3GPP TSG-RAN WG2 Meeting #109e R2-20xxxxx

Elbonia, Online, 24 February – 6 March 2020

**Agenda item: 6.7.2.1**

**Source: Nokia, Nokia Shanghai Bell**

**Title: [AT109e][032][IIOT] Accurate Reference Timing**

**WID/SID: NR\_IIOT - Release 16**

**Document for: Discussion and Decision**

# Introduction

There are two main issues with respect to accurate reference timing objective of IIOT WI, which need to be solved:

* propagation delay compensation
* determination of the need for reference time information for any given connected UE

The status of the issues prior to RAN2@109-e meeting is shortly summarized below.

**Propagation delay compensation**

The following tentative agreement was reached during RAN2#108 meeting:

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| **The following is FFS (Ericsson and LG have concerns):*** R2 assume that UE may perform propagation delay compensation.
* We don’t specify how the UE perform propagation delay compensation.
* For unicast and broadcast, the network can indicate to the UE to not do delay compensation.
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**Determination of the need for reference time information for any given connected UE**

RAN2 sent an LS to SA2 in [1] to request information on “*whether and how the need for reference timing information can be determined for any given connected UE in Rel-16*”. SA2 considered various solutions and decided that no solution will be specified by SA2 for Rel-16. The following reply was provided by SA2 in [2]:

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| **RAN2 question:** RAN2 would like to ask SA2 to provide information on whether and how the need for reference timing information can be determined for any given connected UE in Rel-16.**SA2 reply:** SA2 has concluded that there is no need to send any additional information to NG-RAN to determine the need for reference time delivery. |

The following was the outcome of the online discussion on the proposals made in R2-2002012:

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| * 2a seems non-agreeable
* P5: No particular support for EN-DC
* Can continue offline
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# 2 Accurate reference timing summary

