3GPP TSG-RAN WG2 #110-e R2-20xxxxx

Electronic meeting, 1th - 12th June, 2020

Agenda Item: 6.7.2.1(NR\_IIOT-Core)

Source: NTTDOCOMO, INC.

Title: Report of email discussion [AT110-e][053][IIOT] Accurate Reference Time (NTT DOCOMO)

Document for: Discussion and Decision

# 1 Introduction

This document is to report the summary of the following email discussion:

* [AT110-e][053][IIOT] Accurate Reference Time (NTT DOCOMO)

Scope: Address the following FFSes: FFS 1 whether the UE is allowed to send the same interest message again. FFS 2 the need for a prohibit timer T346. Can also address other proposals provided in the documents under 6.7.2.1 if there is interest (proponents will need to push and explain).

 Intended outcome: Agreements

 Deadline: June 5, 0700 UTC

# 2 Issue summaries

## 2.1 Clock drift issue

In [1]-[10], most of the papers showed the reasoning of resending referenceTimeInfo interest message to the network is based on the concern of UE clock drift. Regarding this clock drifting issue, [8] point out UE can always calculate the reference timing based on DL timing information after receiving the reference time from gNB once. TS 38.331 already specified that“if the referenceTimeInfo field is received in DLInformationTransfer message, the time field indicates the time at the ending boundary of the system frame indicated by referenceSFN”, so the question is whether the time provided by gNB can be always computed/predicted if UE has received *referenceTimeInfo* from gNB once. In detail, whether gNB implementation always provide reference time in a predictable way, i.e. time2 - time1 = (referenceSFN2 - referenceSFN1) \* 10 ms, with the pairs (time1, referenceSFN1), (time2, referenceSFN2) corresponding to two reference time provisioning instances. If this is common understanding among companies, there is no need to resend referenceTimeInfo interest message to the network for resolving clock drift issue.



**Figure 1: Reference time provisioning at gNB side [8]**

**Question1. Whether gNB implementation always provide reference time in a predictable way, i.e. time2 - time1 = (referenceSFN2 - referenceSFN1) \* 10 ms, with the pairs (time1, referenceSFN1), (time2, referenceSFN2) corresponding to two reference time provisioning instances?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Ericsson | Yes | What is delivered from the gNB to the UE is called 5G GM clock, see clause 5.27.1.1 in TS 23.501. Note that gNB is synchronized to the 5G GM clock. Any reasonsable implemenation would synchronize the gNB internal clock (used to derive SFN duration) and the 5G clock. Keeping two separate high-accurcy clocks is costly.  |
| Qualcomm | Yes | Agree with Ericsson. However, we also believe that the answer to this quesiton does not have any specificaiton impact. |
| DOCOMO | Yes | Agree with Ericsson. |
| OPPO | YES |  |
| vivo | No | The 10ms granularity of SFN may not be aligned with the 10ms granularity of the reference time, as the clocks of the SFN and reference time coudl be different. Given that the reference time in the current specificaiton can be a localTime type. |
| CATT | Yes | Answering vivo: in our understanding the UE’s clock is synchronized to the gNB’s clock within +/- 0.1 PPM, per RAN4 requirements. And if it is the TSN working clock which is unstable compared to those, it belong to gNB to derive how frequently it must refresh the reference time (as discussed in SA2’s TR23.734 [5] Section 6.11.1).  |
| Samsung | Yes | gNB has a responsiblitiy to provide the timing informaiton periodically to avoid clock drift. |
| III | Yes | Agree with Ericsson and CATT’s view.  |
| Huawei | Yes, but | gNB implementation can guarantee a predictable provisioning. gNB’s clock is no worst than 0.1 PPM. When the UE clock is used to determine the SFN boundary, the error of adjacent SFN boundary is no more than 1ns, which is enough for IIoT applications. However UE couldn’t always track SFN boundary (would bring much complexity in UE), this is the reason why reference time deliveries from gNB “from time to time“ are needed. |
| Nokia | Yes if clock type iss et to 5GS clock | We agree with vivo that with localTime clock type there will be drift. On the other hand, since the network is delivering this clock, the n it can determine the periodicity with which it has to be to delivered. |
| ZTE | No | Even the gNB‘s clock needs to be synchronized to the MasterClock (UTC or GPS clock), it’s still possible that gNB‘s clock also drift. Therefore, we don’t think gNB implementation can always provide reference time in a “predictable“ way. We can agree it may be possible that gNB can provide time information occasionally, e.g., only when the clock drift in gNB reaches a certain level. Here the thinking is, the gNB only need to consider the clock drift in itself but don’t need to estimate the expected time delivery periodicity for any certain UE (it’s also infeasible for gNB to do this). |

