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

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

**Source: Intel (Rapporteur)**

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

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

**Document for: Discussion and Decision**

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

|  |  |  |
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# 2 Introduction

This document is the report of the following email discussion:

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

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

**Intended outcome:** Report with agreeable proposals

**Deadline:** Long

# 3 Discussion

## 3.1 Network pre-compensation

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

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

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

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

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

|  |  |  |
| --- | --- | --- |
| Company | Support/Don’t support | Comments |
| NTTDOCOMO | support | We see benefits of pre-compensation by gNB in case TA-based PDC is not supported by UE. |
| Ericsson | Don’t support  | As TA commands would anyway be transmitted to the UE, there is no additional benefits in network pre-compensation method. Note that, this assumes that the TA-based method can meet the target sync accuracy level. We share the view that it does not work with broadcast message transmitted in SIB9, and one additional RRC unicast message is needed.Also, the spec is typically written from UE perspective, and not to discuss/mandate a gNB implementation. Assuming UE-based method is supported, what matters is UE knows whether it shall or shall not perform TA-based PDC. It does not need to know if the time is pre-compensated by the network or there is no need to perform PDC to reach the sync target.  |
| Nokia / NSB | Don’t support | In general we prefer to support only UE-side PDC in Rel-17. UE-side should be considered a mandatory feature for devices wanting accurate time synchronization. UE-side PDC is the obvious choice as PD is UE specific and works together with both SIB9 and RRC delivered referenceTimeInfo.Network pre-compensation may have some benefits (e.g. when the UE-side PD estimation procedure is inaccurate). However, as the Rapporteur has nicely summarized, support for network pre-compensation will require a significant RAN3 standardization effort. We do not think the benefits outweighs the standardization effort to make it worth to pursue further in Release-17.  |
| CATT | Don’t support | We agree with the arguments mentioned by the Rapporteur: a gNB-only pre-compensation method can only work if all UEs have the same path delay or the reference time must only be delivered via dedicated signaling for all such UEs, which sounds cumbersome. For simplicity, we suggest that only UE-based PDC is supported in Rel-17. |
| Samsung | Don’t support | As mentioned by other companies, UE-based compensation should be required for broadcast signaling, so it does not make sense that UE requiring accurate time info does not have compensation capability.Regarding the accuracy, we think if information of the propagation delay, e.g. accurate TA, has sufficient granularity, then UE-based compensation will be able to be accurate. Also, the size of TA command/or PD command (?) is small, compared to *ReferenceTimeInfo*. |
| Fujitsu | Don’t support | We understand that NW-side PDC may have benefit when UE-side PDC doesn’t work well and causing inaccuracy. Having said that, UE side PDC seems not cause significant problem and can still work in Rel-17. Given that there are some concerns with NW-side PDC as rapporteur summarized above, we are ok to de-prioritize NW-based PDC in Rel-17. |
| Qualcomm | Don’t support | Strictly speaking for the TA-based method (as indicated by the rapporteur), we do not think network precompensation is technically feasible. Recall that the offset seen by the gNB is RTT *after UE applies a TA offset* that is not tracked by the gNB (gNB only knows the current relative offset, not the absolute offset applied by the UE). Furthermore, gNB sends unacknowledged TA commands, so tracking the cumulative TA is not feasible. Thus, to make pre-compensation work, this information has to be made available to gNB likely via new signalling. At this point the process becomes complex for the overall task, thus we do not support that option. We also do not support changes to legacy TA because:1. The TA procedure is a fundamental procedure for the operation of the air interface, and this procedure has been stable since Rel-15. Modifying the TA feature in Rel-17 will cause unnecessary repeats of the basic test case development and interoperability for this feature.
2. Significant RAN2 and RAN3 efforts to standardize the new feature on top of TA. We do not think that the marginal benefits in accuracy (if any) are worth the effort to develop the needed signalling.
 |
| MediaTek | Support | The reason why network based precompensation is useful is because we avoid the error introduced by TA signaling granularity (520ns@15KHz SCS; 260ns@30KHz SCS). The signaling error would reduce to the ReferenceTime signaling granularity, which is 10ns. On the argument that this does not work with broadcast signaling, any form of accurate propagation delay compensation will require unicast signaling as the propagation delay is UE specific. On the argument that this option comes with RAN3 specification effort – if highly accurate reference time delivery is required, then standardization effort becomes necessary to meet these requirements.On the argument that the gNB does not track TA following cumulative TA updates, this issue can be easily resolved by the NW triggering a RACH (e.g. by PDCCH order) to determine the absolute TA.  |
| OPPO | Don’t support | In general, we agree NW-side PDC can only be performed in some restrictive scenarios, e.g. all UEs have the same propagation delay or the reference time is delivered via dedicated signaling to each UE. Otherwise, UE-side PDC is anyway required. For simplicity, we prefer to focus on UE-based PDC in Rel-17. |
| ZTE | Support | We agree with Nokia that UE-side PDC should be considered a mandatory feature. It’s at least needed in the case that the reference time is broadcasted via SIB. But we also think it is beneficial for the gNB to perform PDC if it’s feasible. For UE in connected mode, the TA accuracy may be deteriorated. The gNB measures the time of the UE uplink signals and can know whether it needs to update the TA. If the PDC is performed by UE, the gNB may need to provide updated TA when it‘s necessary or may need to send the updated TA at the same time when the reference time is sent via unicast. But if the PDC is performed by gNB, gNB only needs to send the reference time that has been compensated with propagation delay and don’t need to frequently update UE’s TA.Therefore, for unicast, it looks simpler for the gNB to perform PDC and cause less signalling overhead. So we think that network pre-compensation also can be supported. |
| Huawei, HiSilicon | Support | We are open to discuss network pre-compensation as we see there are benefits to consider. Network pre-compensation can decouple UE’s TA procedure from the time synchronization procedure. More precise synchronization can be achieved by eliminating error incurred by TA-step granularity. Certain reduction on UE complexity can be achieved as well when a unicast/broadcast reference time information is received, the UE doesn’t need to check the current TA value and perform compensation for the indicated reference time.  |
| Canon | Support | This way the TA command is not transported prior to its usage for path delay compensation and TA indication error is null |
| LGE | Don’t support | It is assumed that different UEs have different propagation delays. So, we think that UE-based PDC is more efficient than network pre-compensation. With UE-based PDC, the common part which is the time referenced at the network without compensating for RF propagation delay is delivered by the broadcast signaling and UE-specific part which is propagation delay for each UE is delivered via dedicated signaling. If the granularity of the legacy TA is not sufficient, we can discuss a new signaling for high resolution. |
| Xiaomi | Support | We see some benefits of supporting the network PDC, which reduces the UE complexity and supports the PDC for the UE not capable of PDC. However we would also accept that the specification may not need to specify the details of the network PDC, and the network PDC does not support the broadcast of reference time information.  |
| Lenovo | Don’t support | We also has the similar view that without dedicate signaling for reference time, NW based PDC may not work well. Also considering there may has impact on RAN3 specification, we think NW based PDC could be de-prioritized and UE based PDC can be specified as first step. |
| Vivo | Support | We think gNB based solution can be a supplementary solution on the top of UE based PDC solution. The reason is that gNB anyway has the capability to compensate the reference time as gNB knows UE specific TA when UE is in connected state. Moreover, gNB based PDC solution can avoid the quantization error of TA command. |

