**3GPP TSG-RAN WG2 #116-e R2-21xxxx**

**Electronic meeting, 1th - 12th November, 2021**

**Agenda Item:** **8.5.2**

**Source: CMCC**

**Title:** **Report of [AT116-e][502][IIOT] Time Synchronization**

**Document for:** **Discussion and decision**

# Introduction

In Rel-17, IIOT WI aims to develop a PDC mechanism(s) including PD estimation, signaling and compensation. This offline discussion aims to address the left issue and reach some agreements for topics in 8.5.2 as follows:

* [AT116-e][502][IIOT] Time Synchronization (CMCC)

Final scope: Discuss the proposals in 8.5.2

Intended outcome: Summary of the offline discussion with e.g.:

§ List of proposals for agreement (if any)

§ List of proposals for further discussion

Final deadline (for companies' feedback): Tuesday 2021-11-02 2400 UTC

**Note1:** All the proposals listed in the summary will be categorized into two types:

**Type1:** proposal for agreement, e.g. reach consensus by the majority.

**Type2:** proposal needs further discussion.

Please noted during the discussion on the RAN2 impact on specification via TA-based or RTT-based solution, we employ the similar strategy in RAN1, add a condition of “If x-based PDC is supported, …” in the proposal description.

# Discussion

## UE-side PDC vs. NW-side PDC

During RAN2 115e, the following was agreed to

**Agreements**

1. RAN2 assumes that gNB can perform pre-compensation. RAN2 agrees to introduce signalling to enable/disable UE-side PDC.
2. The gNB can enable/disable UE-side PDC via unicast-RRC signalling for Rel-17
3. RAN2 shall wait for RAN1 to decide the measurement framework for RTT based PDC method and does not preclude UE-side PDC or gNB based pre-compensation at this point. RAN2 is expecting guidance from RAN1 on what is needed.
4. UE Assistance information from the UE which could for example be used by gNB to activate PDC is not supported
5. Implicit activation of UE-side PDC when a pre-configured threshold is met is not supported
6. UE-based trigger for TA update or RACH procedure for PDC are deprioritized for Release 17

### **2.1.1 The specification scope of PDC in RAN2**

Regarding the issue of specifying NW-side PDC or UE-side PDC in RAN2, **One company** (vivo) expressed that as the gNB knows the timing advance of every UE and is therefore aware of their propagation delays. Hence, it is proposed that **RAN2 confirms that gNB can perform pre-compensation [5].** Meanwhile, **four companies** (Ericsson, Nokia, Lenovo and CMCC) proposed that RAN2 should only focus on the specification impact from supporting UE-side propagation delay compensation, regardless of whether the TA-based or RTT-based PDC method is used. It is proposed in [9] that propagation delay is primary UE specific (and often dynamic) attribute that is therefore ill suited with SIB9 delivery of *referenceTimeInfo*. Hence, the take-away is that RAN2 should not further consider specification impact from gNB PD pre-compensation, but only specification impact from UE-side PDC. In [3][8][14], it is proposedthat in RAN2 support only a UE-side determination of the PDC required to meet the target sync accuracy regardless of whether the TA-based or RTT-based PDC method is used.

**Question 1: Do companies think that RAN2 should only focus on the specification impact from supporting UE-side propagation delay compensation, regardless of whether the TA-based or RTT-based PDC method is used?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | No | RAN1 did not yet concluded which mechanism is used. If RAN2 develops further detail but RAN1 agree not to support, the RAN2 discussion will be useless. Also, even for each mechanism, its detail is not clear at all, e.g. which RS is used. We prefer to focus on discussion based on what were agreed. |
| Nokia, NSB | Yes | We propose to keep the PDC procedure simple and focus only on UE-side PDC. We do not see any reason to complicate the procedure by tailoring RTT or TA to only UE and/or NW side PDC. |
| Huawei, HiSilicon | Yes | We understand for RAN2, the focus can be on the specification impact from supporting UE-side propagation delay compensation. For any issues for network pre-compensation related to network implementation, maybe RAN3 can discuss if there are RAN3 impacts. |
| Lenovo | Yes | We understand whether NW or UE side PDC is used depending on RAN2 decision. And we prefer UE side PDC no matter TA based or RTT based solution is finally decided by RAN1, as we discussed in R2-2110318 |
| LG | Yes but | We generally agree that RAN2 should focus only on UE-side PDCP and not the NW side PDC. However, the details of specification impact can only be discussed after final decision is made in RAN1. |
| TCL | Yes | We agreed the assumption that the gNB can perform pre-compensation, as is listed above in the RAN2 115e agreements. However, the gNB side pre-PDC is supposed to be up to implementation which would have no change on the specification from RAN2 perspective. RAN3 may discuss related issues if there are RAN3 impact. Thus, we may make it simple and focus RAN2 discussion on UE-side PDC.  |

In [9], it proposed that for the use cases such as smart grid and control-to-control with a single Uu interface which does not have a strict time synchronization error budget. Meanwhile, in [2]we think TA-based PDC shall be supported at least for smart grid scenario, and network shall be able to enable/disable UE-side PDC via unicast RRC signalling. Moreover, **RAN1 has indicated that the legacy PDC mechanism based on the existing Rel-15/Rel-16 TA procedure and associated granularity can satisfy the requirements of scenario 3** [13]. Hence, to reduce scope of discussion, it is suggested by rapporteur to attempt conclusion as follows:

