based method is adopted, TRS is used as DL reference signal and SRS can be used for UL reference signal.** |

**Feature lead:** Based on the analysis in section 2.1.1, it can be seen that for 15 kHz, enhanced TA-PDC can meet the budget only if the bandwidth for UL RS is larger than 44 RBs, which means we cannot rely on any uplink signal/channel for PDC, and thus specific SRS configuration should be introduced.

#### First round discussion

Based on the inputs and analysis above, the following proposals are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals before providing your views here.

**Proposal 2.1.2.1-1: If enhanced TA-based PDC with reduced Te is supported, one SRS configuration is configured at least for enhanced TA-based PDC under 15 kHz.**

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### How to signal the enhanced TA for enhanced TA-based PDC

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| ZTE (R1-2110917)  ***Proposal 5:*** *TA-based PDC should be supported for the propagation delay compensation enhancements with reducing the initial transmission error (Te) and reusing the enhanced timing advance MAC CE.* |

**Feature lead**: According to the current agreement in RAN4, it is feasible to reduce the TA command indication granularity to (1/16) of the existing granularity, similar as the granularity for Rel-16 IAB based on the Timing Delta MAC CE. Therefore, it should be straightforward to use MAC CE to indicate the TA command for enhanced TA-based PDC.

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| Huawei (R1-2111926)  If TA-based PDC is supported, then we need to define the range of the enhanced TA command indication. This is related to the distance between the gNB and UE. The service area of control-to-control and smart grid is 1000m 100m and 20km2, the radius would be 178m and 2.5km respectively assuming the area is a circle. Thus the enhanced TA command indication can be from 0 to 16384Tc.  ***Proposal 3: If TA-based propagation delay compensation is supported for PDC, the enhanced TA command indication is from 0 to 16384 Tc.*** |

**Feature lead**: The range for the TA command indication is needed. The proposal from Huawei is used for further discussion, companies can double check if it is correct.

#### First round discussion

Based on the inputs and analysis above, the following proposals are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals before providing your views here.

**Proposal 2.1.3.1-1: If enhanced TA-based PDC with reduced Te and enhanced TA command indication granularity is supported, the enhanced TA command is signaled by MAC CE.**

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**Proposal 2.1.3.1-2: If enhanced TA-based PDC with reduced Te and enhanced TA command indication granularity is supported, the range of the enhanced TA command is from 0 to 16384Tc.**

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## RTT based propagation delay compensation

This section will discuss some key issues for RTT-based propagation delay compensation.

### Evaluation on the achievable time synchronization accuracy for RTT-based PDC

Based on inputs from companies in RAN1#107-e meeting, the total error results are summarized below:

Table Overall synchronization error summary for RTT-based PDC

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| --- | --- | --- | --- |
| Source | overall synchronization error | | Note |
| 15 kHz | 30 kHz |
| Ericsson  (R1-2111191) | 251ns | 158ns | for 15kHz and for 30kHz  for 15kHz and for 30kHz  for 15kHz and for 30kHz  for 15kHz and 4ns for 30kHz  24 PRB for RS  Note: Margin not considered |
| Huawei  (R1-2111926) |  |  | 24RB for DL RS, 44 RB for UL RS, 15 kHz;  24RB for DL RS, 48 RB for UL RS, 30 kHz;  SINR -13 dB; |
|  |  | 104RB for DL RS, 176 RB for UL RS, 15 kHz;  132B for DL RS, 176 RB for UL RS, 30 kHz;  SINR -13 dB; |
| ZTE  (R1-2110917) | 116.75 | 123.25 | for 15kHz and 43 ns for 30kHz  16 ns for 15kHz and 19 ns for 30kHz  20 MHz for RS |
| Nokia  (R1-2111141) | 250.723ns | 157.228ns | Minimum BW reference signals  = 122Tc (24 ≤ BW ≤ 40 RBs) (15 kHz)  = 137Tc (24 RBs) (15 kHz)  = 32Tc (48 ≤ BW ≤ 84 RBs) (30 kHz)  = 87Tc (24 RBs) (30 kHz)  = 0.5/(N\_PRB\*12\*SCS) (24 RBs)  = ½ \*32Tc (k=5)  Note: Margin not considered |
| 110.63ns | 93.414ns | e = 62Tc (44 ≤ BW ≤ 84 RBs) (15 kHz)  = 62Tc (104 RBs) (15 kHz)  = 62Tc (48 ≤ BW ≤ 84 RBs) (30 kHz)  = 62Tc (132 RBs) (30 kHz)  = 0.5/(N\_PRB\*12\*SCS) (276 RBs)  Note: Margin not considered |
| CATT  (R1-2111251) | 216.25ns | 172.25ns | ns  = 100ns  24 PRB for RS for both 15 kHz and 30 kHz |
| Samsung  (R1-2111733) | 115 ns | 94 ns | 132 PRB/176 PRB for DL/UL reference signal |
| Intel  (R1-2111492) | 239ns | 203ns | 24 ≤ BW ≤ 40 for RS for 15 kHz;  48 ≤ BW ≤ 84 for 30 kHz; |
| 193 ns | 186 ns | 176 ≤ BW for RS for 15 kHz;  176 ≤ BW for 30 kHz; |
| OPPO  (R1-2111344) | >275 |  | 24 RB for RS  Note: The value of and are different from the agreed ones |
|  |  | 106 RB for 15 kHz, 51 RB for RS for 30 kHz  Note: The value of and are different from the agreed ones |
| Qualcomm  (R1-2112212) | 245 ns |  | =60 ns  = 100ns  = 100ns |
| Note: | | | |

#### First round email discussion

Based on the inputs and analysis above, the following observations and/or conclusions are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals before providing your views here.

**Proposed observation 2.2.1.1-1: RTT-based PDC under 30 kHz can meet the upper bound (i.e. ±275 ns) of Uu interface synchronicity error budget for control-to-control scenario, at least when the bandwidth for DL RS is larger than 24 PRB and the bandwidth for UL RS is larger than 48 PRBs.**

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**Proposed observation 2.2.1.1-2: enhanced TA-based PDC under 15 kHz can meet the upper bound (i.e. ±275 ns) of Uu interface synchronicity error budget for control-to-control scenario, at least when the bandwidth for DL RS is larger than 104 PRB and the bandwidth for UL RS is larger than 44 PRBs.**

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| Feature lead | Only the values that can leave sufficient room for margins are considered here, thus values like ~ 250 ns under 24 PRBs are not considered, since it is not clear yet whether it can meet the budget or not if margins Y and delta are considered. |
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**Proposed observation 2.2.1.1-3: To achieve the same overall synchronization error, RTT-based PDC requires smaller bandwidth for DL RS and/or UL RS, compared to enhanced TA-based PDC.**

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### Reporting granularity of the Rx-Tx measurement

In RAN1#106 and RAN1#106bis-e meeting, the following was agreed for the granularity.

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| **Agreement**  If RTT-based propagation delay compensation is supported and performed at the UE side, the Rx-Tx measurement report provided from the gNB to the UE should include at least:   * gNB Rx-Tx time difference at a given granularity * FFS whether to include SRS-Resource-ID   Agreement  If RTT-based propagation delay compensation is supported and performed at the gNB side, the Rx-Tx measurement report provided from the UE to the gNB should include at least:   * UE Rx-Tx time difference at a given granularity   **Agreement**  If RTT-based propagation delay compensation is supported, the Rx-Tx time difference is reported with granularity *2k\*Tc*, where *k* is an integer satisfying 0<=*k*<=5.   * FFS the value of *k* * FFS the reporting range of Rx-Tx time difference measurement for PDC |

In this meeting, companies share views below.