**Question2. Whether UE can always calculate the reference timing based on DL timing information after receiving the reference time from gNB once i.e the time provided by gNB can be always computed/predicted by UE if UE has received *referenceTimeInfo* from gNB once?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Ericsson | Yes | Without updates from gNB, UE uses its internal oscillator to calculate the reference time. If UE is in connected, UE can lock its internal oscillator to the gNB’s oscillator and synchronize to gNB’s carrier frequency. There is a mandated mandated RF transmission frequency accuracy requirement of 100ppb (see clasue 6.4.1 from TS 38.101-1).

|  |
| --- |
| The mean value of basic measurements of UE modulated carrier frequency shall be accurate to within ± 0.1 PPM observed over a period of 1 ms of cumulated measurement intervals compared to the carrier frequency received from the NR Node B. |

Assume a linear timing drift based on the max 100ppb, there is a 100ns uncertainty within 1 second. In practice, UE can track the gNB frequency much better than mandated RF transmission, and can be within 10ppb. |
| Qualcomm | Yes | Repeating Qualcomm comment from email discussion:Once the UE receives referenceTime=t corresponding to a frame boundary n, the UE can calculate time for any frame boundary k>n as t+(k-n)T, where T is the deterministic duration of a frame as defined by RAN1.  We assume that the UE remains connected to the gNB and can track frame boundaries for any k>n. Clock drift at the UE only becomes an issue if the UE can no longer track the frame boundaries and ends up relying on an internal clock, e.g. when going out of gNB coverge. We don’t think that is a case of interest anyway.  |
| DOCOMO | Yes | Agree with Ericsson and Qualcomm. |
| OPPO | YES | Agree with Ericsson and Qualcomm. |
| vivo | No | The UE implementation based solution is quite complicated, as it requires the UE to trace the SFN even when the SFN wraps around. Given the reason provided in Question 1, we don’t think the SFN offset based solution can work properly. |
| CATT | Yes | Same understanding as Ericsson and Qualcomm. |
| Samsung | Yes | Same understanding as Ericsson and Qualcomm. |
| III | Yes | Agree with Ericsson and Qualcomm’s view. |
| Huawei | Yes, but | This will incur high UE complexity and goes against the motivation of reference time delivery in RRC connected state. |
| Nokia | Yes if the clock type iss et to 5GS | UE has to synchronize to a cell anyway to receive/transmit data, also in IDLE mode to receive SI, do measurements etc. Hence, we do not hink this sjhould be an issue for any UE. There can be drift if the clock is set to local time, but this is known to the network. |
| ZTE | Not sure | As we don’t think the UE can always predict the time provided by gNB if UE has received referenceTimeInfo from gNB only once (in another word, only if gNB’s clock doesn’t drift, UE may be able to do such prediction), we are not sure UE can always calculate the (accurate) reference timing based on DL timing information.  |

## 2.2 Whether UE resend the same interest message

Regarding whether UE is allowed to resend the same interest message, since it is related to Q1/2, so firstly it is necessary to confirm companies with the following understanding:

**Question 3. Do companies agree with the following understanding? If not, please explain the reasons.**

***If UE can always calculate the reference timing based on DL timing information after receiving the reference time from gNB once, then there is no necessity for UE to resend the same interest message to network.***

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Ericsson | Yes |  |
| Qualcomm | Yes |  |
| DOCOMO | Yes |  |
| OPPO | Yes |  |
| vivo | No | Same reasons as given in Question 2 and 3. |
| CATT | Yes |  |
| Samsung | Yes |  |
| III | Yes |  |
| Huawei | Yes, but | Same reasons as given in Q2/Q3 |
| Nokia | Yes |  |
| ZTE | Yes, but | With comments for Q1 and Q2, we think this may be only an ideal assumption. |

If the answer for Q1/2 are negative (UE could not calculate the time information based on DL timing information), then it is necessary to discuss how to resolve the clock drift issue with the following candidate solutions proposed by companies.