## 2.1 Propagation delay compensation

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| Company (Tdoc) | Proposals | Rationale |
| CATT (R2-2000110) | Proposal 1: R2 assume that UE may perform propagation delay compensation and we don’t specify how the UE perform propagation delay compensation. | Based on previous discussions it was concluded that UE may perform propagation delay compensation based on implementation. It was also a common understanding that we should not specify how this is done in Rel-16. |
| Proposal 2: For unicast and broadcast, the network can indicate to the UE to not do delay compensation. | For unicast, in case gNB did pre-compensation, UE should not do that.For broadcast, UE should not do compensation for small cells. Also, the distance between UE and gNB is different, and UE is needed to implement propagation delay compensation operations when needed. |
| Huawei, HiSilicon (R2-2000427) | Proposal: Postpone the discussion on propagation delay compensation to R17. | The enhancements for propagation delay compensation are needed to meet the synchronization accuracy requirement of 1us in the Rel-17 scenario where TSN clock is behind on of the UEs. Hence, there is a preference to have a unified propagation delay compensation mechanism for all scenarios, including the Rel-17 one. |
| Ericsson, LG, Samsung(R2-2000786) | Proposal 1: As in LTE, in NR Rel-16, R2 assume that UE may perform propagation delay compensation, but we don’t specify how the UE perform propagation delay compensation.Proposal 2 : RAN2 signalling support for propagation delay compensation is not needed in Rel-16 and should be considered in Rel-17.Proposal 3 : As in LTE, the indicated reference time is referenced at the network, i.e., without compensating RF propagation delay. | How to do propagation delay compensation needs input from RAN1 who already finalized their work on IIOT in Rel-16. Hence, it should be left to UE implementation in Rel-16.When it comes to the signalling specification, it is preferred to wait until Rel-17 where this topic will be discussed in more detail. Since no propagation delay compensation related signalling is to be specified, it should be clarified that the reference time information provided by the gNB is referenced at the network. |
| Nokia, Nokia Shanghai Bell(R2-2001047) | Proposal 1: UE is not allowed to apply propagation delay compensation for reference time information if forbidden by the gNB with explicit signalling. | UE propagation delay compensation is required to meet Rel-16 requirements. There is no need to specify how exactly it is done in Rel-16, but the network should be able to forbid the UE from applying it, e.g. in small cell areas. |
| ZTE Corporation, Sanechips, China Southern Power Grid Co., Ltd(R2-2001212) | Proposal 1: It’s suggested that if the network does not indicate the UE not to do delay compensation, the UE should always perform propagation delay compensation with NTA × Tc/2, regardless of the distance between UE and gNB. Proposal 2: UE can apply the propagation delay compensation till valid TA is available. Whether the TA is valid is left to UE implementation. | In case propagation delay compensation is performed by the UE for small cells, even if the accuracy error increases, the requirement of 1us can often still be met. Thus, UE should always perform propagation delay compensation unless prohibited by the network. |
| Qualcomm(R2-2001297) | Proposal 1: Propagation delay compensation (including optional implementation-dependent propagation delay compensation at UE) is not specified in Rel-16, | Since the way the UE does propagation delay compensation will not be specified in Rel-16, it is preferred to leave the whole discussion for Rel-17. In case optional propagation delay compensation is allowed, it is beneficial to have the signalling from the network to prohibit delay compensation as imperfect propagation delay compensation could result in larger errors when compared to not using propagation delay compensation.. |
| CMCC(R2-2001426)Related TP provided in R2-2001427 | Proposal 1: it is proposed that the UEs are responsible for performing the propagation delay compensation.Proposal 2: it is proposed that the study scope of the propagation delay compensation can only focus on the connected UE. | It is impossible for the gNB to perform delay compensation for reference time information delivered via broadcast. |
| Proposal 3: The UE should only compensate propagation delay for high accuracy reference time information according to a certain criteria or signalling indication.Proposal 4: it is proposed that gNB can send an explicit indication for start/ stop the propagation delay compensation on the UE, and the special condition of triggering the start/stop the propagation delay is left to the network’s implementation. | Propagation delay compensation is not required for small cells e.g. with ISD < 200m) |
| Vivo(R2-2000490) | Proposal 1: For unicast and broadcast, the network can indicate to the UE to not do propagation delay compensation.Proposal 2: How to perform the propagation compensation at the UE or the gNB is left to the implementationProposal 3: A NOTE is added in the specification to state that:* NOTE x: When the gNB indicates that the propagation delay compensation is not needed for the reference time provided to the UE, the UE does not perform propagation delay compensation. Otherwise the UE performs the propagation delay compensation for the reference based on the UE implementation.
 | Propagation delay compensation is required for large cells. In case it is not available, an operator may need to deploy larger number of smaller cells instead, increasing its network cost.Proposal 1 is needed to avoid double compensation issue. In Rel-16 specification we leave the implementation up to the UE and gNB while the detailed procedures should be discussed in Rel-17. |
| OPPO (R2-2000705) | Proposal 1: a threshold, e.g., RSRP or RSRQ could be set by gNB. Only when the measurement result of UE is lower than the threshold, UE needs to perform random access for obtaining TA value for propagation delay compensation.Proposal 2: dedicated RACH resource should be assigned to UE for performing RACH for TA acquisition only.Proposal 3: down selection of two choices: a negative confirmation MAC CE or a RAR with an indication of necessity of propagation delay compensation at UE side but no UL grant inside it should be made for gNB to send a reply to UE if gNB decides that propagation delay compensation at UE side is not needed. | Current methods to provide TA to the UE were not designed for the sake of propagation delay compensation for time reference information and enhancements are required in this area. |

Summary:

There are several issues related to propagation delay compensation, which are raised by the companies:

1. Is UE allowed to perform propagation delay compensation for reference time received from the network?
2. Do we specify how propagation delay compensation is applied by the UE?
3. How can the UE know whether it needs to compensate the received reference time for the propagation delay?

On issue 1 and 2, the following proposals are made:

**Option 1:** UE may perform propagation delay compensation, but we don’t specify how the UE perform propagation delay compensation. (CATT, Ericsson, LG, Samsung, Nokia, CMCC, vivo)

**Option 2:** UE may perform propagation delay compensation based on N\_TA × Tc/2 (ZTE, China Southern Power Grid)

**Option 3:** Not specify anything related to propagation delay compensation. (Huawei, Qualcomm)

There is slight majority in favor of option 1 and additionally two companies expressing preference for option 3 indicate also that they would not object to the tentative agreement from the previous meeting (Option 1).