The reference timing becomes inaccurate if both the network and the UE apply the propagation delay compensation, or in other words double compensate. In [4][6][7][8][13], it has been proposed to introduce some measure to indicate to the UE when pre-compensation has been applied by the gNB to avoid double compensation of the propagation delay at both the UE and the network side.

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

|  |  |  |
| --- | --- | --- |
| Company | Agree/Disagree | Comments |
| NTTDOCOMO | Agree |  |
| Ericsson | Disagree, but okay on principle to have an indication. | We agree that the network indicate to the UE whether it shall or shall not perform PDC with the signalled TA commands from the network. However, the format of the signalling (explicit, implicit, etc) and in which RRC message can be for further study. It is not clear from the question, what UE should do if such an indication (i.e., pre-compensation has been performed by the gNB) is NOT transmitted by the network. Should UE compensate with TA or not? A clear and deterministic UE behaviour is preferred. There can be cases in which the reference time is not compensated by the network and there is no need for UE to compensate by the received TA commands, e.g., a small cell or UE’s propagation delay to the gNB is smaller than the targeted time sync level, etc. In this case, network need to indicate explicitly to the UE to NOT to compensate with TA methods. Similarly, there are cases in which network need to indicate explicitly to compensate with TA methods.  |
| Nokia / NSB | Agree/Disagree | We agree that an activation signal is needed for UE-based PDC. When the UE is configured to do PDC it will not expect the gNB to have done any pre-compensation. However, when the UE is not configured for PDC, the UE is not expected to do PDC and it can be left for gNB implementation whether or not it has conducted pre-compensation. Given the very limited time remaining in Rel-17, we would prefer that RAN WGs focus on acquiring the simplest PDC framework supported..  |
| CATT | Agree | There shouldn’t be any ambiguity on who (gNB or UE) performs PDC and both should not be enabled together.  |
| Samsung | Agree but | The NW pre-compensation can be applicable only for unicast delivery of ReferenceTimeInfo. Thus, an indication bit can be included in ReferenceTimeInfo. |
| Fujitsu | Agree | Although we are reluctant to support NW-side PDC, the indication seems to be needed. The side effect is the standardization effort including signalling details and specification development. |
| Qualcomm | Disagree with TA precompensation. Agree with indication | We agree that an RRC-level indication from the network for the UE to enable/disable UE side PDC via RRC configuration.. The network may need to disable UE-side PDC due to 1. network pre-compensation being performed.
2. The cell is small and PDC can introduce a larger error,
3. UE is close, use case does not require tight synchronization, etc.
4. gNB applies a static PDC value to unbias the error, and that will be sufficient for the use case