* Option1. Once UE send the interest request, UE rely on periodic gNB broadcast to refresh its reference time and should no longer resend the request to the network as proposed in [2]. (No change is needed in current RRC CR);
* Option2. Once UE send the interest request, since UE cannot resend UEAssistanceInformation message with referenceTimeInfoInterest set to true, UE may toggle referenceTimeInfoInterest to false, and toggle referenceTimeInfoInterest to true again to request gNB to send the time information [5][8]. (No change is needed in current RRC CR);
* Option3. Adding a level 2 condition, once UE send the interest request, UE toggle referenceTimeInfoInterest to false as proposed in [7]. (change is needed in current RRC CR);
* Option4. Once UE send the interest request with referenceTimeInfoInterest set to true, UE is allowed to resend UEAssistanceInformation message with referenceTimeInfoInterest set to true again. (change is needed in current RRC CR) [6] [8].

**Question 4. If UE could not compute/predict the time information itself due to clock drift issue, which solution is preferred as mentioned above?**

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| --- | --- | --- |
| **Company** | **Preferred Option** | **Comment** |
| Ericsson | 1 | Even if Ericsson answers postively to the Q1/2, Ericsson would like to point out gNB would be implemented according to the option 1, i.e., gNB periodically broadcast/unicast. This is to ajdust accumulated errors when UE uses its internal oscillator to calculate the time, account for random channel variations, and potentially used for propagation delay compensation, etc. The periodicity depends on the deployment scenario, the UE/gNB implemenation and the end-to-end synchronization accuracy. Note that SIB9 is anyway a periodically broadcasted message.  |
| Qualcomm | 1 | If is gNB responsibility to resend timing if it has internal clock drift for any reason whatsoever.  |
| DOCOMO | 1 | Agree with Ericsson and Qualcomm. |
| OPPO | 4 | Different UE model may have different UE clock drift performance, which leads to the problem that relying on gNB periodic broadcast might not sufficient for at least some Ues to mitigate the issue. Considering this, UE on-demand request might be a better choice, or UE should be allowed to provide the clock drift related information in the UEAssistanceInformation for gNB to choose a proper periodicity for unicasting the clock information to UE. |
| Vivo | 4 | Option 1 would only work for the broadcast solution. There is no point to periodically and frequently send the reference time information even though the reference time information is not required so frequently by the UE. |
| CATT | 1 | Network needs to periodically refresh Ues with the reference time. As discussed in SA2’s TR23.734 [5] Section 6.11.1, this is also to cope with variations of the TSN working clock itself. But assuming an ideal TSN working clock reference, given both gNB and UE’s clock requirements associated with the max tolerated RF frequency errors (TS 38.104, TS 38.101-1), we derive in [2] that the network only needs to deliver the reference time at most every 5s to remain within the 1 µs requirement.  |
| Samsung | 1 |  |
| III | 1 | Agree with Ericsson and CATT’s view. |
| Huawei  | 4 | Even UE is allowed to send the same interest request with referenceTimeInfoInterest, we don’t think there is too much signaling penalty. The gNB implementation can adapt the periodicity of reference time delivery and after a few times (at most) there is no need for UE to send the request any more |
| Nokia | Neither | We don’t think this is needed, but if it was then the most reasonable approach is to allow the UE to indicate the required periodicity of reference time updates. All the proposed solutions here are sub-optimal workarounds. Furthermore, we are not sure how Option 1 can work, i.e. if the problem is on UE side, then how is gNB supposed to know what the limitations on UE side are and how often it is supposed to resend information? |
| ZTE | Maybe 4 | We are confused with option1, what does it mean “periodic gNB **broadcast**“? I think what we are talking about is UE-specific request e.g., *UEAssistanceInformation* (note that we already reject on-demand SI), so the only reasonable way is that gNB **unicasts** the clock information to UE as response.With such correction for option 1 and also with the reason mentioned by OPPO, we think it’s infeasible for gNB to unicast the clock information with a periodicity suitable for this certain UE. Option 2 and Option 3 may cause strange procedures, so no need to consider.Option 4 can be considered together with prohibit timer since it’s feasible.  |

