**3GPP TSG RAN WG1 Meeting #103-E R1-200zzzz**

**e-Meeting, October 26th – November 13th, 2020**

**Source: Moderator (Intel Corporation)**

**Title: Summary #3 of RAN WG1 E-mail Discussion [103e-NR-ePos-02]- AI 8.5.2**

**Agenda item: 8.5.2**

**Document for: Discussion and Decision**

# Introduction

In this contribution, we continue discussion on observations captured based on overview of evaluation results provided in contributions submitted for Rel.17 NR Positioning Enhancements WI [1] - [17] and feature lead summary [18] as well as intermediate summary documents [19]-[20] for the RAN WG1 email thread [103e-NR-ePos-02].

We invite companies to provide their views on provided list of observations aiming to converge on evaluation conclusions to be captured in the 3GPP TR on NR Positioning Enhancements.

# Positioning Accuracy Evaluation

## Accuracy Evaluation for Rel.16 NR Positioning Solutions

### Horizontal positioning accuracy in IOO/UMi/UMa

#### Discussion Round #1

1. **(On positioning accuracy in UMa)**
   * **For the case without modeling synchronization and gNB/UE TX/RX timing errors in the UMa scenario**
     + **Based on the results provided by a majority of sources, 10 m level @ 80% of horizontal positioning accuracy is achieved by Rel.16 in UMa scenario**
     + **Results were provided by [2] sources (Ericsson R1-2008764, QC R1-2008618) out of [17] for FR1 band**
       - **For NR positioning evaluations for UMa scenario in FR1 band, the following is observed with respect to horizontal positioning accuracy:**
         1. **Accuracy of ≤** [**10m @ 80%**](mailto:0.2m@90%25) **is achieved in contributions from [2] sources (Ericsson R1-2008764, QC R1-2008618) out of [2] sources**
2. **(On positioning accuracy in UMi)**
   * **For the case without modeling synchronization and gNB/UE TX/RX timing errors in the UMi scenario**
     + **Based on the results provided by a majority of sources, 1 m level @ 80% of horizontal positioning accuracy is achieved by Rel.16 in UMi scenario**
     + **Results were provided by [3] sources (Nokia R1- 2008300, Ericsson R1-2008764, QC R1-2008618) out of [17] for FR1 band**
       - **For NR positioning evaluations for UMi scenario in FR1 band, the following is observed with respect to horizontal positioning accuracy:**
         1. **Accuracy of ≤** [**1m @ 80%**](mailto:0.2m@90%25) **is achieved in contributions from [2] sources (Ericsson R1-2008764, QC R1-2008618) and is not achieved from [1] source (Nokia R1- 2008300)**
3. **(On positioning accuracy in IOO)**
   * **For the case without modeling synchronization and gNB/UE TX/RX timing errors in the IOO scenario**
     + **Based on the results provided by a majority of sources, 1 m level @ 80% of horizontal positioning accuracy is achieved by Rel.16 in IOO scenario**
     + **Results were provided by [6] sources (CATT R1-2007859, Nokia R1- 2008300, Sony R1-2008364, Ericsson R1-2008764, QC R1-2008618, vivo R1-2007665) out of [17] for FR1 and [5] sources (CATT R1-2007859, Sony R1-2008364, Ericsson R1-2008764, QC R1-2008618, vivo R1-2007665) out of [17] for FR2 band**
       - **For NR positioning evaluations for IOO scenario in FR1 band, the following is observed with respect to horizontal positioning accuracy:**
         1. **Accuracy of ≤** [**1m @ 80%**](mailto:0.2m@90%25) **is achieved in contributions from [5] sources (CATT R1-2007859, Sony R1-2008364, Ericsson R1-2008764, QC R1-2008618, vivo R1-2007665) and is not achieved from [1] source (Nokia R1- 2008300)**
       - **For NR positioning evaluations for IOO scenario in FR2 band, the following is observed with respect to horizontal positioning accuracy:**
         1. **Accuracy of ≤** [**1m @ 80%**](mailto:0.2m@90%25) **is achieved in contributions from [5] sources (CATT R1-2007859, Sony R1-2008364, Ericsson R1-2008764, QC R1-2008618, vivo R1-2007665)**