In those cases, it is beneficial for the UE to get an explicit indication that UE side PDC is needed/not needed.  |
| MediaTek | Agree | Such an indication is necessary to avoid ambiguity. |
| OPPO | Agree | There should be an indication to avoid double-compensation.  |
| ZTE | Agree | Yes, it is necessary to introduce an indication in a unicast RRC signaling to indicate whether the UE needs to perform PDC (over the received ReferenceTimeInfo):* Firstly, if network pre-compensation is supported, such indication is needed in order to avoid double compensation.
* Secondly, even if network pre-compensation is not supported, as we think it may be possible that some UEs need to perform PDC while others do not, such indication can also be used for this purpose.
* Moreover, if both of such indication and ReferenceTimeInfo are provided by Unicast RRC signalling, the UE is indicated whether or not to perform PDC over this unicast ReferenceTimeInfo. If only such indication is provided, e.g., no ReferenceTimeInfo is provided in the Unicast RRC signalling, it also can indicate that the UE need (or need not) to perform PDC over the broadcast ReferenceTimeInfo.

Moreover, we think such indication can also be introduced into SIB. In some special deployment scenarios (e.g., small cell deployment and all UEs do not require PDC), a global indication in SIB can be used to completely disable PDC for all the UEs.  |
| Huawei, HiSilicon | Agree | We think a unicast signalling is needed to indicate towards the UE when the reference time information is received. This signalling can the same as discussed in Q3b. In other words, this signalling is used to indicate that the gNB will control whether or not UE shall preform PDC based on TA, instead of leaving it to UE implementation as in Rel-16.  |
| Canon | Agree | Add a specific signalling in the reference time information element relative to the pre-compensation by the base |
| LGE | Agree but | We understand that an indication is needed if network pre-compensation is supported. However, this shows that additional support of network pre-compensation increases complexity. |
| Xiaomi | Agree | This was discussed before, and the intention of the indication is to avoid the issue of the double-compensation at the UE. |
| Lenovo | Agree with comments | We agree the principle of indication to avoid double pre-compensation. And the content of indication can be further discussed, e.g. to indicate UE whether to do UE based PDC or not. |
| vivo | Agree | Such indication is useful to avoid double-compensation. |

### 3.1.2 Network Pre-compensation for RTT-based PDC method

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

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

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

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

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

|  |  |  |
| --- | --- | --- |
| Company | Option supported | Comments |
| NTTDOCOMO | option3 |  |
| Ericsson | Option 1 | Firstly, we assume either UE-side or gNB-side PDC can meet the target sync accuracy level. We slightly prefer the option 1, due to the following concerns (related with spec change efforts) in the option 2:* It has RAN3 impacts. There is a need to account for CU-DU time difference, because RRC signal is generated at the CU while reference signals for time sync and measurement are at the DU.
* It has an “additional” information flow in the UL to report UE Rx-Tx time difference. It is unclear when/how to trigger UE report. Additionally, it is not clear how to make this report as close in time proximity as possible to when the network plans to deliver a 5G reference time. This requires a lot of discussions.