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| *Nokia (R1-2111141)*  In our view, we don’t need all the low granularity available for positioning since the accuracy level for PDC does not need to be as high. It is clear that the error contribution in PDC given by granularity with k=5, i.e. (±8.144 ns)/2, corresponds to less than 1.5% of the control-to-control budget of ±275ns. So, to simplify specification work in terms of granularity signaling, a single granularity can be supported for PDC, such as 32Tc.  **Observation 2.2.3: For a granularity of *2k\*Tc* with *k=5*, the contribution of the indication error corresponds to less than 1.5% of the control-to-control budget.**  **Proposal 2.2.1: A single granularity for the Rx-Tx measurement report, such as 32Tc, is supported for RTT-based PDC. No specification of report granularity configuration should be needed.** |

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| *ZTE (R1-2110917)*  In our understanding, if the RTT-based PDC is supported, it can also be used for the other scenario with lower requirement, e.g., smart grid, where a larger granularity can also work. Considering that multiple granularity can provide more flexibility and forward compatibility, we think all the granularity defined in positioning WI can be supported if RTT-based PDC is supported. In this case, the network can choose suitable granularity for measurement report delivery or configure the granularity for the UE to report the measurement result.  ***Proposal 3:*** *All the granularity for the Rx-Tx time difference measurement reporting defined in TS38.133 should be supported if RTT-based PDC is supported.* |

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| *vivo (R1- 2111008)*  Considering PDC for URLLC support two use cases, i.e., smart grid and control to control use case, various SCS and/or RS bandwidths can be configured for these use cases. On the other hand, the operation frequency range may also be different, e.g., on FR 1 or FR 2. Supporting multiple reporting granularity can provide the better flexibility for the different scenarios and configurations. Therefore, supporting all those values is preferred. The reporting range of Rx-Tx time difference measurement for PDC reuse defined in positioning WI.  ***Proposal 2: If RTT-based propagation delay compensation is supported, Rx-Tx time difference is reported with granularity 2k\*Tc, all k values are supported, e.g., k is an integer satisfying 0<=k<=5.*** |

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| CATT (R1-2111251)  If RTT-based propagation delay compensation is supported, the Rx-Tx time difference is reported with granularity 2k \*Tc, where k is an integer satisfying 0<=k<=5. The value of k needs to be determined. The selection of k is a trade-off between accuracy and reporting overhead. It is preferable that the value of k can be configurable.  **Proposal 1: The value of *k* is configurable.** |

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| Intel (R1-2111492)   * Indication granularity for time difference reporting   + Reuse positioning numbers. According to analysis, there is no need for very tight granularity numbers, since the accuracy is mostly limited by the measurements. From the candidate values 0 <= k <= 5, we think a single value can be picked, if the measurement is carried by PHY/MAC layer indication, or multiple values can be configurable for RRC based indication.   **Proposal 2**   * *For RTT-based scheme,*   + *Rx-Tx time difference reporting granularity factor k is configurable from 0 to 5.*   + *The Rx-Tx time difference reporting range may be reused from positioning* |

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| Huawei (R1-2111926)  ***Observation 3:* *If RTT-based propagation delay compensation is supported, the granularity of 32 Tc for reporting Rx-Tx time difference is sufficient.***  ***Proposal 1: If RTT-based propagation delay compensation is supported, the Rx-Tx time difference is reported with granularity 2k\*Tc and k=5.*** |

**Feature lead**: Based on the contribution, some companies prefer configurable k while some other companies think that fixing it to one value is sufficient. From standard effort perspective, if fixing to one value is sufficient, it would be always good, e.g. we don't need to discuss how to signal the selected k value. Based on the inputs from companies who prefer configurable, seems the main motivation is for flexibility. If it works, at this late stage it would be recommended to fix to one value. In addition, according to the current RAN4 definition for positioning, it seems k = 5 is the one that for sure will be applied to both FR1 and FR2. Therefore, let’s make the tentative proposal to fix it to 5. If any problem identified, we can change to configurable values for sure.

#### First round discussion

Based on the inputs and analysis above, the following proposals are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals before providing your views here.

**Proposal 2.2.2.1-1: If RTT-based PDC is supported, a single granularity 32Tc (i.e. k=5) is supported for Rx-Tx measurement report.**

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### Reporting range of the Rx-Tx measurement

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| **Nokia (R1-2111141)**  From TS 38.133, there is the following gNB (and equivalently for the UE) Rx-Tx time difference measurement report mapping specified for the highest granularity (k=5):  Table 13.2.1-5: gNB Rx-Tx time difference measurement report mapping for reporting resolution of 32Tc (k=5)   |  |  |  | | --- | --- | --- | | Reported Value | Measured Quantity Value | Unit | | RX-TX\_0000 | -985024 > RX-TX | Tc | | RX-TX\_0001 | -985024  RX-TX < -984992 | Tc | | RX-TX\_0002 | -984992  RX-TX < -984960 | Tc | |  |  | … | | RX-TX\_30781 | -64  RX-TX < -32 | Tc | | RX-TX\_30782 | -32  RX-TX  0 | Tc | | RX-TX\_30783 | 0 < RX-TX  32 | Tc | | RX-TX\_30784 | 32 < RX-TX  64 | Tc | | RX-TX\_30785 | 64 < RX-TX  96 | Tc | | … | … | … | | RX-TX\_61564 | 984992 < RX-TX  985024 | Tc | | RX-TX\_61565 | 985024 < RX-TX | Tc |   From the table it can be seen that the Rx-Tx measurement range is equivalent to approximately -0.5ms to 0.5ms, and the report resolution is uniform across the range. Such reporting range is relevant for positioning because of Rx-Tx measurement reports made towards neighbour cells, where there is no timing alignment between DL and UL subframe boundaries. However, for time synchronization we should only consider measurement for the serving cell. The Rx-Tx measurements from UE and serving cell are illustrated below.    Figure 1 - Rx-Tx between UE and serving cell  In case of UE Rx-Tx measurement report (if gNB-side PD estimation is assumed), it is our understanding that values can only be positive, considering that transmissions to the serving cell are time aligned (like UE Rx-Tx time difference measurement report defined for LTE in 36.133). However, the maximum range would depend on the assumption of maximum distance to serving cell.  **Observation 2.2.4: For UE Rx-Tx report, in case gNB-side PD estimation is supported, the measurement report value range should only be positive and designed for the maximum supported distance to the serving cell.**  On the other hand, for the case that UE side PD estimation is supported, the gNB Rx-Tx measurement report from serving cell to UE can consist of negative and positive values due to potential UE transmission timing error and gNB Rx measurement error. As UL transmission timing is controlled by TA, the range of values should not be large, i.e., measured DL and UL subframe boundaries are close in time. In practice, such timing difference should not be more that the cyclic prefix length.  **Observation 2.2.5: For gNB Rx-Tx report, in case UE side PD estimation is supported, the measurement report value range can be negative and positive. A smaller range, e.g. equivalent to cyclic prefix length, should be sufficient since UL subframe transmissions received in gNB are time aligned with DL subframe.**  Nevertheless, we can only conclude that a smaller report range should be supported for PDC which helps on reducing the overhead, but we think it is out of RAN1 scope to define the exact range. As in RAN1#99 discussions from positioning it was agreed the following:   |  | | --- | | Agreement:   * *The reporting granularity for the UE/gNB timing measurements (DL RSTD, the UE Rx-Tx time difference, UL RTOA, gNB Rx-Tx time difference) is defined as , where k is a configuration parameter with a minimum value of at most 0.*   + *Note: RAN4 can determine if -1 can be a minimum value* * *RAN1 assumes that the details of the reporting granularity and ranges for the UE/gNB timing measurements (DL RTSD, the UE Rx-Tx time difference, UL RTOA, gNB Rx-Tx time difference) will be determined by RAN4, including the potential relation of the parameter k to DL PRS bandwidth.* |   Based on that, we suggest following the same approach here, i.e., that the exact range should be defined by RAN4.  **Proposal 2.2.2: RAN1 to conclude that a smaller reporting range for Rx-Tx measurement can be defined for RTT-based PDC, since only serving cell measurement is considered for PDC. The exact range should be determined by RAN4.** |

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| *CATT (R1-2111251)*  The reporting range of gNB Rx-Tx time difference, as defined in Clause 5.2.3 of TS 38.215, is defined from -985024Tc to +985024×Tc. We think there is no need to change it for PDC.  **Proposal 2: The reporting range of Rx-Tx time difference measurement defined in Rel-16 is reused for PDC.** |

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| Intel (R1-2111492)  **Proposal 2**   * *For RTT-based scheme,*   + *Rx-Tx time difference reporting granularity factor k is configurable from 0 to 5.*   + *The Rx-Tx time difference reporting range may be reused from positioning* |

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| *Huawei (R1-2111926)*  Regarding the second FFS from the above mentioned agreement, in positioning the reporting range of Rx-Tx time difference measurement is from -985024Tc to 985024Tc, i.e. from -0.5ms to +0.5ms with the resolution step of 2*k*Tc. It is expected that in PDC we can reuse this Rx-Tx time difference definition as much as possible to reduce the spec impact, so we think the reporting range of Rx-Tx time difference measurement for PDC can be the same as shown in Table 10.1.25.3.1-6 for k=5.  ***Proposal 2: If RTT-based propagation delay compensation is supported for PDC, the reporting range of Rx-Tx time difference measurement is the same as table 10.1.25.3.1-6 in TS 38.133.*** |

**Feature lead**: Most companies prefer to reuse the reporting range defined for positioning. Nokia provide some detailed analysis on both gNB Rx-Tx time difference report and UE Rx-Tx time difference report. Views from companies are needed on the proposal and observations from Nokia. If consensus cannot be achieved, I think we should leave it to RAN4, since RAN4 would be the group to determine the detailed values anyway.