**Question 2: Do companies think that from RAN2 perspective, traditional TA-based PDC shall be supported at least for smart grid scenario, and network can enable/disable UE-side PDC via unicast RRC signalling?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | No (clarification) | Although some features are introduced for particular services, the features should be service-agnostic from specification point of view. Our understanding is that Rel-16 only allows UE implementation-based PDC, but using TA is not mandated at all. Thus, we do not need to agree or disagree “**traditional TA-based PDC shall be supported at least for smart grid scenario”**Anyway, we agree that NW can enable/disable UE-side PDC to avoid the duplication at both UE and gNB. |
| Nokia, NSB | Yes | It is clear that legacy TA is sufficiently accurate for the smart grid scenario and we anticipate that a lot of use cases can be supported with legacy TA for PDC.The activation/deactivation of PDC should be independent on both how referenceTimeInfo is delivered as well as which PDC method is used. We are supportive of the network enabling/disabling UE-side PDC via unicast RRC signaling.  |
| Huawei, HiSilicon | Yes | We would regard at least this as re-confirmation of R16 like behaviour for lesser challenging scenario of smart grid.  |
| Lenovo | Yes | We think legacy TA based PDC is accurate enough for smart grid scenario and shall be supported. |
| LG | No (See comment) | If TA-based PDC is supported, the legacy TA-based PDC should be the way to go. However, it is not yet decided whether either/both/none of TA-based or RTT-based PDC is supported. If RTT-based PDC is sufficient, TA-based PDC may not be needed at all regardless of whether it is based on the legacy TA mechanism or not. So, it is early that traditional TA-based PDC SHALL be supported. |
| TCL | Yes | We agree the traditional TA-based PDC shall be supported at least for smart grid scenario, or in another words, the traditional TA-based PDC is sufficient for use cases with lesser stringent time synchronization error budget, for example. We also agree with Samsung that the features should be service-agnostic from specification point of view. Anyway, we are supportive of the network enabling/disabling UE-side PDC via unicast RRC signaling.  |

### 2.1.2 The usage scope of PDC pre-compensation

For the issue of the usage scope of PDC pre-compensation, only 2 companies (Nokia and Samsung) mentioned that enabling/disabling UE-side PDC is supported only for *ReferenceTimeInfo* by unicast delivery. In [10] [9], it expressed the view that as the propagation delay highly depends on the distance between gNB and UE, it is true that different UEs have different value of the propagation delay. It means that the pre-compensation is not feasible for broadcast delivery method of *ReferenceTimeInfo* by system information. From rapporteur perspective, it is reasonable to limit the usage of this pre-compensation to only unicast delivery.

**Question 3: Do companies think that Enabling/disabling UE-side PDC is supported only for ReferenceTimeInfo by unicast delivery?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | Yes | PDC should be performed with the received reference time by ReferenceTimeInfo. Thus, it is straightforward to configure them together. For broadcast signaling, gNB should configure UE shall perform PDC. |
| Nokia, NSB | No | We are strongly against tailoring the activcation/deactivation signalling to a ReferenceTimeInfo, and DLInformationTransfer and SIB9 for that matter. There is no need to enable a “dynamic” activation/deactivation mechanism for PDC as the need for activation /disabling is expected to be a slow process and most likely not even toggled more than once when the UE establishes an RRC connection.  |
| Huawei, HiSilicon | Yes/No | We want to have more clarification on this proposal. If enabling/disabling is only supported for unicast, then what is the UE PDC behavior for broadcast delivery? What if gNB sends time information with both broadcast and unicast? |
| Lenovo | Yes | We think it is reasonable to enable/disable PDC by UE specific signaling, consider gNB pre-compensation is UE specific |
| LG | No | The question seems to already assume UE-side PDC is enabled/disabled based on *ReferenceTimeInfo*, which we don’t prefer. We tend to agree with Nokia that dynamicity is not needed to act/deact UE-based PDCP, hence no reason to couple with *ReferenceTimeInfo*. |
| TCL | No | We have the same view with Nokia to against limiting the Enabling/disabling UE-side PDC to unicast delivery nor tailoring the activcation/deactivation signalling to a *ReferenceTimeInfo*, and *DLInformationTransfer* and SIB9. More clarification about this proposal is wanted.  |

### 2.1.3 Signaling for PDC mechanism mode indication

In Rel-17, in compensation part, compared to Rel-16, the different approaches of Rel-17 would be employed. It is proposed in [10] , Rel-17 IIOT WI aims to develop a PDC mechanism(s) including PD estimation, signalling, and compensation. In compensation part, the difference of Rel-17 would be whether newly defined PD signalling is used by a UE. The indication can be included in *ReferenceTimeInfo*.

**Question 4: Do companies think it is necessary to introduce the** **RRC signalling to indicate whether gNB provides PD value for UE-side compensation, i.e. (1) PDC based on gNB’s signalling on PD value (2) No UE side compensation (3) UE implementation based Rel-16 PDC?** **And the indication of whether gNB provides PD value for UE-side compensation can be included in *ReferenceTimeInfo*.**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | Yes | Proponent.We think (1) means that UE shall perform Rel-17 PDC by using the derived or delivered value by TA-based or RTT-based, subject to RAN1 conclusion.Indication (3) may be explicitly provided or implicitly indicated by absence of (1) and (2) |
| Nokia, NSB | - | The question is not very clear to us. We do see a need for the network to be able to indicate;1. Whether the UE should do PDC
2. Whether the UE should NOT do PDC
3. Not configuring PDC meaning the UE can behave according to Rel-16.