For the option 1, we prefer RRC signalling since the reference time is provided in RRC and one can re-use IE of gNB Rx-Tx time difference from the positioning specs, e.g., 9.2.40 gNB Rx-Tx Time Difference in TS 38.455. Lastly, we don’t see any benefits to support both option 1 and option 2. |
| Nokia / NSB | Option 1 | For similar reasons as provided in Question 1a, we prefer UE-side PDC.  |
| CATT | Option 1 | We don’t see the need to differentiate RTT-based and TA-based PDC methods and prefer a common solution. |
| Samsung | Option 1 | We prefer a simple option. |
| Fujitsu | Option 1 | We are supporting UE-side PDC. NW-side PDC would be de-prioritized. |
| Qualcomm  | Option 1/Option 3 | UE-side PDC should be the baseline in order to support broadcast timing reference signal. There may be some benefits to also include gNB-side preocompensation when time reference is unicast in terms of efficiency, accuracy and signaling overhead, so we are fine with including a gNB side compensation option as well if need be. |
| MediaTek | Option 1 | For the RTT based mechanism, there’s no significant accuracy benefit associated with gNB-side PDC. Therefore if we go for an RTT based mechanism, it would be better to go with a UE-based approach to avoid RAN3 impact. |
| OPPO | Option 1 | In our understanding, UE-side PDC seems simple than gNB-side solution, if the design philosophy of Timing Delta MAC CE from IAB can be reused. Also, if there is no critical issue on UE-side RTT-based PDC, we suggest to choose one way, i.e. UE-based or gNB-based, for RTT-based and TA-based PDC. |
| ZTE | Option 3 | We tend to agree with CATT that it’s no need to differentiate RTT-based and TA-based PDC methods and a common solution is preferred. Therefore, also for RTT-based PDC method, in the case that reference time is broadcasted, the UE can perform the PDC. In the case of unicasting the reference time, the PDC can be performed by gNB.Moreover, for RTT-based PDC method, It may be more suitable to let the node that calculates RTT to perform PDC. |
| Huawei, HiSilicon | Option 3 | We propose not to preclude any option(s) right now.  |
| Canon | Option 1 |  |
| LGE | Option 1 | From the similar reason of Q1a, we prefer Option 1.We think that RTT-based method and TA-based method are different in terms of PD estimation, but they look similar in terms of PD compensation. |
| Xiaomi | Option 3 | We would slightly prefer to use the TA-based solution for PDC. If companies consider that the RTT-based PDC should be supported, we think both UE-side PDC and gNB-side pre-compensation for RTT based method could be considered. |
| Lenovo | Option 1 | If RTT based PDC solution is preferred, we would like to prioritize UE based PDC as similar reason in Q1 |
| vivo | Option 3 | Considering that reference time can be provide via broadcast method, UE based PDC solution anyway needs to support.gNB based solution can be a supplementary solution for UE based PDC solution, which can avoid the quantization error of TA command. |