#### First round discussion

Based on the inputs and analysis above, the following proposals are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals before providing your views here.

**Question 2.2.3.1-1: Do you agree that the measurement report value range should only be positive for UE Rx-Tx time difference if the propagation delay compensation is performed at the gNB side?**

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**Question 2.2.3.1-2: Do you agree that the measurement report value range can be negative and positive for gNB Rx-Tx time difference if the propagation delay compensation is performed at the UE side? If your answer is yes, do you agree that a smaller value range, e.g. equivalent to cyclic prefix length, should be sufficient?**

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**Question 2.2.3.1-3: Do you agree that we can leave the reporting range to RAN4 if we cannot achieve any consensus for the above two questions?**

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### Detection of Reference Time

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| *Ericsson (R1-2111191)* 3.1 Detection of Reference Time The reference time information (referenceTimeInfo) is provided by gNB via RRC message, where the reference time providing the time at the ending boundary of a system frame, see the quoted text in the Appendix. If *referenceTimeInfo* field is received in *DLInformationTransfer* message, *referenceSFN* field indicates the SFN of PCell. Hence the detection of the reference time depends on SSB detection in the PCell, since SSB provides SFN information.  According to 38.211, PSS, SSS and PBCH within an SS/PBCH block are QCL, while different SS/PBCH blocks cannot be assumed QCL. Thus, different SSB in the SSB burst can be transmitted from different TRP. For data communication purpose, it is only required that DL signal from different TRPs arrive at the UE within a CP for coherent detection. However, CP duration is 4.69 µs and 2.34 µs for SCS = 15 kHz and 30 kHz, respectively, see Table 5. Compared with the Uu interface time synchronization accuracy requirement (hundreds of nanoseconds), CP duration is an order of magnitude too large. This means that the timing at different TRPs cannot be assumed to be synchronized to satisfy the tight clock synchronization needs shown in Table 1. The µs -level time difference detected by SSB at different TRP can overwhelm the propagation delay estimation accuracy.   1. Reference time information reception and propagation delay compensation should be performed with reference to a single, identified, transmission point in the PCell. 2. For any UE, propagation delay should be measured from the TRP that the reference time (referenceTimeInfo) is associated with, regardless of the spatial configuration for data communication.   At physical layer specifications, TRP is not explicitly described. Instead, the TRP is indirectly identified via the SSB index(es) associated with the TRP. Consequently, it is necessary to clarify which SSB(s) the UE should use to detect SFN, so that gNB and UE know which TRP provides the reference time at the desired SFN boundary.   1. Clarify the TRP that referenceTimeInfo is associated with via its SSB index(es).   Additionally, to ensure that the measured propagation delay is for the radio path from the same TRP (e.g., TRP1) used for reference time detection, the DL RS (TRS or PRS) for time synchronization should be QCL-ed with the SSB(s) of the same TRP (e.g., TRP1). Similarly, the SRS should also have the spatial relationship to the same TRP (e.g., TRP1). This is illustrated in Figure 2. Given that the reference time (Tref) is the time at TRP1, both UEa and UEb should measure their propagation delay, Tp,a and Tp,b, from TRP1, so that the clock time at UEa and UEb can be correctly estimated as Tref + Tp,a and Tref + Tp,b, respectively. In contrast, if this is not clearly defined, then UEb may mistakenly measure propagation delay from TRP2, while Tref is the time at TRP1. Here TRP2 refers to the node that UEb uses for data communication.   1. Define spatial property of DL RS (TRS or PRS) and SRS to measure the propagation delay from the TRP that referenceTimeInfo is associated with.     **Figure 2: A UE measures propagation delay from the TRP that the reference time Tref is associated with, regardless of TRP(s) related configuration for data communication.**  Table 5. CP duration for different SCS   |  |  |  | | --- | --- | --- | | SCS | 15 kHz | 30 kHz | | OFDM symbol, duration | 66.67 µs | 33.33 µs | | Cyclic prefix Samples | 288 | 288 | | Cyclic prefix duration | **4.69 µs** | **2.34 µs** | |

**Feature lead:** The issues seems valid. However, whether any specific mechanism is needed to solve the issue is not clear yet. For example, once gNB configure the DL RS and/or UL RS for PDC measurement, then the associated QCL source (i.e. SSB) should be clear also. In this case, the assumption is that UE will detect the associated SSB to get the SFN information for the reference time information. From gNB side, gNB know the associated SSB and will use the corresponding TRP to transmit the reference time information. However, since this issue is brought up the first time, more views from other companies are needed.

#### First round discussion

Based on the inputs and analysis above, the following questions are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals/questions before providing your views here.

**Question 2.2.4.1-1: Do you agree that reference time information reception and propagation delay compensation should be performed with reference to a single, identified, transmission point in the PCell? If your answer is yes, please also provide your view on whether any additional mechanism need to be specified for it, i.e. whether the existing schemes is sufficient or not.**

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**Question 2.2.4.1-2: If your answer to question 2.2.4.1-1 is yes, do you agree to clarify the TRP that *referenceTimeInfo* is associated with via its SSB index(es)?**

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**Question 2.2.4.1-3: If your answer to question 2.2.4.1-1 is yes, do you agree to define spatial property of DL RS (TRS or PRS) and SRS to measure the propagation delay from the TRP that *referenceTimeInfo* is associated with for RTT-based PDC if supported?**

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### TRS/PRS and SRS configuration

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| *Ericsson (R1-2111191)* 3.2 TRS configuration TRS is CSI-RS for tracking. Currently TRS can be periodic or aperiodic, where the configuration of aperiodic TRS depends on that of periodic TRS. Aperiodic TRS and periodic TRS resource have the same bandwidth (with same RB location) and the aperiodic TRS being configured with qcl-Type set to 'typeA' and 'typeD', where applicable, with the periodic CSI-RS resources.  For time synchronization purpose, it is beneficial to also support semi-persistent TRS. This allows the gNB to trigger periodic TRS transmission when the TSN UE needs to perform propagation delay compensation, and disable it with DCI when the UE has finished updating the clock time. In terms of bandwidth (RB location) and qcl-Type, the semi-persistent TRS can share the same as periodic and aperiodic TRS.   1. Introduce semi-persistent TRS for propagation delay compensation.  3.3 PRS configuration Currently, for positioning purpose, the configuration parameters of PRS are sent from LMF. When used for time synchronization purpose, PRS configuration should be introduced in RRC signalling, so that the parameters are sent from the gNB to the UE. Only configuration for serving cell PRS is needed, and those of neighbor cells are not needed. Furthermore, the critical parameters are those for sequence generation and time-frequency resources are needed. These parameters include (see TS 38.211):   * For pseudo random sequence generation: *dl-PRS-SequenceID*; * For mapping to physical resources: *dl-PRSResourceSymbolOffset*, *dl-PRS-NumSymbols,* *dl-PRS-CombSizeN*, *dl-PRSCombSizeN-AndReOffset*, *dl-PRS-ResourceBandwidth*, *dl-PRS-StartPRB*, *dl-PRS-PointA*; * For mapping to slots in a downlink PRS resource set: *dl-PRS-Periodicity-and-* * *ResourceSetSlotOffset*, *dl-PRSResourceSlotOffset*, *dl-PRSResourceRepetitionFactor*, *dl-PRS-ResourceTimeGap*; * For defining the quasi co-location information of the DL PRS resource with other reference signals: dl-PRS-QCL-Info;   Regarding PRS muting, this is for coordinating a UE’s PRS reception from different cells, including non-serving cells. Thus, muting related parameters (e.g., *dl-PRS-MutingOption1*, *dl-PRS-MutingOption2*) are not needed for propagation delay compensation with the serving cell.  For QCL (Quasi Co-Location) information of PRS, the reference signal can be:   * SS/PBCH block, where the SSB index(es) is associated with the TRP of referenceTimeInfo; * TRS   In summary, an IE should be introduced to provide basic RRC parameters for configuring PRS within the PCell.   1. Introduce RRC parameters for configuring PRS within the PCell. 2. The IE for PRS configuration include parameters for sequence generation, mapping to physical resources, mapping to slots in a downlink PRS resource set, and quasi co-location information.  3.4 SRS configuration For positioning purposes, SRS configuration is according to higher layer parameter *SRS-PosResource*. For time synchronization purpose, a separate SRS configuration is needed to provide SRS configuration, for example, *SRS-SyncResource*.  If the higher layer parameter *spatialRelationInfoPos* is configured*,* the corresponding reference signal (RS) information can be those used for time synchronization:   * SS/PBCH block, where the SSB index(es) is associated with the TRP of referenceTimeInfo; * TRS * PRS  1. Introduce RRC IE for configuration SRS for time synchronization purpose. |

**Feature lead**: Views from companies are needed before making any proposal here.

#### First round discussion

Based on the inputs and analysis above, the following questions are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals/questions before providing your views here.