Strongly against indicating these stages in ReferenceTimeInfo, DLInformationTransfer or in SIB9 for that matter. This indication should be a part of an RRC PDC IE. |
| Huawei, HiSilicon | No strong view | We tend to agree that RRC signaling (preferably RRC reconfiguration message with enabling/disabling per UE) could indicate the three alternatives. However more clarifications may be needed on how this mechanism would work.  |
| Lenovo | Too early to discuss | In principle we agree that RRC signaling can indicate which PDC approaches will be used by UE after enabling UE side PDC. But we think it is better to discuss this issue after PDC approaches are finally determined. |
| LG | No | It would be clearer to indicate whether the UE performs PDC or not via a separate RRC parameter than coupling it with *ReferenceTimeInfo*.  |
| TCL | No strong view | We agree to introduce RRC signalling to enabling/disabling UE-side PDC and prefer not to restrict the RRC signalling to indicate the options listed in the Question. However, we are not object to it.  |

### 2.1.4 Signalling to enable / disable UE-side PDC

Regarding the potential specification impact by the agreed signalling to **enable / disable UE-side PDC**，two basic approaches are depicted in the proposals submitted to this meeting:

* **Option1: a new RRC parameter, can be introduced to explicitly enable/disable UE-side PDC [2]** [6]**;**
* **Option2: UE performs PDC based on the latest accumulative TA upon receiving the *referenceTimeInfo* IE** [5];

**Three** companies proposed their approaches on this issue:

From the proposals, **2 out of 3** companies (Huawei, ZTE) propose to introduce a new IE/field to enable / disable UE-side PDC. in [2], it is proposed that an RRC parameter, e.g. *TA-BasedPDC*, can be introduced to explicitly enable/disable UE-side PDC and absence of the parameter means the UE shall apply Rel-16 behaviour, e.g. UE-implementation to apply TA-based PDC. In [6], it is proposed that gNB can just include a 1bit indication in the *DLInformationTransfer* message.

Meanwhile,only **one company** (vivo) expressed that a UE only needs to perform PDC when the referenceTimeInfo IE is received (e.g., via dedicated RRC message). In RAN2# 113e Agreement, RAN2 concluded that “There is no UE clock shift to be discussed”. If UE clock shift is not considered, UE can always keep reference time synchronization with NW after PDC is performed once. Thus, it is reasonable that UE only performs PDC upon receiving the referenceTimeInfo IE [5].

**Question 5: Regarding the potential specification impact by the agreed signalling to enable / disable UE-side PDC, which options do companies prefer? Or others?**

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| --- | --- | --- |
| **Company** | **Option1? 2? ... ?** | **Comment / alternative proposal** |
| Samsung | Option 1 | If UE does not receive any configuration of PDC, the UE may follow Rel-16 mechanism, i.e. UE implementation with proprietary solution.  |
| Nokia, NSB | Option 1 | Option 1 is our clear preference. Option 2 is not clear at all, as it mixes both the PDC method with a condition on which TA value is to be used, and thirdly how the PD value it is delivered.  |
| Huawei, HiSilicon | Option 1 |  |
| Lenovo | Option 1 |  |
| LG | Option 1 |  |
| TCL | Option 1 | Option 1 is clear and simple. Option 2 contains more information and introduced too much unnecessary complexity. We prefer the RRC signalling to be simple to just indicate the UE whether to perform UE-side PDC or not.  |

## **PDC solutions：**TA-based PDC & RTT-base PDC solution

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

1. **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)

1. **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 position).

Besides, **Implicit PDC solution** is proposed in [11] (OPPO), however, we will still focus on the TA-based PDC and RTT-base PDC solution. Some companies discussed on **whether to support of enhancing TA by increasing granularity or reducing Te.** Then, there are the following options to go at this phase:

* **Option 1: Not support it, keeping the legacy TA procedure used for timing alignment of uplink [4];**
* **Option 2: Support [13];**
* **Option 3: Wait for RAN1/RAN4;**

In [13], China Telecommunications suggested that RTT-based solutions shall be selected only when TA-based solutions with better granularity can’t meet the requirements. And in [13], it expressed that TA-based solutions can achieve higher time synchronization accuracy with finer TA granularity, thus meeting the stringent requirements in all the three scenarios. **Since there is a small number of participants touched this issue, the rapporteur suggests insist on previous conclusion:**

**Wait for RAN1/RAN4 to make decision on selection of the specific option for PDC.**

**Question 6: Do companies prefer to wait for RAN1/RAN4 to make decision on selection of the specific option for PDC?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | Yes | Should wait for other responsible WGs |
| Nokia, NSB | Yes | RAN2 should await RAN1 before making the final decision on which PDC methods are to be supported. However, RAN2 can make conditional agreements based on the most likely outcome from RAN1. From our perspective that is to support legacy TA (at least for smart grid) and then RTT as a supplementary PDC method.  |
| Huawei, HiSilicon | Yes | Agree to wait for other WGs |
| Lenovo | Yes |  |
| LG | Yes |  |
| TCL | Yes | Agree to wait for other WGs. And not object to making conditional agreements.  |