Regarding resending the same interest message, another issue is pointed out in [6] that UE may frequently resend the referenceTimeInfo interest request during a short period of time if no reference time information is received i.e. network missed receiving the request from UE or UE missed receiving referenceTimeInfo from network. While in [10], it mentioned RRC message should not be lost, which is guaranteed by RLC AM.

**Question 5. Is there a possibility UE who is configured with referenceTimeInterestReporting-r16 send the referenceTimeInfo interest message to network but no reference time information is received from network?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Ericsson | No | RAN2 does not assume the RRC message can be lost. The reliable delivery is guranteed by lower layers, such as RLC AM and HARQ retransmission.  |
| Qualcomm | No | It is possible due to bad network implementation. But this is not something to be solved in the specificaiton. |
| DOCOMO | No |  |
| OPPO | NO | Agree weith Ericsson |
| vivo | No |  |
| CATT | No | We have the same understanding as Ericsson |
| Samsung | No | AM message is never lost. |
| III | No | Same understanding as Ericsson |
| Huawei | No |  |
| Nokia | No | This may happen due to some outage on the network side, but in such a case resending the request does not help at all. |
| ZTE | Yes | It’s not message lost. We just think *UEAssistanceInformation* is not a message that mandatorily to be replied. |

## 2.3 Whether prohibit timer T346 is needed

Regarding whether the prohibit timer T346 is needed, since it is highly related to discussion result of previous Q1/2/3/4, so it is necessary to confirm companies with the following understandings 1~4 one by one:

**Question 6. Do companies agree with the following understanding? If not, please explain the reasons.**

1. ***If UE can always calculate the reference timing based on DL timing information after receiving the reference time from gNB once, then there is no necessity for UE to resend the interest message to network and prohibit timer T346 is not needed [8].***

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Ericsson | Yes | Interest message is one-shot, i.e., there is no need for UE to re-send the interest message.  |
| Qualcomm | Yes |  |
| DOCOMO | Yes |  |
| OPPO | Yes |  |
| vivo | Yes |  |
| CATT | Agree | For the very same reason as indicated by Ericsson (on-shot request). |
| Samsung | Yes |  |
| III | Yes |  |
| Huawei | Yes |  |
| Nokia | No | There is no need to resend the message, but the prohibit timer is still needed due to the reasons mentioned under Question 7 below. |
| ZTE | Yes, but | With comments for Q1 and Q2, we think “*UE can always calculate the reference timing based on DL timing information*“ may be only an ideal assumption. So it cannot rush to conclude that Interest message is one-shot. |

**Question 7. Do companies agree with the following understanding?**

1. ***Since current RRC CR allow UE to toggle referenceTimeInfoInterest to false, and toggle referenceTimeInfoInterest to true again to request gNB to send the time information (properly implemented UE may not toggle the field often or even if does toggle the field frequently, the network can choose to disable the reporting by releasing the configuration referenceTimeInterestReporting), a prohibit timer T346 would be a safe approach to mitigate the UL signaling overhead [5].***

