**3GPP TSG RAN WG1 Meeting #103-e R1-xxxxxxx**

**E-meeting, October 26 - November 13, 2020**

**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:

|  |
| --- |
| 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 [2][3][4][5][6][7][8][9][10][11][12], and aims to discuss a set of issues in RAN1#103-e. Note that since the reply LS from RAN2 is not available yet, we may be only able to discuss the issues that don’t need any input from RAN2.

# Remaining issues on error components

There are several aspects which have impact on the timing accuracy between UE and gNB. In RAN1#102-e, we discussed the potential error components that would have impact on the time accuracy one by one, and achieved agreements on most of the error components as shown in the Appendix. The following sections summarize the discussion for the remaining error components.

## BS transmit timing error

In RAN1#102e it has been agreed to consider three options on how to represent the BS transmit timing error, which can represent the downlink transmit frame timing error. For example, it can be used to capture the timing error between the SFN timestamp in *referenceTimeInfo* which is captured at the gNB-DU [38.470 section 5.2.2] and the frame timing at the air interface.

|  |
| --- |
| 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
 |

Time Alignment Error (TAE) is defined in TS38.104 as a requirement for the base station. This requirement applies to the frame timing in TX diversity, MIMO transmission, carrier aggregation and their combinations. And this requirement is defined due to the frames of the NR signals present at the BS transmitter antenna connectors or TAB connectors are not perfectly aligned in time, and the RF signals present at the BS transmitter antenna connectors or transceiver array boundary may experience certain timing differences in relation to each other. In a sense, the inaccurate frame timing of BS is caused by the misalignment of the BS transmitter timing in different antenna connectors or transceiver array boundary in different transmitting occasions. So the frame timing accuracy can be seen as same as the TAE.

|  |
| --- |
| 6.5.3.2 Minimum requirement for *BS type 1-C* and *BS type* 1-HFor MIMO transmission, at each carrier frequency, TAE shall not exceed 65 ns.For *intra-band contiguous carrier aggregation*, with or without MIMO, TAE shall not exceed 260ns.For *intra-band non-contiguous carrier aggregation*, with or without MIMO, TAE shall not exceed 3µs.For inter-band *carrier aggregation*, with or without MIMO, TAE shall not exceed 3µs.The time alignment error requirements for NB-IoT are specified in TS 36.104 [13] clause 6.5.3. |

Nokia (R1-2008844) described that TAE can apply between two radio equipment or radio units, and the TAE timing requirement would have to be translated to apply for a single gNB transmit chain.

Based on the contribution, it seems the views are still diverse and we need to further discuss which option below to use for different scenarios:

* **Option 1**:65 ns
	+ ***Support:*** *Vivo, CATT, ZTE, Huawei/HiSilicon*
* **Option 2**: ±130ns for the indoor scenario and ±200ns for the smart grid scenario
* **Option 3**: 82.5 ns
	+ ***Support:*** *Ericsson,*
* **Option 4**: 32.5ns for control-to-control, somewhere between 100ns and 200ns for smart grid
	+ ***Support:*** *Nokia,*
	+ ***Reasons***
		- ***Control to control****: When the TAE requirement applies between antenna-ports connected to different radio equipment entities, TAE is the relative error between them by including the relative error introduced by the fronthaul network (to the last common reference).* *TAE of <65ns should apply for the control-to-control use case and as this can apply between two radio equipment entities connected to the same gNB-DU, this requirement is divided equally for each radio equipment entity, i.e. 65ns/2=32.5ns can be used to represent the SFN timestamp to radio equipment entity air interface timing.*
		- ***Smart grid****: No TAE requirement is applicable to represent the BS frame transmit timing error, instead we have to rely on estimations of the BS frame transmit timing error. GNSS receiver is located at a gNB-DU, which introduces a relative error at the gNB-DU which is captured by RAN2. Leave room to support longer distanced between a gNB-DU and the deployed radio equipment entities, so we propose to assume a BS transmit frame timing error between ±100ns and ±200ns.*
* **Option 5**: 70ns

**Question 2.1-1: Which option should we use for BS transmit timing error for control-to-control? Please provide your reason also.**

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

**Question 2.1-2: Which option should we use for BS transmit timing error for smart grid? Please provide your reason also.**

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

It seems the indicating error would be associated to the indicating granularity of $T^{BS}$. According to what agreed in RAN2 in Rel-16, the granularity is 10 ns here, so the error is +/-5ns. But this has already been considered in network budget based on RAN2 email discussion.