### 2.2.1 Enhancement in TA-based PDC solution

**UE-side TA-based PDC**

And the related proposal raised by **QC** can be discussed:

* **RAN2 should not introduce a PDC solution which changes the legacy TA procedure used for timing alignment of uplink.**
* **If RAN1 decided to support enhanced TA, RAN2 should ensure that this would only be applicable to PDC and not affect existing UL timing requirements.**

And there are **two** companies mentioned **the issue related the TA value delivery:**

**OPPO** proposed that in the case that UE-side PDC is applied for the TA-based PDC solution, the gNB needs to send the enhanced TAC MAC CE with a finer TA value to the UE [11].

Furthermore, **China Telecommunications** further proposed that the gNB can periodically indicate PDC value to UE through an additional MAC CE instead of the legacy TA value, according to the time synchronization requirements. It claimed that additional MAC CEs shall be introduced to indicate PDC values, making the PDC enhancement independent of the legacy TA procedure. Since the gNB needs to consider clock drift, UE’s mobility, and other issues, the new PDC value shall be periodically indicated to UE through the MAC CE according to the time synchronization requirements of the scenario.

The gNB can periodically indicate PDC value to UE through an additional MAC CE instead of the legacy TA value, according to the time synchronization requirements [13]. (1/1)

**Question 7: Which option is companies’ preference, option 1 or option 2?**

* **Option 1: RAN2 should not introduce a PDC solution which changes the legacy TA procedure used for timing alignment of uplink.**
* **Option 2: If RAN1 decided to support enhanced TA, the gNB needs to send the enhanced TAC MAC CE with a finer TA value to the UE.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/option 2** | **Comment / alternative proposal** |
| Samsung | Option 2 (but wait for RAN1) | If TA-based PDC is agree and current TAC does not have sufficiently fine granularity, we have to introduce new signaling. But RAN1 did not conclude this aspect, so we should wait at this moment. |
| Nokia, NSB | - | The question is not clear to us.If enhanced TA is selected from RAN1, then RAN2 should comply with the RAN1 agreement that enhanced TA should not affect the legacy TA procedure.However, for the enhanced TA procedure to work, an enhanced TA command is needed to be able to signal the enhanced TA value to the UE, that it should use for the purpose of PDC. |
| Huawei, HiSilicon | Option 1 | We understand this option 1 is in line with RAN1 agreement in LS in R2-211217. AgreementIf 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.
 |
| Lenovo | Option 2 | But also think this is depending on RAN1 decision |
| LG |  | If RAN1 introduce enhanced TA, 1) that should not impact the legacy TA and 2) RAN2 should comply it. The point of this question is not clear.  |
| TCL | Option 1 | It is agreed that the TA-based PDC should not affect the normal TA command indication granularity. For option 2, we prefer that gNB needs to send the enhanced TAC MAC CE with a finer TA value to the UE only for TA-based PDC. But the legacy TA procedure used for timing alignment of uplink should not be affected.  |

New trigger for TA update

In [6], it also mentioned that RAN2 needs to discuss whether new trigger for TA update needs to be introduced, e.g., if the TA estimation error exceeds several number TA granularity, TA update would be triggered. Here the number of TA granularity can be. Since RAN2 just agreed that UE-based trigger for TA update or RACH procedure for PDC are deprioritized for Release 17 in RAN2#115-e meeting, so **rapporteur proposes to postpone the discussion on the new trigger for TA update.**

NW-side TA-based PDC

RAN2#115-e meeting agreed that “RAN2 assumes that gNB can perform pre-compensation.” Only one company (Intel) proposed in [12], in TS 38.331, IE *ReferenceTimeInfo-r16* is used to provide timing synchronization information. And current Sub-IE *time-r16* ‘s text description precludes the possibility of pre-compensation at gNB side. Therefore the field description of IE *time-r16* needs to be updated to support network pre-compensation e.g. either deleting the highlighted text, or changing the text by referring to the yet to be defined IE to enable/disable PDC. From rapporteur perspective, it is reasonable and to reduce scope of discussion, it is suggested by rapporteur to attempt conclusion:

**Question 8: Do companies agreed that Field description of IE time-16 is updated to support network pre-compensation. (1/1)?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | Yes but | If NW-side PDC is configured, time-r16 should be UE timing. Relevant description of ReferenceTimeInfo IE should be revised. But more important thing is a new signaling whether UE is not allowed to perform UE-side PDC. |
| Nokia, NSB | Not Urgent | This is not urgent as we think this can be resolved in Stage-3 correction phase after the WI is completed. For now we should focus on UE-based PDC which has more spec. impacts. |
| Huawei, HiSilicon | Not really | We think RRC reconfiguration signaling is suitable, since the enable/disable control shall be per-UE instead of per-signaling. |
| Lenovo | Not urgent | Agree with Nokia that this is stage 3 issue and could be discussed later |
| LG | Yes | This is stage-3 details.  |
| TCL |  | We may postpone this discussion and focus on UE-based PDC for now.  |

In [3], an issue was mentioned that when the UE may receive two different values of reference time information, a pre-compensated value in SIB9, and an un-compensated value in the UE-specific DLInformationTransfer message. This requires an understanding from the UE that the broadcast reference time should not be considered, and the UE shall apply the reference time information in the RRC unicast message, i.e., *DLInformationTransfer*.