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| **Company** | **Yes/No** | **Comment** |
| Ericsson | Yes | If it can be confirmed that the interest message is one-shot, then the benefit of the prohibit timer is limited. Nevertheless, as there are still ongoing disucssions and the prohit timer T346 has been introdcued for other UE assistant information, it would be good to introduce it too here. |
| Qualcomm | No | There is no need for a prohibit timer because UE has no need to resend the message. Prohibit timer suggests that there is a valid case when UE resends the message, which is not the case. |
| DOCOMO | No | Agree with Qualcomm. |
| Vivo | Yes, but | The prohibit timer should not prohibit the report of the toggled/changed interest. |
| CATT | No | Based on the on-shot principle, a UE using this technique to request the reference time periodically would be a bad UE impementation and the network can just disable its UAI for reference time. |
| Samsung | Yes | Agree with vivo. The prohibit timer should not prohibit the report of the toggled/changed interest |
| III | No | Agree with Qualcomm |
| Huawei | No | The network shall be able to turn off UE reporting through realeasing *referenceTimeInterestReporting* such that there is no need for a prohibit timer T346. |
| Nokia | Yes | We do not agree with the comment from QCM. If we look at how this is defined for other kinds of assistance information, we see that prohibit timer is used to protect the network from UE frequently changing its assistance information. UE assistance procedure is designed in such a way that the UE never resends the same information and this is not the purpose of prohibit timer. Hence, the prohibit timer is needed specifically to protect the network from bad UE implementations, e.g. such that would toggle their interest back and forth for some reason. |
| ZTE | Yes, but | Tend to agree with vivo and Nokia. |

**Question 8. Do companies agree with the following understanding?**

1. ***If UE is allowed to resend UEAssistanceInformation message with referenceTimeInfoInterest set to true again after it previously sending UEAssistanceInformation with referenceTimeInfoInterest also set to true, a prohibit timer T346 is needed to mitigate the UL signaling overhead [8].***

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| **Company** | **Yes/No** | **Comment** |
| Ericsson | Yes | In this case, the prohit timer T346 is a must. There would not be any condition on when UE can trigger the same interest message. Thus, it cannot be guranteed that the UE does not send the interest message frequently. |
| Qualcomm | N/A | UE has no reason to resend the message. |
| DOCOMO | Yes | Though a prohibit timer is needed in this case, we still believe UE dont‘ need to resend the interest message. |
| Vivo | Yes |  |
| CATT | Yes | But only with this type UAI design (which is different from the one-shot request currently capturedin RRC CR). |
| Samsung | N/A | No need to send the same message. |
| III | Yes | But UE doesn’t need to resend the interest message.  |
| Huawei | No | Don’t think the prohibit timer T346 is useful, UE will only request the reference time when the reference time info is not up to its use. Don’t think UE implementation would be so unreasonable to repeat the same reference time request very frequently. |
| Nokia | Yes | If that would be allowed, the prohibit is even more important, but as explained above, this is not its main purpose currently as the UEs are not allowed to resend the same information in UE assistance info message. |
| ZTE | Yes | Per our understanding, the reasons for UE to resend messages may be as following:1. UE cannot always calculate the reference timing based on DL timing information, so UE needs to (re)request time info based on its own expected frequency/periodicity.2. the *UEAssistanceInformation* may not be responsed immediately.  |

**Question 9. Do companies agree with the following understanding?**

1. ***Even UE is allowed to resend reference time information request , considering the overload concern for UE signalling could be solved by gNB implementation, and the UE-frequently-requiring scenario wouldn’t be realistic, so prohibit timer T346 is not needed [7].***

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| **Company** | **Yes/No** | **Comment** |
| Ericsson | No | The same as to Question 8. There would not be any condition on when UE can trigger the same interest message. Thus, it cannot be guranteed that the UE does not send the interest message frequently. |
| Qualcomm | Yes | UE has no reason to send the message twice. |
| DOCOMO | No | If UE is allowed to resend the interest message, a prohibit timer would be a safe approach. |
| OPPO | Yes | If UE is allowed to send the interest message for multiple times, then the prohibit timer should be leaveraged. |
| Vivo | No strong view | In most cases the UE with good clock will not sent the message very frequent. |
| CATT | ? | Not sure to get the question. How is this question different from Q7? Or Q9? Again, from our perspective:- if the UAI design allows the UE to send consecutive (same) reference time request (different from current RRC CR), then the prohibit timer is required.- if the UAI design is one-shot (as in current RRC CR), and the only way for the UE to request the reference time again is with the trick descibed in Q7 (via true/false toggling), then no prohibit timer is needed.  |
| Samsung | No | NW would need safer way. |
| III | No |  |
| Huawei | Yes |  |
| Nokia | No | We believe prohibit timer is needed regardless of whether the UE can resend the same message or not. |
| ZTE | No | With comments for Q8, we think at least *UE-frequently-requiring* scenario is possible. |