Companies are invited to provide views on above observations in table below

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| Nokia/NSB | Okay. |
| Qualcomm | Update QC Tdoc to R1-2009361. Shoudnt we clarify that the results above are without the optional absolute timing modelling? |
| ZTE | Okay. |
| vivo | Change ‘1m@80%’ to ‘sub-meter level @ 90%’ for aligning observation.  And for the IOO, the results with absolute time and without absolute time are provided by vivo’s Tdoc. Considering the agreement of the last meeting, maybe need to clarify the scenario for the observation.  Agreement:  For the absolute time of arrival modelling in IOO, UMa, Umi, companies may provide the details of their model, if any |
| LG | Okay |
| Intel | Support. |

### Impact of synchronization and gNB/UE TX/RX timing errors

#### Discussion Round #1

1. **(On impact of synchronization and gNB/UE TX/RX timing errors)**
   * **Evaluation results (provided by [6] out of [17] sources) have shown that synchronization and gNB/UE TX/RX timing errors have degraded UE positioning accuracy of the Rel.16 NR Positioning timing-based solutions**
   * **If synchronization and gNB/UE TX/RX timing errors are modelled without compensation, the targeted IIoT accuracy requirements with sub-meter level positioning accuracy are not reached by timing-based solutions of the Rel.16 NR Positioning.**
   * **Accurate synchronization and small gNB/UE TX/RX timing errors are essential to achieve precise performance of the NR Positioning timing-based solutions. Further alignment on the X and Y values are needed in the gNB/UE TX/RX timing error model to facilitate the use of common assumptions across different sources**
   * **The values of X and Y beyond certain limit [1.25 ns and 2.5 ns] allow to approach target positioning accuracies, but the feasibility of X and Y values need to be further discussed by RAN WG4**

Companies are invited to provide views on above observations in table below

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| **CATT** | * + **For the last bullet, should it be “The values of X and Y within certain limit [1.25 ns and 2.5 ns] allow to approach target positioning accuracies, but the feasibility of X and Y values within the limitation need to be further discussed by RAN WG4** |
| **Huawei/HiSilicon** | **We are not sure how [1.25ns and 2.5ns] is obtained from the evaluation.**  **In addition, whether synchronization error will specified/discussed in RAN4 cannot be decided by RAN1, and we are not sure whether other WGs may be involved, e.g. RAN2 or RAN3, SA groups.**  **Therefore, we suggest the following rewording**  **but the feasibility of X and Y values need to be further discussed** |
| vivo | For the first and second sub-bullet, we think the performance of multi-RTT can meet sub-meter level requirement with synchronization.  Besides, in our evaluation, the sub-meter level requirement can be achieved when timing error small than 2ns, so we wouldn’t say that ” the targeted IIoT accuracy requirements with sub-meter level positioning accuracy are not reached”.   |  |  | | --- | --- | | [Case E72], [SH, perfect sync], [FR1], [DL-TDOA]  [BS timing error 1ns, UE timing error 0.5ns] | 0.42 | | [Case E73], [SH, perfect sync], [FR1], [DL-TDOA]  [BS timing error 2ns, UE timing error 0.5ns] | 0.83 |   So, for the First and second sub-bullet, suggest modifying as below   * + **Evaluation results (provided by [6] out of [17] sources) have shown that ~~synchronization and~~ gNB/UE TX/RX timing errors have degraded UE positioning accuracy of the Rel.16 NR Positioning timing-based solutions**   + **Evaluation results (provided by [6] out of [17] sources) have shown that synchronization ~~and gNB/UE TX/RX timing errors~~ have degraded UE positioning accuracy of the Rel.16 NR Positioning timing-based solutions except for multi-RTT.**   + **~~If synchronization and gNB/UE TX/RX timing errors are modelled without compensation, the targeted IIoT accuracy requirements with sub-meter level positioning accuracy are not reached by timing-based solutions of the Rel.16 NR Positioning.~~**   For the third sub-bullet, suggest modifying as below   * + **Accurate synchronization and small gNB/UE TX/RX timing errors are ~~essential~~ helpful to achieve precise performance of the NR Positioning timing-based solutions. ~~Further alignment on the X and Y values are needed in the gNB/UE TX/RX timing error model to facilitate the use of common assumptions across different sources~~**  |  |  | | --- | --- | | [Case E67], [SH, perfect sync], [FR1], [DL-TDOA]  [BS timing error 0.5ns, UE timing error 0.5ns] | 0.3 | | [Case E76], [DH, perfect sync], [FR1], [DL-TDOA]  [BS timing error 0.5ns, UE timing error 0.5ns] | 0.31 |   For the last sub-bullet, suggest to remove it as target requirement has not been decided. |
| LG | Agree. |
| Intel | Agree with the proposal.  We think that RAN1 can determine X and Y values that do not significantly degrade the positioning performance and check feasibility of determined X and Y values with RAN4.  It will facilitate fair comparison of the evaluation results over different companies.  Given that values are provided in brackets, our understanding that they can be further discussed. |
| Nokia/NSB | There are solutions which do not suffer from synchronization errors, so it is not correct to say they are essential, and it should be highlighted that certain methods are not effected by them. We think the final bullet could be removed as well. |
| Futurewei | Do not agree with the last bullet. It is not RAN1 to set and recommend the values for X and Y. Last bullet should be revised to:   * + **~~The values of X and Y beyond certain limit [1.25 ns and 2.5 ns] allow to approach target positioning accuracies, but~~ the feasibility of X and Y values need to be further discussed by RAN WG4** |
| ZTE | Okay with the proposal in principle. RAN1 can decide X and Y values that will not significantly degrade positioning accuracy according to evaluation results. While other WGs may need to check feasibility of X and Y values. |