**Question 9: Do companies agreed when reference time information is received in both the *DLInformationTransfer* message and the SIB9, the UE applies the reference time info in the *DLInformationTransfer* message?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | No | UE can use the latest information. |
| Nokia, NSB | Yes | This was discussed already in Rel-16 where we agreed that this is already the UE behavior (to prioritize RRC over SIB). We do not see any need to further specify this. |
| Huawei, HiSilicon | No strong view | If the network disables UE-side PDC for both unicast and broadcast, the proposal seems reasonable. |
| Lenovo | Yes | Dedicate signaling always overrides broadcast signaling |
| LG | Yes | It seems straightforward that the pre-compensated and broadcasted reference time info should not be used by the UEs performing UE-specific PDC.  |
| TCL | No with comments | We agree with Samsung to use the latest information. But, for the case the reference time information is received in both the *DLInformationTransfer* message and the SIB9, the UE applies the reference time info in the *DLInformationTransfer* message.  |

### 2.2.3 Enhancement in RTT-based PDC solution

#### 2.2.3.1 Way forward on discussion on RTT-based PDC solution in RAN2

As mentioned by some companies, although RAN1 has not yet agreed on whether to support RTT-based PDC method. To avoid deadlock between RAN1 and RAN2 on the design of RTT based method, we try to analyze the relevant RAN1 agreements and discuss the potential signalling flow, protocol level measurements exchange for RTT-based method along with RAN1 and RAN4 ongoing work.

* **Option 1: wait for RAN1/RAN4(0)**
* **Optoin 2: RAN2 to discuss the RAN2 impact in terms of signalling framework/flow design of RTT based method along with RAN1 and RAN4 ongoing work. [2][4][7][9][13][12][14]** **(7/7: NTT DOCOMO, Intel, Nokia, CMCC, Qualcomm, Huawei, China Telecommunications)**

**Question 10: This is a critical question which will impact the progress of this feature, i.e., do companies agreed that RAN2 to prioritize discussing the RAN2 impact in terms of framework and flow design of RTT based method that is needed to support RTT-based PDC along with RAN1 and RAN4 ongoing work?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | No | Most of features on RTT-based mechanism is what RAN1 should decide. Based on the conclusion, RAN2 needs to support the signaling. Otherwise, RAN2 discussion may be useless. |
| Nokia, NSB | Yes | We strongly believe that this would be beneficial and most likely also adapted from RAN1.From our perspective RAN2 should discuss the signalling framework needed for PDC to support legacy TA and RTT PDC methods for UE-side PDC only.  |
| Huawei, HiSilicon | Yes (Option 2) | For the sake of progressing, RAN2 can prioritize discussing the RAN2 impact in terms of framework and flow design of RTT based method, simply because there are more issues to be solved in RAN2 with RTT based method, not necessarily in favor of RTT based solution. For TA based solution, the work for RAN2 would be simpler.  |
| Lenovo | Yes |  |
| LG | Option 2, if possible | However, it is not clear how RAN2 start discussing the RAN2 impact without the detailed procedure not finalized yet in RAN1. |
| TCL | Yes | RAN2 can discuss RAN2 impact in terms of framework and flow design of RTT based method and TA based method, and conditional agreements can be reached.  |

#### **2.2.3.2 Signaling** Framework **for RTT-based PDC method**

As specified in TS38.305, the current NR RTT positioning method makes use of the UE Rx-Tx time difference measurements and DL-PRS-RSRP of downlink signals received from multiple TRPs, measured by the UE and the measured gNB Rx-Tx time difference measurements and UL-SRS-RSRP at multiple TRPs of uplink signals transmitted from UE. The UE measures the UE Rx-Tx time difference using assistance data received from the LMF, and the TRPs measure the gNB Rx-Tx time difference measurements using assistance data received from the positioning server. The measurements are used to determine the RTT at the LMF which are used to estimate the location of the UE. Hence, there are two basic approaches:

**Option1**: reusing Multi-RTT based signalling flow (0)

**Option2:** the timing synchronization in I-IoT can be independent of positioning [2][12][14][7] (4/4: CMCC, Intel， Huawei, NTT DOCOMO)

Figure 1 shows the architecture in 5GS applicable to positioning of a UE with NR access. The AMF receives a request for some location service associated with a particular target UE from another GMLC and then sends a location services request to an LMF. The LMF processes the location services request which may include transferring assistance data to the UE to assist with UE-based and/or UE-assisted positioning and/or may include positioning of the UE. The LMF then returns the result of the location service back to the AMF. A gNB may control multiple TRPs/TPs.



**Figure 1: UE Positioning Overall Architecture applicable to NG-RAN [14]**

Some companies [2][12][14][7] expressed that the current LMF-based architecture and procedure which involving CN network and positioning server (LMF) . This will cause excessive resource overhead and/or extended transmission delay, measurement delay, which is not feasible in the IIOT scenarios are too complex. We tend to support that positioning functions for IIOT PDC are only located in the related UE and gNB, without the involvement of LMF and AMF.