**Question 2.2.5.1-1: do you agree to introduce semi-persistent TRS for RTT-based PDC? If the answer is yes, you can also provide the detailed configuration for semi-persistent TRS.**

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**Question 2.2.5.1-2: do you agree to introduce new RRC IE for SRS configuration for RTT-based PDC?**

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| Feature lead | Based on the agreements we achieved in previous meetings below, my assumption is that new RRC IE will be introduced. However, if there is misunderstanding, we can clarify here again.  **Agreement**  Support the following configurations for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.   * At least one CSI-RS for tracking (TRS) configuration for Rx – Tx time difference estimation at UE side if PRS is not configured * At least one SRS configuration for Rx – Tx time difference estimation at gNB side   **Agreement**  For RTT-based PDC, only a single pair of CSI-RS for tracking (TRS)/PRS and SRS configuration, i.e. one CSI-RS for tracking (TRS)/PRS configuration for Rx – Tx time difference estimation at UE side and one SRS configuration for Rx – Tx time difference estimation at gNB side, is configured for PDC in Rel-17, if RTT-based PDC is supported. |
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**Question 2.2.5.1-3: do you agree to introduce RRC parameters for configuring PRS within the PCell for RTT-based PDC? If your answer is yes, do you agree that the IE for PRS configuration include parameters for sequence generation, mapping to physical resources, mapping to slots in a downlink PRS resource set, and quasi co-location information?**

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### How to make sure the gNB/UE measure the same RS pair

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| *ZTE (R1-2110917)*  In RAN1#106b-e, it was agreed that one CSI-RS for tracking (TRS)/PRS configuration for Rx-Tx time difference estimation at UE side and one SRS configuration for Rx-Tx time difference estimation at gNB side are configured for PDC in Rel-17 if RTT-based PDC is supported. However, if the UE and the network measure the different RS pair, it may lead to double gNB Rx-Tx time difference errors and UE Rx-Tx time difference errors in the evaluation. More details can be found in the section 5.2 below copied from our contribution [4]. Therefore, since Alt 1 for evaluation has been adopted with only one gNB Rx-Tx time difference error and UE Rx-Tx time difference error considered, measuring the same RS pair should be ensured. For example, the information that which RS pair is measured should be indicated from the network to the UE.  ***Proposal 2:*** *The network should indicate to the UE that which RS is measured such that the network and the UE can measure the same RS, if RTT-based PDC is supported. For example, the frame number for the TRS/PRS and SRS can be indicated.* |

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| *Huawei (R1-2111926)*  In RAN1#106bis-e, it was discussed about how to ensure the same pair of TRS/PRS and SRS for RTT measurement but unfortunately no consensus yet. Based on the Rx-Tx time difference definition below, TUE-RX is the UE received timing of downlink subframe #i if TRS is in DL subframe #i, and TUE-TX is the UE transmitted timing of uplink subframe #j that is closest in time to the subframe #i. So if there is also SRS transmission in subframe #(j+1), then the UE still uses the uplink timing of subframe #j rather than subframe #(j+1) to obtain the Rx-Tx time difference. The pair should be DL subframe #i and UL subframe #j. For the gNB RTT measurement it can be same as UE RTT measurement to ensure the same pair of TRS/PRS and SRS. For the A-SRS transmission in a subframe, we think the same mechanism can be used, i.e. if this subframe is closest in time to the subframe #i, then it should be used for RTT measurement.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **5.1.30 UE Rx – Tx time difference**   |  |  | | --- | --- | | **Definition** | The UE Rx – Tx time difference is defined as TUE-RX –TUE-TX  Where:  TUE-RX is the UE received timing of downlink subframe #*i* from a Transmission Point (TP) [18], defined by the first detected path in time.  TUE-TX is the UE transmit timing of uplink subframe #*j* that is closest in time to the subframe #i received from the TP.  Multiple DL PRS resources can be used to determine the start of one subframe of the first arrival path of the TP.  For frequency range 1, the reference point for TUE-RX measurement shall be the Rx antenna connector of the UE and the reference point for TUE-TX measurement shall be the Tx antenna connector of the UE. For frequency range 2, the reference point for TUE‑RX measurement shall be the Rx antenna of the UE and the reference point for TUE‑TX measurement shall be the Tx antenna of the UE. | | **Applicable for** | RRC\_CONNECTED | |   ***Observation 2: UE RTT measurement can be based on the pair of DL subframe #i and UL subframe #j that is closest in time to the subframe #j if PRS/TRS is transmitted in subframe #i and SRS is transmitted in subframe #j.*** |

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| *OPPO (R1-2111344)*  ***Observation 5: With no solution to handle inconsistent Rx-Tx time difference measurements between gNB and UE, the evaluation of RTT-based PDC should consider an additional error component as small as 89.5ns and as large as 260ns for 15kHz SCS and 130ns for 30kHz SCS.***  ***Observation 7: The RTT-based PDC evaluation shows that, for some given channel conditions,***   * ***If inconsistent RTT measurements between UE and gNB do not happen, RTT-based PDC can meet 275ns error budget for BW no smaller than 10MH and for both 15kHz and 30kHz SCS.*** * ***If inconsistent RTT measurements between UE and gNB can happen at least due to UE autonomous adjustment, RTT-based PDC can meet 275ns error budget for BW no smaller than 20MHz for both 15kHz and 30kHz SCS, conditioned on that the DL SFN timing detection is based on full-bandwidth DL-RS (e.g.,CSI-RS).*** |

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| *Intel (R1-2111492)*  From the last meetings, the following details of RTT-based scheme were identified:   * Whether / how to handle inconsistent RTT measurement in gNB and UE due to change of uplink TX timing   + It seems a baseline to assume that the change in uplink TX timing is not expected when RTT procedure is being performed   + Alternatively, gNB may request a UE to defer TX timing adjustments until RTT measurement procedure is completed |

**Feature lead**: Based on the discussion in RAN1#106bis-e meeting, it seems companies think either there is no inconsistent RTT measurement issue, or if the inconsistent exist it should be avoided by some other way, which means there is no additional error component to be added in the RTT-based PDC caused by a change in the uplink TX timing. In RAN1#106bis-e meeting, the following proposal was discussed also to address the potential inconsistent RTT measurement issue, but there is no consensus achieved.

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***For one pair of CSI-RS for tracking (TRS)/PRS and SRS configuration, UE/gNB may assume that the latest CSI-RS for tracking (TRS)/PRS and SRS transmission event is used for RTT measurement.***

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In this meeting, both ZTE and Huawei proposed some way to solve the issues. Views from companies are needed.

#### First round discussion

Based on the inputs and analysis above, the following questions are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals/questions before providing your views here.