## 3.2 Propagation Delay Compensation Activation/Deactivation

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

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

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

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

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

|  |  |  |
| --- | --- | --- |
| Company | Option supported | Comments |
| NTTDOCOMO | Option 3 | UE conduct PDC or not based on a pre-configured threshold.This question should be decoupled with if gNB pre-compensation is supported or not to avoid duplicated compensation issue. If only UE-side PDC is supported, for stationary UEs (e.g. smart grid sensors), we do not see necessity to (de)activate the PDC, since once the UE is placed far from the base station where it needs delay compensation, it should always conduct the PDC (i.e. always activated). While for mobile UEs (e.g. AGV in smart factory), since they are moving around in the factory, when it is far from the base station, it needs to perform PDC, otherwise not. UE knows whether it needs to perform PDC based on TA value and a pre-configured threshold, unicasting RRC signalling of (de)activating PDC consume lots of dedicated radio resource, which is not desirable in case of high density of UEs in the cell. As such, we believe a pre-configured threshold method (i.e. UE conduct PDC if the TA is larger than the threshold, otherwise not) is more efficient with low cost of signalling.  |
| Ericsson | Option 1 | For TA-based method, UE-side PDC may be needed to reach the sync target. Depending on the distance from the UE to the gNB, only some but not all UEs need PDC. Thus, the option 1 should be supported. With the similar arguments, it is not clear the use case/benefits of the option 2.  |
| Nokia / NSB | Option 1 | For similar reasons as provided in Question 1a, we prefer to support only UE-side PDC in Rel-17. We support unicast PD activation/deactivation. We do not see any significant gains in supporting broadcast option, and as PD is a UE specific, it is natural to specify on a UE basis.  |
| CATT | Option 1 | UE-side PDC activation/deactivation is UE specific, the option1 is the best choice to achieve it. |
| Samsung | No need | We assume Q3a is not about NW’s pre-compensation but about other cases.In case that UE does not require any PDC due to 1) short distance to gNB or 2) UE’s required accuracy is low. Then, NW can just use Rel-16 compensation mechanism, i.e. leave it up to UE implementation. UE will just do its best by using its own way or do nothing. Rel-16 compensation shall be configured for backward compatibility. Thus, no additional indication is needed. |
| Fujitsu | Option 1/Option 3 | We think that dedicated signalling is proper given that different UEs may have different propagation delays.We are open to discuss other Options. |
| Qualcomm | Other | Agree with Samsung. Rel-16 UE-implementation solution relying on TA does not need explicit enable/disable since it is an implementation solution relying only on UE. If RAN1 ends up standardizing a TA solution requiring that then we can revisit. |
| MediaTek | Option 1 | Agree with Ericsson |
| OPPO | Option 1/Option 3 | Whether to trigger Rel-17 PDC scheme depends on the scenario, i.e. Rel-17 PDC scheme is only needed for scenario2. Also, Rel-17 PDC scheme can only be triggered under the certain condition, e.g. the gNB-UE distance is so small that the error caused by the one-way delay is even smaller than the error caused by the PDC itself. It seems using unicast indication is a proper way. We are fine with Option1, and also fine to discuss other unicast solution (i.e. Option 3, if it focuses on unicast solution). |
| ZTE | Option 1 and Option 2 | With reference to our comments in Q1b and also some above reasons mentioned by companies, we think an indication in unicast signaling to enable/disable UE-side PDC is needed, e.g., to enable/disable UE-side PDC per-UE.We also think a global indication in SIB can be beneficial to completely disable PDC for all the UEs, e.g., in some special deployments. |
| Huawei, HiSilicon | Option 1 |  We prefer the unicast signalling as within one cell, UEs might in different needs regarding PDC.  |
| Canon | Option 2 |  |
| LGE | Option 1 |  If PDC activation/deactivation is considered, we think that dedicated signalling is needed because UEs may be in different scenarios or difference distances. |
| Xiaomi | Option 1 and Option 2 | Option 1 only works for unicast-RRC signalling of the reference time provision. Option 2 should be supported when the reference time is provided via SIB. |
| Lenovo | Option 1 | Not all UEs are always use PDC. Dedicate RRC signaling is suitable when to enable partial UE to perform UE-side PDC |
| vivo | Option 1 and option 2 | Both options should be supported. Option 1 is used to control whether PDC should be performed at specific UE, especially for the case that reference time is provided via unicast method.Option 2 is applicable to specific deployment scenario (e.g. small cell), where all of the UEs do not need to perform PDC. |

**Question 3b: For companies who support Option 1 in Question 3a and agree that network indicates to the UE when pre-compensation has been performed by the gNB in Question 1b, please indicate your company view on whether the signalling can be same for both cases.**

|  |  |  |
| --- | --- | --- |
| Company | Same/Different/Other | Comments |
| Ericsson | Same  | The same for both cases, i.e., the network indicates to the UE whether it shall or shall not perform PDC with the signalled TA commands from the network. |
| Nokia / NSB | Same | We do not see a reason to specify two different PDC activation mechanisms (one for UE-side PDC and one for NW-side PDC). For UE-side PDC, the gNB should be able to instruct the UE on which PD method (TA or RTT-based) it should use for PDC. |
| CATT | Different | We think the below scenario is reasonable: neither of gNB and UE does PDC(Neither of them does PDC) , so we don’t think the signalling can be same for both cases. |
| Fujitsu | Same/Other | It is good to be same as much as possible to minimize specification impact. Having said that, it is good to wait for the conclusion of Question 1b before discussing signalling details since different signalling may be better than same signalling. |
| MediaTek | Same (for now) | For the moment, it makes sense to assume that we reuse the same signalling as they result in similar UE behaviour. Whether any differences exist between the two cases can be better determined once RAN1 discussions on the detailed procedure progresses further. |
| OPPO | Same/Other | Agree with Fujitsu. |
| ZTE | Same | We also think same signaling may be feasible. The indication is just used to indicate whether UE shall or shall not perform PDC. For example, if the indication is set to the value that UE should not perform PDC, it may means the PDC is not needed at all or it can also mean the PDC has been performed by gNB. No matter which meaning, the UE behavior is similar. |
| Huawei, HiSilicon | Same | As we comment for Q1b.  |
| Xiaomi | Same | The gNB can simply indicate the UE on whether the PDC at the UE is needed. |
| LGE | Same |  |
| Lenovo | Same |  |
| vivo | Same |  |
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### 3.2.2 UE-side PDC activation/deactivation for RTT based method