In [2], it just expressed that RTT-based PDC solution will result in resource overhead, power consumption, as well as few additional signalling overhead and UE processing complexity. Among these incurred costs, we think resource overhead and power consumption need to be further studied. We propose **if RTT-based PDC solution is adopted, methods to avoid excessive resource overhead and power consumption shall be further investigated.**

However, this means the architecture, signalling flow/parameter and measurement procedure for all needs to be re-consideration, as the preferred architecture for RTT-based PDC shown in figure 3.



**Figure 3: UE Positioning Overall Architecture applicable to NG-RAN [14]**

The timing synchronization in I-IoT can be independent of positioning , e.g. support that positioning functions for IIOT PDC are only located in the related UE and gNB, without the involvement of LMF and AMF. [2][12][14][7] (4/4)

**Question 11: Which option is companies’ preference, option 1 or option 2?**

**Option1**: reusing Multi-RTT based signalling flow

**Option2:** the timing synchronization in I-IoT can be independent of positioning, i.e. without LMF and AMF involvement.

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| **Company** | **Option 1/ option 2**  | **Comment / alternative proposal** |
| Samsung | Option 2  | We generally support Option 2. We prefer to have commonality among TA-based and RTT-based as much as possible. |
| Nokia, NSB | Neither | We would propose an alternative formulation of Option 2:“PDC method Option 2 (RTT), should focus on the signaling between the UE and gNB.” |
| Huawei, HiSilicon | Option 2 | The two features, i.e. timing synchronization and positioning, shall be independent.  |
| Lenovo | Option 2 |  |
| LG | Option 2 |  |
| TCL | Option 2 | We prefer the timing synchronization should be independent of positioning.  |

#### **2.2.3.3 Signaling** Flow **for RTT-based PDC method**

**In UE-side PDC RTT method**, required additional signalling from RAN2 perspective is:

Define the information of gNB Rx-Tx time different measurement report in Uu interface. The detailed information IE can reuse IE nr-UE-RxTxTimeDiff-r16 defined in LPP protocol (TS 37.355). This signalling can be seen as the implicit RRC signalling to enable UE-side PDC. For RTT based PDC, RAN2 to discuss and decide **how the RX-TX time difference is reported by UE** with the following three options.

* **Option1: L1 signaling**
* **Option2: MAC signaling**
* **Option3: RRC signalling [12] [7]**

For the additional signalling, one discussion point is whether those signalling should be RRC signalling or MAC CE or even L1 indication. RRC signalling is preferred in [12] since:

* RAN2 already agreed to use unicast RRC signalling to enable/disable PDC.
* Using RRC signalling is more aligned with existing measurement framework.
* RRC signalling is ciphered, therefore is helpful to protect user privacy.

**Question 12: Do companies agreed that if RTT-based PDC is supported, RAN2 to introduce RRC signaling for Rx-Tx time difference measurement (de)activation and measurement report?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | No(but wait for RAN1) | We think the measurement of PD occurs frequently, considering stringent synchronization requirement. We do not think heavy RRC signaling is useful.But we prefer to wait for RAN1. |
| Nokia, NSB | Yes | As we see it the activation/deactivation mechanism is the same as used for a TA based PDC method. There can be a difference in the configuration of reference signals that RAN2 can discuss already now. The Rx-Tx measurement report should also be delivered over RRC (we see no need to support lower layer signaling options). The content of the Rx-Tx measurement report is discussed by RAN1.  |
| Huawei, HiSilicon | Yes for measurement reportBut to use MAC signaling for measurement (de)activation | For measurement activation/deactivation, L2 signalling is much faster, which is similar to e.g. legacy SRS activation/deactivation MAC CE. |
| Lenovo | Yes | Suitable to use RRC signaling for measurement report, but no strong view on activation/deactivation |
| LG | Yes | It is sufficient to act/deact by RRC and reporting via RRC seems to be more aligned with the existing measurement framework. Note that, if measurement report is to be sent by MAC CE, it is questionable how to get a proper UL grant timely given that the MAC CE does not trigger BSR/SR/RA procedure. |
| TCL | Yes but... | Agree to use RRC signalling for measurement report.Agree with Samsung for PD occurs frequently, and use RRC signalling for PDC activation/deactivation may lead to signalling overhead. Therefore, we prefer to use MAC signalling (e.g. MAC CE) or L1 signalling to perform PDC activation/deactivation, MAC CE might be more suitable.  |

##### Measurement Objective

One company (**Nokia**) proposed in [9], that per RAN1 agreement**,** in uplink, SRS is in general agreed to be supported, and in downlink, currently CSI-RS for tracking (TRS) and PRS will both be supported. The most important aspect of the Rx-Tx measurement is that it is clear which reference signal is used at the UE and the gNB, then the gNB need to manage which CSI-RS, PRS and SRS resources can be used for PDC. And in [9], it is proposed that for RTT based PDC, all variants of CSI-RS, PRS and SRS configuration options from Release-16 can be used for purposes of PDC. Meanwhile, **Intel** proposed that if RTT-based PDC is supported and PRS is to be used for UE Rx-Tx time difference measurement, broadcasted PRS configuration (as in posSibType6-1) is used.