**Question 2.2.6.1-1: Which option do you prefer to ensure the same pair of RS is used for RTT measurement for RTT-based PDC?**

* **Option 1: RTT measurement is based on the pair of DL subframe #i and UL subframe #j that is closest in time to the subframe #i if PRS/TRS is transmitted in subframe #i and SRS is transmitted in subframe #j.**
* **Option 2: Indicate to the UE the subframe number for the TRS/PRS and SRS for RTT measurement.**
* **Option 3: None of the above**

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### How to signal the Rx-Tx time difference measurement report

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| *ZTE (R1-2110917)*  In positioning, the Rx-Tx time difference measurement is reported via RRC signaling. From RAN1 persepctive, there is no issue on the reporting latency since the receiver can keep its measurement report record for a long time. In addition, the PDC is performed only when needed. Therefore, RRC signaling for Rx-Tx time difference measurement reporting is adequate if RTT-based PDC is supported.  ***Proposal 4:*** *RRC signaling for Rx-Tx time difference measurement reporting should be supported if RTT-based PDC is supported.* |

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| *Intel (R1-2111492)*  **Proposal 1**   * *For RTT-based UE side compensation, the gNB Rx-Tx time difference measurement is indicated to UE(s) using L1 group-common DCI signaling,*   + *FFS details* |

**Feature lead**: This issue was discussed in RAN1#106b-e meeting, but no any conclusion achieved. Some companies think that it should belong to RAN2 scope, while some prefer L1 signaling instead of RRC signaling.

#### First round discussion

Based on the inputs and analysis above, the following questions are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals/questions before providing your views here.

**Question 2.2.6.1-1: Which option do you prefer for Rx-Tx time difference reporting signaling?**

* **Option 1: Detailed signaling design is up to RAN2.**
* **Option 2: The Rx-Tx time difference is reported via RRC signaling.**
* **Option 3: The Rx-Tx time difference is reported via L1 group-common DCI signaling.**
* **Option 4: None of the above**

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### UE/gNB Rx – Tx time difference definition for RTT-based PDC

The current definition for UE Rx-Tx time difference and gNB Rx-Tx time difference defined in TS 38.215 for positioning is shown below.

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| 5.1.30 UE Rx – Tx time difference   |  |  | | --- | --- | | **Definition** | The UE Rx – Tx time difference is defined as TUE-RX –TUE-TX  Where:  TUE-RX is the UE received timing of downlink subframe #*i* from a Transmission Point (TP) [18], defined by the first detected path in time.  TUE-TX is the UE transmit timing of uplink subframe #*j* that is closest in time to the subframe #i received from the TP.  Multiple DL PRS resources can be used to determine the start of one subframe of the first arrival path of the TP.  For frequency range 1, the reference point for TUE-RX measurement shall be the Rx antenna connector of the UE and the reference point for TUE-TX measurement shall be the Tx antenna connector of the UE. For frequency range 2, the reference point for TUE‑RX measurement shall be the Rx antenna of the UE and the reference point for TUE‑TX measurement shall be the Tx antenna of the UE. | | **Applicable for** | RRC\_CONNECTED |   5.2.3 gNB Rx – Tx time difference   |  |  | | --- | --- | | **Definition** | The gNB Rx – Tx time difference is defined as TgNB-RX –TgNB-TX  Where:  TgNB-RX is the Transmission and Reception Point (TRP) [18] received timing of uplink subframe #*i* containing SRS associated with UE, defined by the first detected path in time.  TgNB-TX is the TRP transmit timing of downlink subframe #*j* that is closest in time to the subframe #*i* received from the UE.  Multiple SRS resources for positioning can be used to determine the start of one subframe containing SRS.  The reference point for TgNB-RX shall be:  - for type 1-C base station TS 38.104 [9]: the Rx antenna connector,  - for type 1-O or 2-O base station TS 38.104 [9]: the Rx antenna (i.e. the centre location of the radiating region of the Rx antenna),  - for type 1-H base station TS 38.104 [9]: the Rx Transceiver Array Boundary connector.  The reference point for TgNB-TX shall be:  - for type 1-C base station TS 38.104 [9]: the Tx antenna connector,  - for type 1-O or 2-O base station TS 38.104 [9]: the Tx antenna (i.e. the centre location of the radiating region of the Tx antenna),  - for type 1-H base station TS 38.104 [9]: the Tx Transceiver Array Boundary connector. | |

In RAN1#107-e meeting, Ericsson propose to reuse the current definition with updates to the DL RS and UL RS description for RTT-based PDC.

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| --- | --- | --- | --- | --- | --- | --- |
| *Ericsson (R1-2111191)*  For the RTT-based method, the relevant measurement quantities are:   1. UE Rx – Tx time difference 2. gNB Rx – Tx time difference   Depending on the entity that performs the propagation delay compensation, either (a) or (b) is reported. For example, if UE is the entity that performs the compensation, then gNB measures Rx – Tx time difference and sends the measurement to the UE.  Both (a) and (b) have been carefully defined in 38.215 for the purpose of positioning, see below. For the time synchronization purpose, the definitions can be reused as is, except that the reference signals should be updated to include those for time synchronization also. Specifically, the yellow highlight sentence for UE Rx – Tx time difference need to be updated to include TRS, and the yellow highlight sentence for gNB Rx – Tx time difference need to be updated to include SRS for propagation delay compensation.  In terms of the reference point for measurements, the existing definition should be used, e.g., Rx antenna connector, Tx antenna connector. The reference point cannot be baseband. For example, in the latest RAN4 discussion of reference point for Te, it was agreed to include ‘antenna’ in the Te definition (see R4-2115371).   1. Existing definitions of UE Rx – Tx time difference and gNB Rx – Tx time difference are reused with updates to the DL RS and UL RS description.   TS 38.215 V16.4.0:   |  |  | | --- | --- | | **Definition** | The UE Rx – Tx time difference is defined as TUE-RX –TUE-TX  Where:  TUE-RX is the UE received timing of downlink subframe #*i* from a Transmission Point (TP) [18], defined by the first detected path in time.  TUE-TX is the UE transmit timing of uplink subframe #*j* that is closest in time to the subframe #i received from the TP.  Multiple DL PRS resources can be used to determine the start of one subframe of the first arrival path of the TP.  For frequency range 1, the reference point for TUE-RX measurement shall be the Rx antenna connector of the UE and the reference point for TUE-TX measurement shall be the Tx antenna connector of the UE. For frequency range 2, the reference point for TUE‑RX measurement shall be the Rx antenna of the UE and the reference point for TUE‑TX measurement shall be the Tx antenna of the UE. | | **Applicable for** | RRC\_CONNECTED |  |  |  | | --- | --- | | **Definition** | The gNB Rx – Tx time difference is defined as TgNB-RX –TgNB-TX  Where:  TgNB-RX is the Transmission and Reception Point (TRP) [18] received timing of uplink subframe #*i* containing SRS associated with UE, defined by the first detected path in time.  TgNB-TX is the TRP transmit timing of downlink subframe #*j* that is closest in time to the subframe #*i* received from the UE.  Multiple SRS resources for positioning can be used to determine the start of one subframe containing SRS.  The reference point for TgNB-RX shall be:  - for type 1-C base station TS 38.104 [9]: the Rx antenna connector,  - for type 1-O or 2-O base station TS 38.104 [9]: the Rx antenna (i.e. the centre location of the radiating region of the Rx antenna),  - for type 1-H base station TS 38.104 [9]: the Rx Transceiver Array Boundary connector.  The reference point for TgNB-TX shall be:  - for type 1-C base station TS 38.104 [9]: the Tx antenna connector,  - for type 1-O or 2-O base station TS 38.104 [9]: the Tx antenna (i.e. the centre location of the radiating region of the Tx antenna),  - for type 1-H base station TS 38.104 [9]: the Tx Transceiver Array Boundary connector. | |

**Feature lead**: In RAN1#106bis-e meeting, this issue was discussed but with no consensus. Some companies commented that how to update the spec can be done later based on the agreed mechanism. Some other companies felt pre-mature to discuss now since it depends on the discussion on other aspects. Therefore, it is recommended not to discuss this issue for now. Once we get other issues done, we can see if any good time to discuss it.