**Question 10. If there are other reasons showing T346 is necessary, please comment it bellow.**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
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## 2.4 Further enhancement

In [9], it mentioned since the clock accuracy of each UE might be different, setting them with a common timer might result in a problem UE with a worse clock drift cannot send the RRC message with *referenceTimeInfo* if needed. So it proposed the configuration of timer should take the UE clock accuracy performance e.g. clock drift rate into account.

**Question 11. Do companies agree with the following enhancement in rel-16?**

***A prohibit timer configured according to the UE clock accuracy performance should be introduced to prevent the UE from sending the RRC message requesting for the referenceTimeInfo IE too frequently, which saves transmission resource over uu interface.***

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Ericsson | Yes | This is covered by Question 7 and Question 8 above. In addition, how to set the exact timer value is up-to network implemeantion.  |
| Qualcomm | No | Why have a prohibit timer to prohibit a behavior that UE is not going to do anyway? (prohibit timer should just be assumed to have value infinity). |
| DOCOMO | No | We do not see necessity to introduce a prohibit timer in this release. |
| OPPO | Yes | As explained in the answer to Q4 |
| vivo | Yes, but | The UE clock accuracy performance is not known by the gNB so far. |
| CATT | No | Again it depends on the UAI design. With the one-shot design (current spec), we share the same understanding as Qualcomm. |
| Samsung | No | UE should not have such an inaccurate clock. |
| III | No | prohibit timer configured according to the UE clock accuracy performance can be discussed in next release |
| Huawei | No | 1. UE only requests reference time info when it is needed, 2. the signalling load of such reference time request won’t be significant, 3. gNB can always turn off UE’s request though “*referenceTimeInterestReporting*”, 4. setting the value of T346 for every UE would be difficult for gNB, too big or too small value will make this timer harmful/useless. |
| Nokia |  | Prohibit timer is needed as explained above. How the network chooses a value is up to network implementation, but it has nothing to do with clock drift as already indicated in section 2.1 by many companies. |
| ZTE | Yes, but | With the reason mentioned by vivo, it’s difficult for gNB to configure suitable time length for prohibit timer for a certain UE. gNB can only do this with best effort. |

## 2.5 Other issues

**Question 12. If there are any issues which are not mentioned in section 2.1~2.4, please comment it bellow.**

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| **Company** | **Yes/No** | **Comment** |
| ZTE | Yes | In current running CR, it’s not crystal clear which message would be used to response UE when the gNB receives request for reference time information from UE. Based on the output of email discussion in last meeting [R2-2004150], we understand the Option 1 is supported by majority and can be agreed, in which *DLInformationTransfer* is the only suitable response message. Therefore, we suggest to add some clarification to reflect this agreed understanding. |

# 3. Conclusion

TBD

# 4 References

1. R2-2004830 Remaining issues on Accurate Reference timing NTT DOCOMO, INC.
2. R2-2004585 Open issues on Accurate Reference Timing CATT discussion
3. R2-2004676 Remaining issues for accurate reference time request Nokia, Nokia Shanghai Bell
4. R2-2004736 Remaining issues on the UE request of the reference time vivo discussion
5. R2-2004957 Remaining details on UE request of reference time Ericsson discussion
6. R2-2005040 FFS for UE request for accurate reference timing ZTE Corporation, Sanechips, China Southern Power Grid Co., Ltd discussion
7. R2-2005152 Request of accurate reference time delivery Huawei, HiSilicon discussion
8. R2-2005300 On UE request of reference time provisioning Intel Corporation discussion
9. R2-2005340 Discussion on the need of prohibit timer and retransmission of the same interest message OPPO discussion
10. R2-2005646 Confirmation of UE assistance with referenceTimeInfoInterest Samsung discussion