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

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

|  |  |  |
| --- | --- | --- |
| Company | Agree/Disagree | Comments |
| NTTDOCOMO | Agree |  |
| Ericsson | Disagree | No strong view but tend to disagree. We are fine to wait for and align with RAN1, if this is the majority view. Some principles can already be discussed, and we wonder if RAN1 would ever discuss the signalling framework/flow (which is the RAN2 scope). For example, RAN1 has already left the decision on UE-side PDC or gNB-side PDC to RAN2, and maybe the intention is already clear that there is no interest for RAN1 to discuss when UE should start to measure UE Rx-Tx (as the example described above). Nevertheless, it is okay to wait and confirm. |
| Nokia / NSB | Agree/Disagree | We propose that RAN2 discussed the overall PDC signalling framework.The details of the RTT method requires a RAN1 decision (e.g. reference signal configuration, measurement definitions, measurement reports), but whether the Rx-Tx measurement report is delivered from the gNB to the UE or vice-versa can still be discussed. So can the need to support multiple reference signal configurations and whether these are aperiodic or periodic (and if so periodicities).  |
| CATT | Agree | In order to avoid invalid discussion, we prefer to wait for RAN1’s decision. |
| Samsung | Agree |  |
| Fujitsu | Agree | It is ok that RAN2 can wait for RAN1 progress, but RAN2 can parallelly work on overall PDC signalling and procedure. |
| Qualcomm | Disagree | Agree with Ericsson. RAN1 scope will not be relevant to the UE side enable/disable here. The signalling flow itself is known from the positioning framework (for example we have included that in our paper R2-2008972), so discussing how to enable/disable UE side PDC for one of many reasons we mentioned in Q1b can start normally. |
| MediaTek | Agree | We prefer to wait on RAN1 to progress, to avoid conflicting discussions. |
| OPPO | Agree | Fine to wait for RAN1 to avoid the collision. |
| ZTE | Agree | Fine to wait for RAN1 to avoid the collision. |
| Huawei, HiSilicon | Agree | Input from RAN1 can be used and no harm to wait.  |
| Canon | Agree |  |
| LGE | Agree |  |
| Xiaomi | Agree |  |
| Lenovo | Agree |  |
| vivo | Agree |  |

## 3.3 Other methods for PDC Triggering and Assistance Information from UE

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

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

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| NTTDOCOMO | ? | For RRC\_CONNECTED, gNB knows how far UE is away in the cell, there is no need to inform gNB of activating PDC using assistance info from UE.While assistance information which includes UE’s preferable periodicity of referenceTimeInfo update is helpful for network for configuration, since the periodicity could be related to UE’s clock accuracy. Is this also relative to rapporteur’s question? |
| Ericsson | No | The benefits are unclear. It was agreed in RAN2#110-e that:* UE can calculate/predict the reference timing based on DL timing information after receiving the referenceTimeInfo from gNB once. (No spec impact)

 In RAN2#113, it was further confirmed that:* There is no UE clock drift issue to be addressed

The rationale is that RAN4 specifies in TS 38.101 that UE clock is locked to DL frequency with at least ±0.1 PPM precision. This means +/- 1ns timing drift over 10ms, and a refresh time of 1s is sufficient to remain within the 1 µs accuracy. After UE receiving one 5G reference time corrected by PDC, UE tracks the time with an internal oscillator corrected by a frequency locking to the gNB clock. Another PDC might be needed together with another reference time delivery by gNB, but gNB is aware of when that would happen. |
| Nokia / NSB | Yes/No | We do support UE assistance information for the sake of PDC and time synchronization services, but we also acknowledge that the timeframe in Rel-17 is be too short to properly discuss these.  |
| CATT | No | There is no need for any assistance information to activate PDC. Network can derive it by itself by tracking the UE’s distance to gNB from available UL measurements (e.g. SRS). |
| Samsung | No |  |
| Fujitsu | No |  |
| Qualcomm | See comment | The issue is regarding how the network can obtain the information of whether PDC is needed for the UE and at what accuracy level. Given that SA2 are/had been discussing that from their side (Should it be signalled from CN to RAN), this issue should be resolved jointly with SA2. In any case, this discussion maybe be a bit far from PDC. |
| MediaTek | No | Agree with others that the benefits are unclear. |
| OPPO | See comment | As we mentioned in Question 3a, whether to trigger Rel-17 PDC scheme depends on the scenario. The scenario related information should be indicated to the gNB for the decision of PDC enabling. Such information can be indicated from UE or CN, and we are open to either one. |
| Huawei, HiSilicon | No | We think the Uu error budget information indicated by SA2 would be beneficial and sufficient for gNB to determine on whether or not PDC is needed. We don’t see the motivation to introduce other assistance information from the UE side.  |
| Canon | Yes |  |
| LGE | Yes |  It may be helpful for supporting time synchronization that UE assists gNB to activate PDC by requesting PD information update when PD seems changed much without compensation. |
| Xiaomi |  | We would like to firstly understand the use cases for the UE assistance information for the activation of PDC. |
| Lenovo | No | Not so clear about the benifits |
| vivo | No | RAN can obtain the Uu error budget information of a specific UE from CN, which is enough for RAN to decide whether to activate PDC or not. |
|  |  |  |