## Implicit propagation delay compensation

OPPO (R1- 2111344) proposes an implicit PDC method as below

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| OPPO (R1- 2111344)  For implicit PDC, the principle of propagation delay compensation is given in Figure 2.  propagation_delay_estimation.gif  Figure Implicit PDC  In Figure 2, the gNB clock (*clkBS(t)*) and UE clock (*clkUE(t)*) at the same moment of *t*, after UE reception of the UE-specific RRC in figure (corresponding to k=1) or a follow-up SIB9 ReferenceTimeInfo (corresponding to k=2,3…), satisfy , assuming the DL PD equals to UL PD which is also the assumption in one-way propagation delay estimation in explicit PDC. This means the UE can estimate as  (3)  Note that , i.e., the clock difference between gNB and UE, is exactly what we defined in our earlier contributions[2] [3]. The corresponding clock sync error for implicit PDC is given by  (4)  where is the quantization error in carrying and .   * and are the SFN timing measurement errors for and , respectively, i.e., the same as for explicit PDC. * and are timing measurement errors for and , respectively, associated with the SRS transmission. * is the quantization error in RRC signaling carrying and .   The comparison between in (2) and in (4) shows:   * The accuracy of explicit PDC relates to errors of six timing measurements, including two measurements giving and , and four timing measurements in deriving PD; while the accuracy of implicit PDC relates to errors of four timing measurements, including , , and . * The errors associated with and have coefficients of 1 for explicit PDC and coefficient of ½ for implicit PDC.   We further have  where the inequality of “>0” comes from the fact that the one-way propagation delay estimation on PD would use the timing measurements whose errors correspond to and (Remember PD takes the same time reference as the local clock in both Figure 1 and Figure 2, and the and are associated with UL-SRS in Figure 2 --- the same type of UL-RS that could be used in PD estimation in Figure 1). In general, can be lower-bounded by , we can have  (5)  where is the total DL Tx/Rx timing error associated with the DL transmission (e.g., SIB9) that helps UE to determine the SFN timing, and is the total DL Tx/Rx timing error associated with the DL transmission used in one-way delay estimation.  ***Observation 2: The synchronization error of implicit PDC on Uu-interface can be evaluated as***  ***This error is smaller than that of explicit PDC, if the same assumptions are made between the two methods for the following timing error components***   * ***UL Tx/Rx timing errors associated with SRS transmission; and*** * ***DL Tx/Rx timing errors associated with DL transmission containing ReferenceTimeInfo IE; and*** * ***time granularity in ReferenceTimeInfo IE.***  2.4 Evaluation of implicit PDC The evaluation for implicit PDC based on equation (4) is given in Table 4, where the most generous upper-bound of is applied to BW≥5MHz for both SCS=15kHz and SCS=30kHz. For BW=5MHz and SCS=15kHz, additional assumption of SFN boundary timing detection based on DL-RS also allows more accurate timing evaluation, as noted as “Evaluation method 2” and “Evaluation method 3” in Table 4.  Table 4 Evaluation of implicit PDC   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | SCS | BW | Errors with SFN timing (ns) | | Errors with UL SRS transmission (ns) | | Quantization error in signaling | Total sync error (ns)  (against 280ns budget) | |  |  |  |  |  | | 15kHz | 5MHz (25RB, Evaluation method 1) | 32.5 |  | | 50 | ≤ 2.2 | ≤280 | | 5MHz (25RB, Evaluation method 2, SIB9 along w/ DL-RS) | 32.5 |  | |  | 5 |  | | 5MHz (25RB, Evaluation method 3, SIB9 along w/ DL-RS) | 32.5 | = | | = | 5 |  | | ≥10MHz (52RB) | 32.5 |  | |  | 5 |  | | 30kHz | Any BW≥5MHz | 32.5 |  | | 50 | 5 | ≤217.7 | |

**Feature lead:** This implicit PDC was discussed a lot in RAN1#106b-e meeting but still no consensus yet. The situation is that almost all companies don’t want to continue the discussion and want to have the conclusion that “There is no consensus to support/specify implicit PDC in Rel-17” based on the discussion in RAN1#106b-e. This is the last meeting of Rel-17, from moderator perspective, I don’t have any good idea on how to move forward, and especially the implicit PDC itself is actually RAN2 mechanism and RAN1 is not able to judge whether it is feasible or not.

### First round discussion

Based on the inputs and analysis above, the following questions are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals before providing your views here.

**Question 4.4-1: Do you think we need to continue the discussion of implicit PDC? Please provide your reasons also.**

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| --- | --- |
| *Company* | *View* |
|  |  |
|  |  |

**Question 4.4-2: Do you have any further comment/question/views on implicit PDC based on the previous discussions and the latest contribution from OPPO?**

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| --- | --- |
| *Company* | *View* |
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**Question 4.4-3: Do you have any good idea on how to handle implicit PD?**

|  |  |
| --- | --- |
| *Company* | *View* |
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## Way forward on PDC in RAN1 for Rel-17

Companies show views about how to move forward on PDC in RAN1 for Rel-17

|  |
| --- |
| Nokia (R1-2111141)  As seen from the analyses, either RTT or TA-based PDC can satisfy the synchronicity budget for the control-to-control use case under certain conditions. So, a decision on which method should be specified for covering the strictest use case should take into account other factors, such as, overhead of the method, power limitation, complexity, specification effort, etc.  In our view, enhanced TA procedure has no advantage compared to RTT based PDC considering that a dedicated reference signal and also a dedicated indicator is needed for the enhanced TA method. Additionally, as can be seen from the analyses, RTT can achieve a higher accuracy with same or lower reference signal bandwidth than enhanced TA. This can be translated to a lower ‘sounding’ overhead for RTT method, and a better multiplexing capability when providing service to multiple UEs within the coverage area. Lower power limitation constraint is also a plus for RTT method, given that lower bandwidth reference signals can be used, so it is more likely that cell edge UEs have sufficient power budget when transmitting the UL reference signal.  At the same time, an enhanced TA based PDC will require more specification effort as there are not yet available accuracy requirements for a reduced Te, and a separate TA signalling need to be introduced only for the sake of PDC in a way that it does not affect the normal transmit timing procedure and requirements. While for RTT there is Rx-Tx specification from positioning that just need to be extended for PDC, i.e., including the support for the reference signals for PDC and Rx-Tx report.  **Observation 2.3.1: Between enhanced TA and RTT based PDC, the latter has better accuracy, lowest overhead, better coverage and is less complex to specify by reusing definitions from positioning specifications.**  For covering the less strict time synchronization use cases, legacy TA based PDC is obviously the simplest method. It does not require any additional measurement procedure or any complex capability in UE side, as every UE should already be able to obtain TA and, from that, determining propagation delay is straightforward. It also has no additional overhead, as it does not require any additional reference signal and report exchange. Moreover, it only requires RAN2 specification effort to enable/disable legacy TA based PDC.  **Observation 2.3.2: Legacy TA based PDC reuses existing capability of UEs, has no overhead, has the lowest specification effort, and is sufficient to satisfy the synchronicity budget of less strict use cases as concluded in RAN1. Not supporting Legacy TA based PDC should be carefully justified.**  **Proposal 2.3.1: RAN1 to support Legacy TA-based PDC to cover the less strict use cases with the zero overhead and support RTT-based PDC method for covering the strictest time synchronization use cases.** |

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| LGE (R1- 2112055)  Observation #1: Based on reply LS from RAN4, discuss to support either RTT-based PDC or TA-based PDC for minimal specification effort in RAN1#107-e. |

|  |
| --- |
| Qualcomm (R1-2112212)  ***Proposal 1: TA*** ***based propagation delay compensation is not considered for enhancement for propagation delay compensation.***  ***Proposal 2: RTT based propagation delay compensation (option 2) is good candidate for propagation delay compensation.*** |

**Feature lead**: As expected, we need to make decision on what enhanced PDC method to support in this meeting. For TA-based PDC, there is no consensus in RAN4 on the reduced Te value unfortunately. I don’t expect that RAN1 can conclude on the reduced Te too. Without the reduced Te, I expect that it would be very difficult to agree the support of TA-based PDC. For implicit PDC, based on the previous discussions, it seems no way to agree on it either. From moderator perspective, it seems RTT-based PDC is the one that we may be able to go. Hopefully companies can be flexible and constructive, considering that this is the last meeting in Rel-17.

Some initial comparison between TA-based PDC and RTT-based PDC are summarized as below also.