On the third point indicated above, the following proposals are made:

**Option 1:** There is no signalling from the network to indicate to the UE when it can or cannot perform propagation delay compensation. (Ericsson, LG, Samsung, Huawei)

**Option 2:** The network can indicate to the UE when (not) to do delay compensation (CATT, Nokia, ZTE, China Southern Power Grid, CMCC, vivo, Qualcomm)

There is a majority in favor of option 2. Supporters of option 1 prefer to specify a solution in Rel-17 while supporters of option 2 indicate that applying propagation delay compensation in small cell environment can decrease the accuracy of the synchronization and that there is a risk of double compensation. Since one of the companies indicating support for option 1, indicated that they would not object to option 2, it is proposed to follow this option.

Furthermore, it has been proposed to clarify that the timing information is referenced at the network side, as in LTE.

It is also proposed not to discuss optimizations with respect to TA delivery/request in Rel-16.

**Proposed way forward after online discussion:**

Since it seemed impossible to agree on specifying any signalling related to UE propagation delay compensation, it is proposed not to pursue this. Considering this, it seems very important to clarify that the reference time is referenced at the network, without compensating for the RF delay as otherwise it is unclear what the reference time actually refers to. It is proposed to copy the sentence which is captured in 36.331 specifications, i.e.:

“The indicated time is referenced at the network, i.e., without compensating for RF propagation delay.”

**Proposal 1: Capture for the reference time information in 38.331 that “The indicated time is referenced at the network, i.e., without compensating for RF propagation delay.”**

**Question 1: Do you agree with Proposal 1?**

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| **Company**  | **OK / NOK** | **Rationale** |
| Qualcomm | OK | In the interest of progress, we are okay to proceed with this proposal. A proper design for propagation delay compensation will happen in Rel-17 anyway. |
| Samsung | OK | For Rel-16, we can follow LTE rule. |

It was a common understanding that propagation delay compensation may be done by UE implementation, but there were different views on whether this should be captured in the specifications. It is then proposed to first agree that:

**Proposal 2: In Rel-16, propagation delay compensation may be done by UE implementation.**

**Question 2: Do you agree with Proposal 2?**

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| **Company**  | **OK / NOK** | **Rationale** |
| Qualcomm | OK | With the understanding that the specification will not mandate how the UE does this, this option in-theory allows interested deployments to procure UEs with the right behavior. However, we don’t expect in Rel-16 timeframe that any realistic deployments will actually need to do this, because the focus is on small-area coverage cases. |
| Samsung | OK |  |

It was a common understanding that this potential agreement would not impact Stage-3 specifications. The question is whether we should mention anything on this topic in Stage-2 specifications:

**Question 3: Which option do you prefer and why:**

**Option 1:** Capture in Stage-2 specifications that propagation delay compensation can be done by the UE based on implementation.

**Option 2:** Do not capture in Stage-2 specifications that propagation delay compensation can be done by the UE based on implementation.

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| **Company**  | **Preferred option** | **Rationale** |
| Qualcomm | Option 2 | Such specification would have been necessary or at least useful if there were any interoperability issues to address.We don’t see any UE-gNB interoperability elements in this feature especially after ruling out P2a (related to network signalling to prohibit propagation delay compensation). |
| Samsung | Option 1 | Specification should provide at least a rough guideline to UE implementation to avoid misunderstanding of NW behavior. Stage-2 specification is a perfect place for this. |

**Proposal 3: TBD.**

## 2.2 Determination of the need for reference time information for any given connected UE

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| Company (Tdoc) | Proposals | Rationale |
| Huawei, HiSilicon (R2-2000428) | Proposal 1: UE can send request for reference time information when needed. | “According to the reply from SA2, SA2 will not send any additional information to NG-RAN to determine the need for reference time delivery. So there may be cases where UE needs reference time information while the gNB doesn’t offer timely. This may lead to difficulties for UE to perform time sensitive communications. In order to better support TSC, it is necessary for UE to initiate the request for reference time information when needed.” |
| Proposal 2: Support RRC\_CONNECTED UEs to request SIB9 with reference time information from the gNB in IIOT.Proposal 3: It is up to gNB implementation to perform BWP switching to enable SIB9 receiving or send reference time information through unicast RRC signalling if the requesting UE cannot receive the SIB9 on the current BWP. | “UE may not be able to receive the timing information from SIB9 due to the absence of the searchSpaceOtherSystemInformation IE from the configuration of the active downlink BWP.” Hence, it should be possible for RRC\_CONNECTED UE to request SIB9 delivery via OSI mechanism.  |
| Vivo(R2-2000489) | Proposal 1: The report of the UE interest of the reference information reuses the signalling procedure as already agreed for the CONNECTED on-demand SI as follows:* The UE is allowed to report its interest of reference time information when the SIB1 indicates that SIB9 is an on-demand SIB (i.e. *si-BroadcastStatus* is set to *notBroadcasting*).
* The UE interest of reference time information is reported via the *DedicatedSIBRequest* message.