## Error related to DL propagation delay estimation

UE decides the downlink propagation delay according to the TA value obtained from TA command sent by gNB. According to the current TA mechanism, the TA command delivery is realized by implementation. Since the TA command delivery belongs to the behavior which gNB has ability to control, it is assumed that gNB can deliver the TA command in time at least to the UEs which have requirement of high accuracy time synchronization.

### Asymmetry between downlink and uplink channel

UE estimates the downlink propagation delay as half of the TA value obtained from gNB, which introduces error due to the asymmetry between downlink and uplink propagation delay. **In TDD system**, the downlink and uplink channel fading can be seen strongly correlated with each other while the time gap between them is short enough. And **the asymmetry between downlink and uplink propagation delay is mainly due to the change of small scale fading**. **In FDD system**, the situation is a little worse since the downlink and uplink signal are transmitted at different carrier frequencies. In general, devices in factory or electric system have low mobility, so it can be assumed that the downlink and uplink channel with time gap of dozens of milliseconds have the same large scale fading. Then **the asymmetry is mainly caused by the change of multi-path distribution**.

In last meeting, it was agreed to not consider asymmetry for control-to-control scenario as below, while it is still open for smart grid scenario.

|  |
| --- |
| RAN1#102-E Agreements:Asymmetry between downlink and uplink channel for control-to-control scenario is not considered.   |

Based on the views in the contributions for this meeting, the following options are proposed by companies:

* **Option 1:** 160ns
* **Option 2:** 0ns, i.e. do not consider this error for smart-grid scenario
	+ ***Support:*** *Nokia,*
	+ ***Reasons***
		- *Will not be easily possible to put this as a separate error source because this is also accounted for in the UE reception timing estimation error as well as the gNB UL reception timing estimation error, which is largely impacted by actual channel fading*

So it needs to decide whether to consider this for smart grid scenario.

**Question 2.2.1: Do we need to consider asymmetry between downlink and uplink channel for smart-grid scenario? If yes, what value should we assume?**

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

### TA adjustment accuracy

TA adjustment accuracy is also one aspect to consider and the values defined in TS 38.133 was agreed for evaluation in last meeting.

|  |
| --- |
|  RAN1#102-E 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.  |

Nokia (R1-2008844) raised a question whether the initial transmission error (Te) and the timing advance adjustment error can be used simultaneously?

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *Nokia R1-2008844*In [1] it was discussed whether TA adjustment error (sometimes denoted TA-err or TA-adj) and the UE initial timing error (Te) should both be considered. It is agreed to apply both Te and TA-err in the analysis, but it should be clarified if such case where both should be includes exists. Below is a copy of the text related to both Te and TA-err from 38.133.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 7.1.2 RequirementsThe UE initial transmission timing error shall be less than or equal to Te where the timing error limit value Te is specified in Table 7.1.2-1. This requirement applies:- when it is the first transmission in a DRX cycle for PUCCH, PUSCH and SRS or it is the PRACH transmission.The UE shall meet the Te requirement for an initial transmission provided that at least one SSB is available at the UE during the last 160 ms. The reference point for the UE initial transmit timing control requirement shall be the downlink timing of the reference cell minus . The downlink timing is defined as the time when the first detected path (in time) of the corresponding downlink frame is received from the reference cell. *N*TA for PRACH is defined as 0. (in *Tc* units) for other channels is the difference between UE transmission timing and the downlink timing immediately after when the last timing advance in clause 7.3 was applied. *N*TA for other channels is not changed until next timing advance is received. The value ofdepends on the duplex mode of the cell in which the uplink transmission takes place and the frequency range (FR). is defined in Table 7.1.2-2.**Table 7.1.2-1: Te Timing Error Limit**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency Range** | **SCS of SSB signals (KHz)** | **SCS of uplink signals s(KHz)** | **Te** |
| 1 | 15 | 15 | 12\*64\*Tc |
| 30 | 10\*64\*Tc |
| 60 | 10\*64\*Tc |
| 30 | 15 | 8\*64\*Tc |
| 30 | 8\*64\*Tc |
| 60 | 7\*64\*Tc |
| 2 | 120 | 60 | 3.5\*64\*Tc |
| 120 | 3.5\*64\*Tc |
| 240 | 60 | 3\*64\*Tc |
| 120 | 3\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 [6] |