* ***Support Legacy TA-based PDC to cover the less strict use cases*** 
  + *Nokia, NSB*
  + ***Reasons***
    - ***Worst performance*** 
      * *Can only meet the synchronization budget of less strict use cases*
    - ***Least specification effort***
      * *does not require any additional measurement procedure*
      * *only requires RAN2 specification effort to enable/disable legacy TA based PDC*
    - ***Least additional signaling/RS overhead***
      * *No additional overhead*
    - ***Least UE complexity*** 
      * *does not require any complex capability in UE side, as every UE should already be able to obtain TA*
* ***Support RTT-based PDC*** 
  + *Nokia, NSB, Ericsson*
  + ***Reasons***
    - ***Best performance***
      * *Higher accuracy with the same or lower reference signal bandwidth compared to TA-based PDC*
      * *Better multiplexing capability when providing service to multiple UEs*
      * *Lower power limitation constraint due to lower bandwidth reference signals*
    - ***Lower Signaling/RS overhead compared to enhanced TA-based PDC***
      * *Less RS overhead required to achieve similar performance*
    - ***Comparable specification effort compared to TA-based PDC*** 
      * *Require additional measurement procedure for Rx-Tx time difference*
      * *Define signalling for reporting Rx-Tx time difference*
      * *Define a dedicated reference signal for RTT measurement*
    - ***More complexity compared to legacy TA-based PDC***
* ***Support enhanced TA-based PDC*** 
  + *ZTE,*
  + ***Reasons***
    - ***Medium Performance***
      * *Lower accuracy with the same or lower reference signal bandwidth compared to TA-based PDC*
      * *Higher accuracy than the legacy TA-based PDC*
    - ***Higher Signaling/RS overhead compared to RTT-based PDC***
      * *Higher RS overhead expected*
    - ***Comparable specification effort compared to RTT-based PDC*** 
      * *Define accuracy requirements for a reduced Te in RAN4*
      * *Define a separate TA signalling for PDC*
      * *Define a dedicated reference signal for enhanced Te*
    - ***More complexity compared to legacy TA-based PDC***

### First round discussion

Based on the inputs and analysis above, the following proposals are made for further discussion. Please all companies check the discussion/analysis above to understand the reason to make these proposals before providing your views here.

**Proposal 2.4.1-1:For Rel-17 PDC,**

* **Support legacy TA-based PDC for at least the less strict time sync use cases, e.g. smart grid scenario**
* **Support RTT-based PDC method for at least the strictest time synchronization use cases, e.g. control-to-control scenario**

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| *Company* | *View* |
| Feature lead | Based on the current situation, it seems the proposal above is the potential compromised way we can do. Note that for legacy TA-based PDC, there might be no RAN1 impact, but there should be some RAN2 impact, e.g. *enable/disable legacy TA based PDC at the UE side* |
|  |  |
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# References

1. RP-201310, *Revised WID: Enhanced Industrial Internet of Things (IoT) and ultra-reliable and low latency communication (URLLC) support for NR* , Nokia, Nokia Shanghai Bell
2. R1-2100024 Reply LS on propagation delay compensation enhancements
3. R1-2110917 Discussion on propagation delay compensation enhancements ZTE
4. R1-2111008 Remaining issues on propagation delay compensation enhancements vivo
5. R1-2111141 Discussion on enhancements for PDC and CSI Nokia, Nokia Shanghai Bell
6. R1-2111191 Propagation Delay Compensation Enhancements for Time Synchronization Ericsson
7. R1-2111251 Discussion on propagation delay compensation enhancements CATT
8. R1-2111344 Enhancement for support of time synchronization OPPO
9. R1-2111492 Remaining open issues for propagation delay compensation Intel Corporation
10. R1-2111733 Discussion for propagation delay compensation enhancements Samsung
11. R1-2111926 Enhancements for support of time synchronization Huawei, HiSilicon
12. R1-2112055 Discussion on propagation delay compensation enhancements LG Electronics
13. R1-2112212 Enhancements for support of time synchronization for enhanced IIoT and URLLC Qualcomm Incorporated
14. 3GPP RAN1#105-e, R1-2104171, Reply LS on UE transmit timing error

# Appendix Agreements in the past meetings

**RAN1#102-e**

Agreements:

* Take the following use cases as the representative use cases for further study on propagation delay compensation enhancements in Rel-17.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **User-specific clock synchronicity accuracy level** | **Number of devices in one Communication group for clock synchronisation** | **5GS synchronicity budget requirement**  **(note)** | **Service area** | **Scenario** |
| 2 | Up to 300 UEs | ≤900 ns | ≤ 1000 m x 100 m | * Control-to-control communication for industrial controller |
| 4 | Up to 100 UEs | <1  µs | < 20 km2 | * Smart Grid: synchronicity between PMUs |

Agreements:

* 8\*64\*Tc/2 as the TA indicating error is assumed in the evaluation.

Agreements:

For 5GS synchronicity budget requirement,

* One Uu interface is assumed for smart grid.
* Two Uu interfaces are assumed for control-to-control.

Agreements:

For BS transmit timing error, further study the following three options:

* **Option 1**:65 ns
* **Option 2**:±130ns for the indoor scenario and ±200ns for the smart grid scenario
* **Option 3**:82.5 ns

Agreements:

The value defined in Table 7.1.2-1 for initial transmit timing error (Te) in TS 38.133 should be considered for evaluation of the time synchronization.

Agreements:

Asymmetry between downlink and uplink channel for control-to-control scenario is not considered.

Agreements:

100 ns is assumed for BS detecting error.

Agreements:

Timing advance adjustment accuracy defined in Table 7.3.2.2-1 in TS 38.133 is assumed for evaluation of the time synchronization.

Agreements:

Both 15 kHz and 30 kHz are assumed for both control-to-control and smart grid for evaluation of the time synchronization.

Agreements:

Send an LS to RAN2 with the content including

* Inform RAN2 the two representative use cases concluded in RAN1 for further study;
* Ask RAN2 for input about Uu interface error budget for each of the two use cases;

Agreements:

The following options for propagation delay compensation are further studied in RAN1

* **Option 1**: TA-based propagation delay
  + **Option 1a**: Propagation delay estimation based on legacy Timing advance (potentially with enhanced TA indication granularity).
  + **Option 1b**: Propagation delay estimation based on timing advanced enhanced for time synchronization (as 1a but with updated RAN4 requirements to TA adjustment error and Te)
  + **Option 1c:** Propagation delay estimation based on a new dedicated signaling with finer delay compensation granularity (Separated signaling from TA so that TA procedure is not affected)
* **Option 2**: RTT based delay compensation:
  + Propagation delay estimation based on an RAN managed Rx-Tx procedure intended for time synchronization (FFS to expand or separate procedure/signaling to positioning).

Draft LS R1-2007445 is approved, with final LS in R1-2007446.

**RAN1#103-e**

Agreements:

* Take 65 ns as the assumption of transmit timing error for evaluation of the overall time synchronization error for control-to-control.
* Asymmetry between downlink and uplink channel for smart grid scenario is not considered.
* ~~TA adjustment accuracy is not considered for the evaluation of time synchronization error.~~
* *errorBS,DL,TX* is included in the equation for calculating the overall time synchronization error.

Agreements:

TA adjustment accuracy is not considered for the evaluation of time synchronization error.

Agreements:

For evaluation of the overall time synchronization error for smart grid, companies can take one of the following two options as the assumption for BS transmit timing error:

* Option 1: 200 ns
* Option 2: 65 ns

**RAN1#104-e**

Agreements:Take ±100 ns as the assumption for downlink frame timing detection error (errorUE,DL,RX) at the UE for evaluation of the overall time synchronization error for TA based propagation delay compensation, if downlink frame timing detection error needs to be considered separately.

* Send a LS to RAN4 to ask for clarification on whether downlink frame timing detection error is included in Te or not
  + In the LS, to include more details about option 1 (included) & option 2 (not included); also including the necessary background
* FFS whether to apply the same value to RTT-based propagation delay compensation, and the corresponding condition (if any) if the same value will be applied

**Decision:** As per email posted on feb 5th, the draft LS is endorsed. Final LS is approved in [R1-2102245](file:///C:\Users\c00387628\AppData\Local\Temp\Docs\R1-2102245.zip).

**RAN1#104b-e**

Agreements:If downlink frame timing detection error needs to be considered separately from propagation delay estimation error, take ±100 ns as the assumption for downlink frame timing detection error (errorUE,DL,RX) at the UE for evaluation of the overall time synchronization error for RTT based propagation delay compensation

Agreements: Take the following equation for evaluation of the DL propagation delay estimation error for TA based propagation delay compensation:



* Either option 1 or option 2 below will be applied based on the RAN4 reply to RAN1 LS [R1-2102245](file:///C:\Users\c00387628\AppData\Local\Temp\Docs\R1-2102245.zip).



* FFS whether *errorBS,DL,TX* in the above equation should be included or not.