**Question 6: Do companies support that UE-side PDC may be implicitly activated when a pre-configured threshold is met? FFS how such threshold is pre-configured.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| NTTDOCOMO | Yes | UE knows whether it should compensate propagation delay based on TA and the pre-configured threshold. The threshold can be pre-configured by dedicated RRC signalling. Assume the robots are moving around in the smart factory, when UE is far from the base station where it exceeds a pre-configured threshold, UE needs to perform PDC, otherwise not. Especially, in case of high density of UEs in the cell, this method save lots of dedicated RRC signalling of (de)activating PDC. For pingpong issue, it’ a rare case, and if UE move back and forth around the place where it is a threshold for PDC, network is also confused whether to activate or deactivate the PDC for it. |
| Ericsson | No | See above |
| Nokia / NSB | No | We do not support an implicit PDC trigger e.g. based on a threshold. Specifying a threshold is not straight forward and the benefits of such procedure is expected to be very small as it is not expected that PDC needs to be frequently activated/deactivated. |
| CATT | No | UE-side PDC should be in gNB’s control. For the pre-configured threshold, we are not sure about the use scenario and fail to see how to configure it in practice. |
| Samsung | No |  |
| Fujitsu | No | Please see comment to Question 3a. |
| Qualcomm | No | Implicit activation via threshold would not be very beneficial especially if the network can just enable/disable UE-side PDC. Also choosing and configuring a threshold can get complicated. |
| MediaTek | No |  |
| OPPO | No |  |
| ZTE | No | In the complicated deployment scenarios, it is difficult to find a suitable reference target for measuring the distance between UE and gNB, and so it is also difficult to define/configure a suitable threshold for the purpose of triggering UE-side PDC. |
| Huawei, HiSilicon | No | Network could explicitly control whether or not PDC is needed for the UE via control signalling discussed above. |
| Canon |  | No strong opinion |
| LGE | No | We think that PDC is performed using the PD information given by gNB and it’s controlled by gNB. |
| Xiaomi |  | No strong view. The benefit of the pre-configured threshold should be evaluated first, given that the gNB would be able to enable/disable the UE PDC at any point of time. |
| Lenovo | No | The activation/deactivation of UE-side PDC controlled by NW is enough. We do not see much benefit to let UE to do that  |
| vivo | No | For connected UE, activation of UE side PDC can be controlled by NW.  |

There are also other proposals whether a new trigger for TA update can be introduced e.g if TA estimation error exceeds several times TA granularity (not applicable to SCS > 60KHz) [8], or if UE can trigger random access or RACH procedure and proactively acquire PD estimation if it does not have valid TA e.g for UEs in RRC\_IDLE or RRC\_INACTIVE state [7][12][14][16]. RAN2 in the last meeting #114e indicated in LS to SA2 [18] that it is beneficial for NG-RAN to receive time synchronization error budget available for Uu interface. Having this information regarding time synchronization budget, it is rapporteur’s understanding that in RRC\_CONNECTED the gNB may send MAC CE for timing update whenever required and UE may not need to trigger a TA update.