Proposal 2: The UE interest of reference time information includes 1 bit indication on whether the UE needs to acquire the reference time information. Proposal 3: The UE interest of reference time information includes 1 bit indication on whether the required time type is *localClock*.Proposal 4: RAN2 is kindly requested to discuss how the gNB sends the dedicated reference time information again to the UE due to the UE’s clock shifting after the first transmission of the reference time to the UE.  | OSI mechanism can be reused for the sake of SIB9 request, but for IIOT use case some additional information is required, i.e. whether the request is for reference time information and whether the requested clock is a local clock. Furthermore, the UE may require to be updated with the reference time information periodically and it is unclear how the gNB may identify such need. |
| Ericsson(R2-2000787) | Proposal 1: No additional RRC standardization efforts are needed to allow the UE to request accurate reference information.Proposal 2 : For the SIBs related to NR IIoT WI (i.e., SIB9), the on-demand SIB request feature for RRC\_CONNECTED UEs is not supported. | Based on SA2 reply it is concluded that NG-RAN has sufficient information to determine that a UE needs accurate reference timing. It is then proposed not to specify dedicated request solution nor support OSI in RRC\_CONECTED for SIB9. |
| Nokia, Nokia Shanghai Bell(R2-2001048) | Proposal 1: There should be a mechanism for UE in RRC\_CONNECTED mode to explicitly request the accurate reference time delivery from gNB.Proposal 2: UEAssistanceInformation message shall be used by the UE to request reference time delivery from the gNB. | Even though SA2 discussed the topic, they decided no to specify any solution in Rel-16. Hence, there is no way for gNB to know whether the reference time information is required by the UE. It is proposed to use UE assistance information procedure for such indication so that it is possible to differentiate whether the UE requires timeInfoUTC or referenceTimeInfo. |
| ZTE Corporation, Sanechips, China Southern Power Grid Co., Ltd(R2-2001233) | Proposal 1: It’s suggested to provide an accurate reference timing request indication, e.g., in RRC Msg5 for indicating whether accurate reference timing delivery by unicast is needed by the UE. Proposal 2: It’s suggested to also optionally indicate an accurate reference timing delivery periodicity from the UE to the eNB. | According to SA2 reply LS, there is no possibility to determine the need of reference time information at the UE. It does not make sense to deliver the information for UEs which do not use TSC service. Furthermore, the periodicity with which the UEs need to receive the information depend, e.g. on the quality of UE’s internal clock.  |

Rapporteur’s summary:

Companies seem to agree that sending unnecessary reference time information is wasteful from both network and UE perspective (e.g. waste of resources, processing and battery). Most companies (Huawei, vivo, Nokia, ZTE) indicated that SA2 reply LS means that there is no way for RAN to now whether the UE requires to be provisioned with refence time information while one company (Ericsson) thought it means that there is sufficient information for RAN to know this. It should be noted that neither SA2 LS nor any contribution clarifies how this could be possible while it was indicated that gPTP is using user plane and hence is transparent for RAN.

There are several options indicated in the contributions from the companies:

**Option 1:** Reuse on-demand SI request in RRC\_CONNECTED mechanism for SIB9. (Huawei)

**Option 2:** Reuse on-demand SI request in RRC\_CONNECTED mechanism for SIB9 with additional assistance information. (vivo)

**Option 3:** Utilize UE assistance information procedure. (Nokia)

**Option 4:** Add indication in message 5. (ZTE, China Southern Power Grid)

There is no clear majority for any of the options. The topic should be discussed further and it would be worth considering such factors mentioned by the companies such as:

* reference time information may be required by the UE periodically
* for unicast, reference time information has a dedicated message, i.e. DLInformationTransfer
* SIB9 may contain both timeInfoUTC and referenceTimeInfo fields
* The need for reference time information from the UE may change during the duration of the connection