**Question 13: Do companies agreed that if RTT-based PDC is supported, the following signalling related to measurement objective is needed, or/and others?**

1. If RTT-based PDC is supported, the gNB may configure the CSI-RS/PRS resource ID along with the SRS resource ID that the UE may use for purposes of PDC.
2. If RTT-based PDC is supported, all variants of CSI-RS, PRS and SRS could be employed.
3. If RTT-based PDC is supported and PRS is to be used for UE Rx-Tx time difference measurement, broadcasted PRS configuration (as in posSibType6-1) is used.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | Wait for RAN1 | RS configuration should be discussed after RAN1 conclusion. It is not entirely clear what is needed and what is not needed. |
| Nokia, NSB | Yes | Obviously we agree, but as we also mention in contribution the details on reference signals for RTT will be agreed by RAN1 so RAN2 should await RAN1 decision.The same applies for the content of the Rx-Tx measurement report.Regarding c) we se no need to limit the scope of the supported PRS configurations. |
| Huawei, HiSilicon | No | Too early to decide. RAN1’s input is needed.The detailed signaling design can be discussed in later stage. |
| Lenovo | Wait for RAN1 |  |
| LG | Wait for RAN1 |  |
| TCL | Wait for RAN1 input | We may wait for RAN1 input, and discuss in detail later. |

##### Measurement report signalling

It is proposed in [2][9] that for UE-side PDC is supported with RTT based PDC, and that the gNB signals the UE with Rx-Tx measurement report allowing the UE to calculate the RTT and hence DL PD estimation. The RRC framework can be utilized for the gNB to deliver Rx-Tx measurement reports to the UE.

**Question 14: Do companies agreed that if RTT-based PDC is supported, the following signalling related to measurement report is needed, or/and others?**

1. If RTT-based PDC is supported, the gNB delivers Rx-Tx measurement report to the UE via RRC signalling.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | No(but wait for RAN1) | We think the measurement of PD occurs frequently, considering stringent synchronization requirement. We do not think heavy RRC signaling is useful.But we prefer to wait for RAN1. |
| Nokia, NSB | Yes | For UE-side PDC this is the simplest option with least overhead (when RTT-based PDC is supported). |
| Huawei, HiSilicon | Yes |  |
| Lenovo | Yes |  |
| LG | No strong view |  |
| TCL | Yes | It’s simple |

##### Measurement Periodicities

It is illustrated that in [9], for PDC it will be important that the periodicities are at least in the same order of SIB9, which delivery rate can be from 80ms up to 5s. The same set of periodicities can be applied to both TA and RTT based PDC methods (i.e. not be limited to a specific PDC method). From rapporteur perspective, this may require more RAN1 input:

If RTT-based PDC is supported, PDC update periodicities should not be lower than 80ms and can be set to be similar as SIB9 periodicities.

However, it can be left for gNB implementation to select the most appropriate periodicities and RS configuration.

**Question 15: Do companies agreed that if RTT-based PDC is supported, the following signalling related to measurement periodicities is needed, or/and others?**

1. If RTT-based PDC is supported, PDC update periodicities should not be lower than 80ms and can be set to be similar as SIB9 periodicities.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | No | NW already knows the required periodicity. We do not need to configure anything. |
| Nokia, NSB | - | We do not see any need for us to limit the periodicities of reference signals. Our analysis only targeted to find our if the existing supported periodicities would be useful when configured for the purpose of PDC, and we concluded that they are. Therefore, there is no need to downscope/upscope periodicities. The gNB can be left to handle the suitable options to be configured. |
| Huawei, HiSilicon | Not sure | RAN1 may provide a suggestion |
| Lenovo | Need suggest from RAN1 |  |
| LG |  | Maybe we need input from RAN1? |
| TCL |  | We may ask RAN1 for suggestion  |

##### Trigger condition for UE to start RX-TX time different measurement and reporting

Additionally, how to trigger UE to report RX-TX time difference is an open issue. Generally, the following three options are proposed:

* **Option1: Periodical UE Rx-Tx time difference measurement/reporting.**
* **Option2: gNB explicitly indicate UE to conduct RTT measurement/reporting using dedicated signaling.**
* **Option3: event based trigger e.g. UE start RTT measurement/reporting when UE is far away from gNB.** [7]

Considering PDC is only needed when UE is far away from the gNB, periodically UE Rx-Tx time difference measurement reporting is also not efficient from power saving perspective, therefore event type UE Rx-Tx time difference measurement and reporting could be introduced for RTT based PDC.

**Question 16: Do companies agreed that if RTT-based PDC is supported, the following signalling related to measurement report triggering is needed, or/and others?**

1. RAN2 to discuss the trigger condition for UE to start RX-TX time different measurement and reporting.
2. Introduce event triggered RX-TX time different measurement and reporting.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | Wait for RAN1 |  |
| Nokia, NSB | - | From our perspective the simplest framework is to configure a periodic RTT procedure. This is what is used in positioning, and with a periodic delivery of SIB9 it is only natural to allow the gNB to align the PDC procedure with it.Event based triggers assume that the UE is sufficiently aware of the current PD error, which might not be the case. |
| Huawei, HiSilicon | Yes | The signaling overhead of RTT-based PDC shall be checked, especially when large bandwidth reference signaling is configured for higher sync accuracy. Besides, at least the UL reference signaling shall be per UE, which would worsen the resource utilization.  |
| Lenovo | Wait for RAN1 |  |
| LG | Wait for RAN1 | It would be better to avoid duplicate discussion in RAN1 and RAN2. |
| TCL | Wait for RAN1  |  |

## UE Capability

In [6][11], ZTE and OPPO mentioned that the gNB needs to send the above indication information only to the R17 UE which has the ability to apply PDC. Therefore, UE needs to report its capability to network and then gNB will use unicast RRC signaling to send the above indication only if it knows that UE can support PDC.