…7.3.2.2 Timing Advance adjustment accuracyThe UE shall adjust the timing of its transmissions with a relative accuracy better than or equal to the UE Timing Advance adjustment accuracy requirement in Table 7.3.2.2-1, to the signalled timing advance value compared to the timing of preceding uplink transmission. The timing advance command step is defined in TS 38.213 [3].**Table 7.3.2.2-1: UE Timing Advance adjustment accuracy**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **UL Sub Carrier Spacing, SCS kHz** | **15** | **30** | **60** | **120** |
| **UE Timing Advance adjustment accuracy** | ±256 Tc | ±256 Tc | ±128 Tc | ±32 Tc |

 |

Our understanding of Te is that this applies only for the first transmission in a DRX cycle, i.e. the UE has been sleeping and has just returned to the active state. This means that the UE has not received a TA command in this DRX cycle yet to compensate for a potential change of PD during the sleeping state, since the last TA command update. The UE must maintain its uplink transmission timing, relative to the latest DL received timing reference (an SSB available within the last 160ms) within Te. TA adjustment accuracy (TA-err) applies when the UE has received a TA command, and hence the two timing error requirements; TA-err and Te should not be applied simultaneously in our analysis. **Proposal 2: Timing advance adjustment accuracy error component and the initial timing error component Te is not to be considered in the same timing accuracy case study.**  |

**Feature lead view**: More views are needed on this issue.

**Question 2.2.2: Do you think the initial transmission error (Te) and the timing advance adjustment error can be used simultaneously? Please provide your reasons also.**

* **Yes**:
* **No**: *Nokia/NSB,*

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

### Downlink frame timing error

The downlink frame timing error also impacts the accuracy of the estimation for downlink propagation delay $P\_{DL}$, it can represent the error associated with UE downlink frame timing detection. Based on views from tdocs submitted in this meeting and the discussion in RAN1#102-e, there are the following options.

* **Option 1**: 100ns i.e. same as gNB UL detection error
* **Option 2**: Downlink frame timing error is not needed to be considered separately

**Question 2.3.3: Do we need to consider downlink frame timing error? If yes, what value should we assume?**

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

# Evaluation on the achievable time synchronization accuracy over Uu interface in Rel-16

In order to evaluate whether any enhancements needed in Rel-17 to meet the requirement, we need the check the performance that can be achieved by Rel-16 mechanisms first.

Based on the agreements achieved in RAN1#102-e and the views in the contributions, the potential error components that will have impact on the time synchronization accuracy over Uu interface are as below:

* **BS transmit timing error (**$error\_{BS, DL, TX})$: Details as shown in section 2.1
	+ Value to be decided
* **Downlink frame timing error (**$error\_{UE, DL, RX}$**):** Details as shown in section 2.3.5
	+ Value to be decided
* **UE Initial transmit timing error (**Te**)** : Details as shown in section 3.2.2 in R1-2007068
	+ The value defined in Table 7.1.2-1 for initial transmit timing error (Te) in TS 38.133



* **BS detecting error (**$error\_{BS, UL, RX}$**)** : Details as shown in section 3.2.3.2 in R1-2007068
	+ 100 ns
* **Asymmetry between downlink and uplink channel (**$error\_{Asymmetry}$**)**: Details as shown in section 2.21
	+ Value to be decided
* **TA indicating error (**$error\_{TA\\_indication}$**)**: Details as shown in section 3.2.3.3 in R1-2007068
	+ ±8\*64\*Tc/2μ
* **TA adjustment accuracy (**$error\_{TA\\_adjustment}$**)**: Details as shown in section 2.2.2
	+ The value defined in Table 7.3.2.2-1 in TS 38.133



## Equation to calculate the overall time synchronization error over Uu interface

Once the factors that will have impact on the error of the time synchronization are set, we need some method to calculate the overall error of the time synchronization based on Rel-16 mechanism to see whether enhancement is needed or not, if needed then how to improve the accuracy of time synchronization. Note that the overall time synchronization error for the enhanced schemes (i.e. propagation delay compensation and RTT-based propagation delay compensation) can be further evaluated in section 4.