**Continuation of the discussion:**

It seems to be a common understanding that the network needs to be able to determine whether a certain UE requires to be provided with reference time information at a given time. During the online session, there were different views on whether this can be done already based on information from Core Network or not. It is then proposed to gather companies understanding on this issue by discussing the following question:

**Question 4: In your opinion, is it possible for RAN to determine, based on information from Core Network, that a certain UE requires to be provided with reference time information at any given time? If yes, please explain how and provide references to the related 3GPP specifications.**

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| **Company** | **Yes/No** | **Comments** |
| Qualcomm | Yes | RAN can determine need for reference timing based on information received from core network by using an existing N2-SM parameter (S-NSSAI) can be used to inform NG-RAN about the need for reference time delivery:* UEs which are required to receive time synchronisation information are configured with a specific S-NSSAI.
* Based on local NG-RAN configuration, if NG-RAN serves at least one UE that has a PDU session with an S-NSSAI that is locally configured for reference time delivery, then NG-RAN delivers 5G reference time information.

Independent of whether RAN can determine need for reference timing based on information received from core network, we believe there is value in UE being able to request reference timing since above S-NSSAI based approach may not always be implemented. |
| Samsung | Yes | According to SA2 LS, they said there is no need to send “additional” information. Our understanding of this conclusion indicates that there are some mechanisms for NW to know the presence of UEs requiring timing information but SA2 does not want to introduce a new “additional” information.Regarding the exact way to know, S-NSSAI can be used. QoS related information, e.g. TSCAI can be used. Also, gNB can implicitly acquire the information from UE’s capability reporting on IIOT feature. Although those information may not be perfect, we think NW can use those information if NW wants to reduce the signalling. |

**Proposal 4: TDB**

Since most of the submitted contributions proposed to rely on AS mechanism to request time information, it is also requested for the companies to provide their preferences for the options identified previously in the summary:

**Question 5: Considering that AS mechanism is required, which is your preferred option for the UE request of reference time information and why:**

**Option 1:** Reuse on-demand SI request in RRC\_CONNECTED mechanism for SIB9

**Option 2:** Reuse on-demand SI request in RRC\_CONNECTED mechanism for SIB9 with additional assistance information

**Option 3:** Utilize UE assistance information procedure

**Option 4:** Add indication in message 5

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| **Company** | **Preferred option**  | **Rationale** |
| Qualcomm | Option 1 | We don’t have a strong view however, and are also okay to defer this decision to a later meeting.We don’t see value in any specific assistance information. |
| Samsung | Option 3 | We have a concern on on-demand SIB. ReferenceTimeInfo is included in SIB9, which is Rel-15 SIB not Rel-16 SIB. If we allow request for Rel-15 SIB, then the UE needs to know whether the gNB supports this feature or not. If the UE does not know, then UE sends unnecessary SI request which Rel-15 gNB does not understand. However, if we restrict to Rel-16 SIBs then based on the schedulinginfo UE knows that the gNB supports Rel-16 SIBs. If reference timing is included in Rel-16 SIB then we are fine with on-demand SI request. But if reference timing is already present in SIB9 and there is no need for new Rel-16 SIB, then Option3 is preferred.Another aspect is that on-demand SI request may be used only for SIB reception or dedicated transfer in RRCReconfiguration message. It cannot be used for DL information transfer. |

**Proposal 5: TBD**

## 2.3 Other issues

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| Company (Tdoc) | Proposals | Rationale |
| vivo(R2-2000491)Related TPs in:* R2-2000492 (38.331)
* R2-2000493 (36.331)
 | Proposal 1：Support the acquisition of the NR reference time for UE in EN-DC operation.Proposal 2: The reference time of the NR PSCell is provided to the UE via dedicated signaling. | Depending on the operator deployment, a variety of network architectures and UE types will co-exist and it may happen that an EN-DC UE is used to transmit/receive TSC service data. Proposal 2 is given to simplify the UE and network implementation. |
| Qualcomm(R2-2001297) | Proposal 2: Once a RRC connected UE receives timing via unicast, it shall only use timing received via unicast while it is RRC connected. | There can be situations where the network broadcasts reference time information and at the same time sends it via unicast signalling to certain UEs. It should be clarified which information is applied by the UE in this case. |
| CMCC (R2-2001426) | Proposal 5: if the UE received the instructions are conflict between what it received in DLInformationTransfer message and the information received in SIB9 message, the field received in DLInformationTransfer message allows overriding the field received in SIB9 message. | The reference time information received in SIB9 may different from the one received in DLInformationTransfer message. |