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

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| NTTDOCOMO | No | Same understanding with rapporteur.  |
| Ericsson | No | The benefits are unclear. Reference time delivery is used to time stamp a gPTP message and subsequently sync with an external clock. There are ongoing data transmissions and there is no need to consider RRC\_IDLE/RRC\_INACTIVE state. In addition, since the PDC is used together with a reference time delivery by gNB, gNB can initiate a PDCCH order to update TA. |
| Nokia / NSB | No | We do see the potential in a UE-side PDC update trigger, but it can be down-prioritized in Rel-17. There is no benefits of a UE side PDC update via RACH due to low time accuracy of the RACH preamble detection.The benefits of a UE side PDC trigger procedure comes when the gNB can trust in the UE DL frame tracking capabilities, and then can relax its PDC configuration. The current performance requirements to the UE leaves little room for benefits of such procedure. We would like this to be properly studied and hence it is better to leave the such enhancements for Rel-18.  |
| CATT | Yes | For legacy procedure, the RACH procedure is used to acquire initial synchronization and MAC CE for timing update if needed. Some enhancement can be considered in the current release to further balance, otherwise, we lose the chance to further improvement. |
| Samsung | No |  |
| Fujitsu | No | Same understanding with rapporteur. |
| Qualcomm | No | In some scenarios, PD can abruptly change for a UE affecting the synchronization accuracy (e.g., abrupt change in NLOS multipath cases, handovers, etc.), therefore, it is beneficial to enable the UE to detect change in PD and trigger a PDC request.However, we do not support triggering TA or RACH to correct PDC since this interferes with legacy procedures for relatively little benefit, but we are open to exploring the possibility/benefits of deploying UE-side signalling requesting PDC with an RTT implementation for example. |
| MediaTek | No | Accurate reference time delivery is only needed when there are gPTP messages to transmit. Therefore it is pointless to consider PDC for RRC\_IDLE/INACTIVE states.In connected mode, the NW can always trigger the RACH procedure using a PDCCH order. We do not see any benefit with additionally having a UE based RACH trigger/TA update procedure. |
| OPPO | No | The benefit is unclear. If we only focus on RRC connected state, the gNB can anyway trigger RACH procedure if needed. |
| ZTE | No, but | We agree with rapporteur’s understanding that in RRC\_CONNECTED the gNB may send MAC CE for timing update whenever required and UE doesn’t need to trigger a TA update.But the related issue is, as mentioned in [8], in existing specifications, the gNB decides whether to update TA based on measurements for the UE uplink signals. As long as the signals fall within the CP range, the gNB can correctly receive the uplink data sent by UE. For example, for SCS = 15KHz, short CP duration = 4.69 ms, long CP duration = 5.21 ms. In other words, when the SCS is 15 kHz, the tolerable TA estimation error is about 10 TA granularity. However, for TSN service, we now have the requirement of 1us accurate reference timing and timing synchronization error between a gNB and a UE no worse than 540ns, the above trigger for TA update (when it exceeds the tolarable TA estimation error) may cause large TA estimation error. Such large TA estimation error may cause PDC is infeasible and further cause 1us accurate reference timing cannot be fulfilled. Therefore, we think a new trigger for TA update would still be needed, e.g., when TA estimation error is more than 540ns, TA update would be triggered. As TA estimation error is with unit of TA granularity and TA granularity corresponds to SCS, it’s more suitable to define the new trigger for TA update according to SCS, e.g., for any SCS, if the TA estimation error exceeds several TA granularity, TA update would be triggered. |
| Huawei, HiSilicon | No |  Agree with the rapporteur’s observation. We doubt that UE used for IIoT would move to RRC\_IDLE or RRC\_INACTIVE state very often. We can consider the enhancements in the future release if we can find applicable use cases. |
| Canon | Yes |  |
| LGE | Yes | Although it is expected that gNB sends PD information to UE properly when PD compensation needs to be updated, it may be helpful for supporting time synchronization that UE requests PD information updates (e.g. TA update) to assist gNB when PD seems changed much. |
| Xiaomi | Yes |  |
| Lenovo | No | Same understanding as rapporteur |
| vivo | Yes | In R16, 5GS is modeled as a TSN switch, which needs UE to keep in connected state for forwarding TSN data (e.g. TSN service stream and gPTP message).In R17, 5GS can be modeled as time-aware system as described in IEEE 802.1AS. This means that UE as an end station may only needs to keep in connected state to receive gPTP message for time synchronization while UE can stay in idle/inactive state to perform session based on predefined manner. For this kind of UE, they need to trigger RACH procedure for obtaining the latest TA if the current maintained TA at UE side is no longer valid. |

# 4 Conclusion

TBD.

# 5 References

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

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

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

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

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

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

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

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

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

[10] R2-2105766 Synchronization and Error Budget Samsung

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

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

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

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

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

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

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

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

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