Based on the contributions, the following options are proposed:

**Option 1:**

$$error\_{total}\leq error\_{BS, DL, TX}+\frac{error\_{BS, UL,RX}+error\_{TA\\_indication}+error\_{Asymmetry}}{2}-\frac{Te}{2}$$

* + ***Support:*** *OPPO, CATT*

**Option 2:**

$$error\_{total}\leq error\_{BS, DL, TX}+\frac{error\_{BS, UL,RX}+error\_{UE, DL,RX}+error\_{TA\\_indication}+error\_{TA\\_adjustment}}{2}+\frac{Te}{2}$$

* + ***Support:*** *Ericsson*

**Option 3:**

$$error\_{total}\leq error\_{BS, DL, TX}+\frac{error\_{BS, UL,RX}+error\_{TA\\_indication}+error\_{TA\\_adjustment}}{2}+\frac{Te}{2}$$

* + ***Support:*** *Intel*

**Option 4:**

$$error\_{total}\leq error\_{BS, DL, TX}+\frac{error\_{BS, UL,RX}+error\_{TA\\_indication}}{2}+\frac{Te}{2}$$

* + ***Support:*** *Qualcomm*

**Option 5:**

$$error\_{total}\leq error\_{BS, DL, TX}+error\_{UE, DL,RX}+\frac{error\_{BS, UL,RX}+error\_{TA\\_indication}}{2}+\frac{Te}{2}$$

* + ***Support:*** *Vivo*

**Option 6:**

 $error\_{total}\leq \frac{error\_{UE, DL,RX}-error\_{BS, UL,RX}-error\_{TA\\_indication}}{2}-error\_{BS, DL, TX}-\frac{Te}{2}$

* + ***Support:*** *Nokia*

**Option 7:**

$$error\_{total}\leq \frac{error\_{BS, DL, TX}}{2}+\frac{error\_{BS, UL,RX}+error\_{TA\\_indication}+error\_{TA\\_adjustment}}{2}+\frac{Te}{2}$$

* + ***Support:*** *ZTE*

**Option 8:**

$$error\_{total}\leq \frac{error\_{BS, DL, TX}}{2}+\frac{error\_{UE, DL,RX}+error\_{BS, UL,RX}+error\_{TA\\_indication}}{2}+\frac{Te}{2}$$

* + ***Support:*** *Samsung*

**Feature lead:** The views are quite diverging. The difference among the options are summarized as below:

* + Whether to consider $error\_{Asymmetry}$ ?
	+ Whether to consider $error\_{TA\\_adjustment}$ ?
	+ Whether to consider $error\_{UE, DL,RX}$?
	+ How to include $error\_{UE, DL,RX}$ if it will be considered for the overall time synchronization error, i.e. whether it is $error\_{UE, DL,RX}$ or $\frac{error\_{UE, DL,RX}}{2}$?
	+ Whether $error\_{BS, DL, TX}$ or $\frac{error\_{BS, DL, TX}}{2} $should be used?

The first 3 questions will depend on the discussion in section 2.2.1, 2.2.2 and 2.2.3. Therefore, here we can focus on the remaining questions.

**Question 3.1-1: Which one do you think we need to include in the equation for calculating the overall time synchronization error, i.e.** $error\_{BS, DL, TX}$ **or** $\frac{error\_{BS, DL, TX}}{2}$**? Please give your reasons also.**

|  |  |
| --- | --- |
| *Company* | *View* |
| Feature lead | The following aspects would be related in order to determine which one to use:* Whether $error\_{BS, DL, TX}$ is part of propagation delay error or not? If it is part of propagation delay error, then it seems reasonable to use $\frac{error\_{BS, DL, TX}}{2}$ in the equation considering we use TA/2 to get the propagation delay.
* Whether to use $error\_{BS, DL, TX}$ to capture the timing error between the SFN timestamp in *referenceTimeInfo* which is captured at the gNB-DU [38.470 section 5.2.2] and the frame timing at the air interface? In this case, it seems reasonable to use $error\_{BS, DL, TX}$ in the equation.
 |
|  |  |