Companies raise two additional issues:

* Support of accurate reference time provisioning for UEs in EN-DC
* Which is the valid reference time information for the UE in case UE receives it via both unicast and broadcast signalling

For the first issue, modifications are proposed for 36.331, but it is unclear whether such EN-DC enhancements are in the scope of NR IIOT WI.

For the second issue, both companies raising the issue propose similar solution.

It should be noted though that specifying priority between unicast and broadcast time seems to arise certain issues, e.g.

* Once the UE receives the time information via unicast, isn’t it allowed to apply the one from SIB9 for the duration of the connection? What if the source and target clock drift and information needs to be updated?
* In case it is allowed to fall back to broadcast info, do we need to specify when the UE is allowed to do that?

It is also unclear whether priority between unicast and broadcast reference time information is something that would require specification or could be left to UE implementation.

**Continuation after online session:**

During the online session it was clarified that EN-DC specific enhancements should not be pursued, so it is proposed to agree:

**Proposal 6: No EN-DC specific enhancements are pursued for accurate reference time objective of Rel-16 IIOT WI.**

**Question 6: Do you agree with Proposal 6?**

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| **Company** | **OK / NOK** | **Comments, if any** |
| Qualcomm | OK |  |
| Samsung | OK |  |

The issue of the valid reference time information for the UE in case UE receives it via both unicast and broadcast signalling has not been discussed during the online session. Companies are then requested to provide their views on the following:

**Question 7: Do you think it is required to specify that: “If the UE received different reference time information via DLInformationTransfer message and via SIB9 message, the field received in DLInformationTransfer message takes precedence over the field received in SIB9 message.”**

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| **Company** | **Yes / No** | **Rationale** |
| Qualcomm | No if P1 is agreed | Nothing to specify because both times are same if P1 is agreed.  |
| Samsung | No | Both DLInformationTransfer and SIB9 are transmitted by one gNB which should provide the same timing information. If UE uses a single propagation delay compensation mechanism, UE does not receive significantly different timing information. Thus, we do not need to specify it and we can leave it to UE implementation. |
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**Proposal 7: TBD**

# 3 Conclusions

# 4 List of referenced documents

1. R2-19142213 LS to SA2 on reference time delivery, Source: RAN2
2. S2-1912769 Reply LS on reference time delivery, Source: SA2
3. R2-2000110 Remaining Issues on Propagation Delay Compensation CATT
4. R2-2000427 Discussion on propagation delay compensation Huawei, HiSilicon
5. R2-2000428 Remaining issues of reference time delivery Huawei, HiSilicon
6. R2-2000489 UE report of the TSC interest vivo
7. R2-2000490 Discussion on propagation delay compensation in rel-16 vivo
8. R2-2000491 Discussion on provisioning of timing information for EN-DC vivo
9. R2-2000492 TP on 38.331 of provisioning of timing information for EN-DC vivo
10. R2-2000493 TP on 36.331 of provisioning of timing information for EN-DC vivo
11. R2-2000705 Consideration on propagation delay compensation for TSC OPPO
12. R2-2000786 On downlink delay compensation Ericsson, LG, Samsung
13. R2-2000787 On UE need for time synch Ericsson
14. R2-2001047 Propagation delay compensation Nokia, Nokia Shanghai Bell
15. R2-2001048 Determining the need for accurate reference time delivery Nokia, Nokia Shanghai Bell
16. R2-2001212 Propagation Delay Compensation in TSC ZTE Corporation, Sanechips, China Southern Power Grid Co., Ltd
17. R2-2001233 Request for accurate reference timing delivery in TSC ZTE Corporation, Sanechips, China Southern Power Grid Co., Ltd
18. R2-2001297 Open issues in Accurate Reference Timing Delivery Qualcomm Incorporated
19. R2-2001426 Remaining Issues for Propagation Delay Compensation CMCC
20. R2-2001427 TP on IIoT Running RRC for Propagation Delay Compensation CMCC