**Question 17: Do companies agreed to introduce a new UE capability on the support of accurate time synchronization or Rel-17 PDC mechanism?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | Yes | Supported feature should be signaled by UE capability, as always. |
| Nokia, NSB | Yes | We think this is a natural outcome of this Rel-17 WI. |
| Huawei, HiSilicon | Yes | We can discuss this in a later stage. |
| Lenovo | Yes |  |
| LG | Yes |  |
| TCL | Yes | We may postpone it and wait for Rel-17 outcome.  |

# Contact information

|  |  |
| --- | --- |
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| LG | SunYoung LEE, ssunyoung.lee@lge.com  |
| TCL | hejun.wang@tcl.com |

# Conclusions

# References

1. R2-2109302 RE: LS on Time Synchronization IEEE 1588 WG LS in To:RAN, SA Cc:RAN2
2. R2-2109599 Discussion about propagation delay compensation for accurate time synchronization Huawei, HiSilicon discussion Rel-17 NR\_IIOT\_URLLC\_enh-Core
3. R2-2109776 Summary of PDC Issues Ericsson discussion
4. R2-2109925 Propagation Delay Compensation for TSN Qualcomm Incorporated discussion Rel-17
5. R2-2109990 Discussion on propagation delay compensation vivo discussion Rel-17 NR\_IIOT\_URLLC\_enh-Core
6. R2-2110107 Remaining FFSs on time synchronization and PDC ZTE Corporation, Sanechips, China Southern Power Grid Co., Ltd discussion NR\_IIOT\_URLLC\_enh-Core
7. R2-2110199 Discussion on propagation delay compensation for TSN NTT DOCOMO INC. discussion Rel-17
8. R2-2110318 Left issues for propagation delay compensation Lenovo, Motorola Mobility discussion Rel-17
9. R2-2110442 Views on Support of Propagation Delay Compensation Nokia, Nokia Shanghai Bell discussion Rel-17 NR\_IIOT\_URLLC\_enh
10. R2-2110496 Issues on Propagation Delay Compensation Samsung discussion
11. R2-2110587 Consideration on the support of time synchronization enhancement OPPO discussion Rel-17 NR\_IIOT\_URLLC\_enh-Core
12. R2-2110801 Remaining issues of timing synchronization Intel Corporation discussion Rel-17 NR\_IIOT\_URLLC\_enh-Core
13. R2-2110963 Discussion about propagation delay compensation enhancements China Telecommunications discussion
14. R2-2111046 Time synchronization for TSN based on RAN1 progress CMCC discussion Rel-17 NR\_IIOT\_URLLC\_enh-Core
15. R1-2104136, Final feature lead summary on propagation delay compensation enhancements, Huawei

#  Annex –Agreements on PDC

In RAN2#113-e and RAN2#115-e meeting, regarding the Propagation delay for TSN, it was agreed that:

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| --- |
| **Agreements*** RAN2 assumes that gNB can perform pre-compensation. RAN2 agrees to introduce signalling to enable/disable UE-side PDC.
* The gNB can enable/disable UE-side PDC via unicast-RRC signalling for Rel-17
* RAN2 shall wait for RAN1 to decide the measurement framework for RTT based PDC method and does not preclude UE-side PDC or gNB based pre-compensation at this point. RAN2 is expecting guidance from RAN1 on what is needed.
* UE Assistance information from the UE which could for example be used by gNB to activate PDC is not supported
* Implicit activation of UE-side PDC when a pre-configured threshold is met is not supported
* UE-based trigger for TA update or RACH procedure for PDC are deprioritized for Release 17

**Assumptions:**- There is no UE clock drift issue to be addressed- The source and target gNB are tightly synchronized to the same master clock within the budget and there is no need to optimize anything for HO **Agreements**- gPTP message interruption during mobility is not considered in the Rel-17 IIoT WI (i.e. no further specification impact are considered)- RAN2 to confirm which PDC option to choose is up-to RAN1 to decide |

And in last RAN1#106 meeting, regarding the Propagation delay for TSN, RAN1 had achieved the following conclusion:

|  |
| --- |
| **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
 |

And in previous RAN1 meeting, regarding the Propagation delay for TSN, RAN1 had achieved the following conclusion:

|  |
| --- |
| 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).
* 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.

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*$error\_{UE, DL, RX}$ is based on other signals (e.g. CSI-RS) instead of SSB.
* *errorBS, UL,RX*$error\_{UE, DL, RX}$ 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 |

**Key agreements specific for RTT-based PDC**

|  |
| --- |
| Agreement (Note: Agreements from RAN1#106-e and RAN1#106b-e are merged)For evaluation of the overall time synchronization error for RTT-based propagation delay compensation,* Alt.1 for RTT-based PDC

AgreementFor 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

AgreementSRS 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.AgreementIf 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.

AgreementSupport 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

AgreementIf 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

AgreementIf 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

AgreementSend 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

AgreementFor 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.AgreementIf 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

  |