**Question 3.1-2: Which one do you think we need to include in the equation for calculating the overall time synchronization error, i.e.** $error\_{UE, DL,RX}$ **or** $\frac{error\_{UE, DL,RX}}{2}$ **if we need to consider downlink frame timing error based on the discussion in section 2.2.3 ? Please give your reasons also.**

|  |  |
| --- | --- |
| *Company* | *View* |
| Feature lead | Similar as question 3.1-1, the following aspects would be related in order to determine which one to use:* Whether $error\_{UE, DL,RX}$ is part of propagation delay error or not? If it is part of propagation delay error, then it seems reasonable to use $\frac{error\_{UE, DL,RX}}{2}$ in the equation considering we use TA/2 to get the propagation delay.
* Whether to use $error\_{UE, DL,RX}$ to capture the timing error at the UE side to receive the indicated reference timing information.
 |
|  |  |

**Question 3.1-3: Do you have any other views on the determination of which equation to use for the overall synchronization time error?**

|  |  |
| --- | --- |
| *Company* | *View* |
| Feature lead | If companies want to share more reasons to justify the equation you propose, you can include it here.  |
|  |  |

## Overall time synchronization error over Uu interface

Once we achieve consensus on the equation to be used for calculating the overall time synchronization, we can get the overall time synchronization error achievable based on Rel-16 scheme based on the following assumption we agreed in RAN1#102-e.

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

Some companies provide some evaluation in the contribution based on their equation, and share the views on whether enhancements in Rel-17 needed or not. Note that it may depend on the reply LS from RAN2 on the overall Uu interface budget also.

* TA-based mechanism in Rel-16 cannot satisfy the time synchronization accuracy of the control-to-control use case
	+ ***Support:*** *Vivo, Ericsson, CATT, LG, Qualcomm*
* TA-based mechanism in Rel-16 can satisfy the time synchronization accuracy of the smart grid use case
	+ ***Support:*** *Vivo, Intel, Qualcomm*

**Feature lead:** Let’s wait for the discussion in section 3.1 first. If the reply LS from RAN2 can be available during this meeting, we can consider to discuss again on whether enhancements needed or not.

**Question 3.2: Do you have any addition thinking or suggestion here?**

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

# 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. Based on the contributions submitted to this meeting, option 3 below are proposed also.

* **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).
* **Option 3: gNB-side pre-compensation**

At the moment, there is no consensus yet if enhancements are needed, and also RAN2 is discussing the error budget of Uu interface. Therefore, right now what we can do is to see if any further clarification needed on the above options to get a common understanding in RAN1. Some brief summary on each option are given as below, based on the views in the contributions.

* **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)
	+ ***Support:*** *LG,*
	+ *Cons*
		- *May be not very useful for TA adjustment due to hardware limited*
	+ **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)

**Question 4.1-1: Do you have any question on the clarification of the above three options?**

|  |  |
| --- | --- |
| *Company* | *View* |
| Feature lead | Some companies mentioned that option 1c is not that clear, therefore proponents of option 1c are encouraged to provide more details on option 1c if any.  |
|  |  |

* **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).
	+ ***Support:*** *Ericsson, Qualcomm, Intel, Nokia, OPPO*

Regarding option 2, the main issues mentioned in the contributions mainly include the following aspects:

* + Whether to expand or separate procedure/signaling to positioning?
	+ What equation to use for evaluating the overall time synchronization error for RTT based method?
	+ Whether the propagation delay is calculated at the UE side or gNB side?

The following questions are set to collect the views from companies.