Agreements:

* Observation 1: Propagation delay compensation based on existing Rel-15/Rel-16 TA procedure and associated granularity, with no enhancements in RAN1, is sufficient for meeting the Uu interface synchronicity error budget in LS R2-2010837 for the smart grid scenario.
* Observation 2: RAN1 needs to further study and specify the feasible enhancement (if any with RAN1 spec impact) for propagation delay compensation for control-to-control scenario, in order to meet the synchronicity budget of Uu interface in LS R2-2010837.

Working assumption:



Agreement:

Take the following as the evaluation assumptions for both RTT-based PDC and TA-based PDC.

* The UE may acquire an up-to-date PD estimation after waking up from DRX. This implies that gNB may signal an update timing advance value or complete a Rx-Tx measurement procedure.
* *errorUE,DL,RX* is based on other signals (e.g. CSI-RS) instead of SSB.
* *errorBS, UL,RX* iss based on other uplink signals instead of contention based PRACH, e.g. SRS.
* Further study and specify new procedure/signaling (if necessary) to ensure that the PD estimation can be acquired after DRX for the adopted PDC method.

Agreement:

Existing DL reference signal(s) are used for Rx – Tx time difference estimation at UE side for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.

* FFS whether PRS can be used for UE Rx – Tx time difference estimation or not
* FFS which DL reference signal(s) to be used if/when PRS is not used

**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.

**RAN1#106-e**

**Agreement**

SRS can be used for Rx – Tx time difference estimation at gNB side for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.

**Agreement**

Send LS to RAN4 to ask for feedback on the following questions:

* **Question 1**: Is it feasible to support a smaller value than the current Te for the use of propagation delay compensation, assuming the existing conditions in TS 38.133 for Te requirement? If not, is it feasible under new conditions (e.g. using TRS instead of SSB)? If the answer is yes, please also provide feedback on how much it can be reduced at most.
* **Question 2**: Is it feasible to introduce enhanced TA command indication granularity? If the answer is yes, please also provide feedback on how much it can be reduced at most (e.g. reduced to (1/16)\* (16\*64\*Tc/2)) similar as the granularity for Rel-16 IAB based on the Timing Delta MAC CE and related condition.
* Note 1: The alternatives in the working assumption achieved in RAN1#104bis-e together with the examples in Table 4.2-2 will be included in the LS to give some background for RAN4
* Note 2: The agreement “both SCS 15 kHz and 30 kHz are assumed for both control-to-control and smart grid for evaluation of the time synchronization” achieved in RAN1#102-e will be included in the LS for RAN4 information also.
* Note 3: Inform RAN4 that the enhancements on Te and TA command indication granularity for propagation delay compensation may or may not have impact on normal TA related procedure, depending on which candidate option for TA-based PDC is adopted. Note that this is just for RAN4 information.
* Note 4: Whether RAN1 will introduce specification enhancements is still undetermined.

**Agreement**

If RTT-based propagation delay compensation is supported,

* CSI-RS for tracking (TRS) can be used for Rx – Tx time difference estimation at UE side, if PRS is not configured for the UE.
* PRS can be used for Rx – Tx time difference estimation at UE side, if PRS is configured for the UE.

**Agreement**

Send LS to RAN4 to ask for defining the following for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.

* UE Rx-Tx time difference measurement accuracy *errorUE,RxTxDiff* based on CSI-RS for tracking
* gNB Rx-Tx time difference absolute accuracy *errorUE,RxTxDiff* based on SRS

**R1-2108513** Feature lead summary on propagation delay compensation enhancements Moderator (Huawei)

**Agreement**

Support the following configurations for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.

* At least one CSI-RS for tracking (TRS) configuration for Rx – Tx time difference estimation at UE side if PRS is not configured
* At least one SRS configuration for Rx – Tx time difference estimation at gNB side

**Agreement**

If RTT-based propagation delay compensation is supported and performed at the UE side, the Rx-Tx measurement report provided from the gNB to the UE should include at least:

* gNB Rx-Tx time difference at a given granularity
* FFS whether to include SRS-Resource-ID

**Agreement**

Take the following two alternatives as the equation for evaluation of the overall time synchronization error for RTT-based propagation delay compensation. RAN1 to select one of the alternatives in RAN1#106bis-e.

* **Alt. 1:**



* + is to reflect the error due to indication granularity of Rx-Tx time difference
  + and reflects the measurement inaccuracy of gNB Rx-Tx time difference, and the measurement inaccuracy of UE Rx-Tx time difference, respectively.
  + Note: The equation may be updated after clarification on the gNB TX-RX timing difference and UE TX-RX timing difference
* **Alt. 2:**



* + is to reflect the error due to indication granularity of Rx-Tx time difference
  + Note: Alt.2 assumes that gNB can coordinate the time of TA procedure and the time of PD compensation, so that the DL frame timing error and BS transmit timing error for propagation delay estimation is correlated to (e.g. the same as) that for the transmission of RRC signaling carrying the reference time clock

Note: FFS whether / how to handle inconsistent RTT measurement in gNB and UE due a change of uplink TX timing

**R1-2108618 Draft LS on TA-based propagation delay compensation Moderator (Huawei)**

**Decision:** The draft LS is endorsed with the following note

* Note: It’s pending further discussion in RAN1 whether the WA is to be confirmed including which alternative is to be selected

Final LS is approved in R1-2108635.

**RAN1#106bis-e**

Agreement

For evaluation of the overall time synchronization error for RTT-based propagation delay compensation,

* Alt.1 for RTT-based PDC

Agreement

For evaluation of the overall time synchronization error for TA-based propagation delay compensation,

* Alt.1 for TA-based PDC

Agreement

For evaluation of the overall time synchronization error for RTT-based propagation delay compensation with Alt.1, it is assumed that

* The UE Rx-Tx time difference measurement accuracy based on PRS defined in Table 10.1.25.2-2 in TS 38.133 v17.3.0 is taken as the reference for the UE Rx-Tx time difference measurement accuracy
* The gNB Rx-Tx time difference accuracy based on SRS for positioning defined in Table 13.2.2.2-1 in TS 38.133 v17.3.0 is taken as the reference for the gNB Rx-Tx time difference accuracy based on SRS for PDC

Agreement

For RTT-based PDC, only a single pair of CSI-RS for tracking (TRS)/PRS and SRS configuration, i.e. one CSI-RS for tracking (TRS)/PRS configuration for Rx – Tx time difference estimation at UE side and one SRS configuration for Rx – Tx time difference estimation at gNB side, is configured for PDC in Rel-17, if RTT-based PDC is supported.

Agreement

If RTT-based propagation delay compensation is supported and performed at the gNB side, the Rx-Tx measurement report provided from the UE to the gNB should include at least:

* UE Rx-Tx time difference at a given granularity

Conclusion

When evaluating enhanced TA-based PDC, there is no need to replace Te by TA adjustment error.

Agreement

Send an LS to RAN2 and CC RAN4 with the content including:

* The latest available status on PDC methods in RAN1, e.g. key agreements achieved for TA-based PDC and RTT-based PDC.

[**R1-2110594**](file:///C:\Users\L00367611\AppData\Local\Temp\Docs\R1-2110594.zip) **Draft LS on propagation delay compensation Huawei**

**Decision:** The draft LS is endorsed. Final version is approved in [R1-2110647](file:///C:\Users\L00367611\AppData\Local\Temp\Docs\R1-2110647.zip).

Agreement

For evaluation and comparison of enhanced TA-based PDC and RTT-based PDC, the timing detection error = 0.5/(RS BW) = 0.5/(N\_PRB\*12\*SCS) can be used to achieve and , if needed in the evaluation equation separately, where N\_PRB is the number of PRBs of the RS bandwidth used in the detection by UE and gNB, respectively.

* Note: Detection error achieved by evaluations is not precluded if available.

Agreement

If enhanced TA-based PDC with reduced Te based on TRS is supported in Rel-17, one CSI-RS for tracking (TRS) configuration is configured for enhanced TA-based PDC.

* FFS whether/how to configure UL signal for enhanced TA-based PDC

Agreement

If enhanced TA-based PDC with enhanced TA command indication granularity is supported in Rel-17,

* The enhanced TA command indication granularity introduced for enhanced PDC is applied for PDC purpose, which doesn’t have impact on normal TA procedure, i.e. normal TA procedure will still follow the existing TA command indication granularity.

Agreement

If RTT-based propagation delay compensation is supported, the Rx-Tx time difference is reported with granularity *2k\*Tc*, where *k* is an integer satisfying 0<=*k*<=5.

* FFS the value of *k*
* FFS the reporting range of Rx-Tx time difference measurement for PDC