**Question 4.1-2: Do you prefer to expand the procedure/signaling to positioning, or introduce a separate procedure for option 2 (i.e. RTT based propagation delay compensation)? Please provide your reason also.**

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

**Question 4.1-3: Which Alternative do you prefer to calculate the overall time synchronization error for RTT-based method? Please provide your reason also.**

**Alternative 1:**

$$error\_{total, RTT}\leq \frac{error\_{BS, DL, TX}+error\_{UE, DL, RX}+error\_{UE, UL, TX}+error\_{BS, UL, RX}}{2}$$

* + ***Support:*** *Qualcomm,*

**Alternative 2:**

$$error\_{total, RTT}\leq \frac{error\_{UE,DL,RX}+error\_{BS, UL, RX}-error\_{UE, UL, TX}+error\_{RxTxDiff, report} }{2}-error\_{BS, DL, TX}$$

* + $error\_{RxTxDiff, report}$ is to reflect the error due to report granularity of Rx-Tx time difference
	+ ***Support:*** *Nokia*

**Alternative 3:**

$$error\_{total}\leq \frac{error\_{BS, DL, TX}+error\_{UE, DL,RX}+error\_{BS, UL,RX}+error\_{RxTxDiff, report}+T\_{e}+error\_{indication}}{2}$$

* + $error\_{RxTxDiff, report}$ is to reflect the error due to report granularity of Rx-Tx time difference
	+ $error\_{indication}$ is to reflect the error due to the granularity of propagation delay indication
	+ ***Support:*** *Samsung*

**Alternative 4:**

$$error\_{total}\leq error\_{BS,DL,Tx}+\frac{error\_{UE,DL,rx}+error\_{BS,UL,rx}+error\_{RxTxDiff, report}}{2}$$

* + $error\_{RxTxDiff, report}$ is to reflect the error due to report granularity of Rx-Tx time difference
	+ ***Support:*** *Ericsson*

|  |  |
| --- | --- |
| *Company* | *View* |
| Feature lead | Note that the denotation might not be exactly the same as in your contribution, to make it easier to compare the difference I tried to uniform the denotation. If any appropriate, please indicate here.  |
|  |  |

R1-2008283 (OPPO) raised the issue that we need to discuss whether the propagation delay is calculated at the UE side or gNB side for RTT based method. It seems most companies think it is done at the gNB side.

**Question 4.1-4: whether the propagation delay is calculated at the UE side or gNB side for RTT based method? Please provide your reason also.**

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

Intel (R1-2008988) propose to discuss *gNB-based pre-compensation of the reference time information* also.

* **Option 3: gNB-based pre-compensation of the reference time information**
	+ ***Support:*** *Intel*

**Question 4-5: Do you have any comment/question on option 3?**

|  |  |
| --- | --- |
| *Company* | *View* |
| Feature lead | The following was given in Intel (R1-2008988):==============As RAN2 already discussing, there is a leftover R16 mechanism of gNB-based pre-compensation and adjustment of the reference time information. As it is shown in section 2, it has good performance with the restriction that the reference time info in this case could not be suitable for all UEs. Additionally, mechanisms to inform the UE about pre-compensation are required to avoid double compensation.============== |
|  |  |

# 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. R1-2007659 Discussion on propagation delay compensation enhancements vivo
3. R1-2007711 Propagation Delay Compensation Enhancements for Time Synchronization Ericsson
4. R1-2007853 Discussion on propagation delay compensation enhancements CATT
5. R1-2008061 Discussion on propagation delay compensation enhancements LG Electronics
6. R1-2008163 Discussion for propagation delay compensation enhancements Samsung
7. R1-2008283 Enhancements for Propagation Delay Compensation OPPO
8. R1-2008318 Enhancements for support of time synchronization Huawei, HiSilicon
9. R1-2008825 Discussion on propagation delay compensation enhancements ZTE
10. R1-2008844 Discussion on enhancements for propagation delay compensation Nokia, Nokia Shanghai Bell
11. R1-2008988 On propagation delay compensation for enhanced timing synchronization Intel Corporation
12. R1-2009261 Enhancements for support of time synchronization for enhanced IIoT and URLLC Qualcomm Incorporated
13. R1-2008464 Discussion on Orphan symbol handling for unlicensed spectrum Apple
14. R1-2009014 Processing time for COT sharing in FBE ETRI
15. TS 22.104 V17.3.0, “Service requirements for cyber-physical control applications in vertical domains”

# 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:

* $\pm 8∙64∙T\_{c}/2^{μ}$±8\*64\*Tc/2μ 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.