## Accuracy Evaluation for NR Positioning Enhancements

### LOS / NLOS Identification and NLOS Mitigation

#### Discussion Round #1

1. **(On LOS/NLOS identification and NLOS mitigation)**
   * **Evaluation results for LOS/NLOS identification and NLOS mitigation in indoor factory scenario were provided by [9] sources out of [17]:**
     + **The [6] sources show that LOS/NLOS identification provides performance gain and reporting of the LOS/NLOS link type need to be considered as NR positioning enhancement relative to Rel.16 solutions.**
     + **The [2] sources compared NR positioning performance of LOS/NLOS detection algorithm(s) and have shown that it has better performance compared to the outlier rejection algorithms.**
     + **The [1] source shows that implementing NLOS mitigation can improve positioning accuracy. In InF-SH scenario, gain from the method of LOS classification is marginal.**
     + **The [2] sources show that the outlier rejection algorithm has better performance than LOS/NLOS detection algorithm.**
   * **LOS/NLOS identification and NLOS mitigation are recommended as a solution to overcome the problem of NLOS excess propagation delay offset for indoor factory scenarios especially in the NLOS-heavy scenarios like InF-DH.**

Companies are invited to provide views on above observations in table below

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| **CATT** | **Since the last bullet is an observation, but not a proposal, suggest rewording it to: “LOS/NLOS identification and NLOS mitigation are observed to be a viable solution to…”** |
| Qualcomm | Based on the above evaluations, it is not clear that “LOS/NLOS identification and NLOS mitigation” is recommended. Outlier rejections are implementation-based algorithms that already can be used in NR Rel-16 for “LOS/NLOS identification and mitigation”. There are 4 companies that compare both schemes, and it looks like a tie currently based on the results.  As suggested in previous comments, we suggest to keep just the bullets that summarize the results without drawing further conclusions. |
| **vivo** | **Suggest modifying as below:**   * + **Evaluation results for LOS/NLOS identification and NLOS mitigation in indoor factory scenario were provided by [9] sources out of [17]:**     - **The [6] sources show that LOS/NLOS identification provides performance gain ~~and reporting of the LOS/NLOS link type need to be considered as NR positioning enhancement relative to Rel.16 solutions.~~**     - **The [X] sources show that the outlier rejection algorithm provides performance gain.**     - **The [2] sources compared NR positioning performance of LOS/NLOS detection algorithm(s) and have shown that it has better performance compared to the outlier rejection algorithms.**     - **The [1] source shows that implementing NLOS mitigation can improve positioning accuracy. In InF-SH scenario, gain from the method of LOS classification is marginal.**     - **The [2] sources show that the outlier rejection algorithm has better performance than LOS/NLOS detection algorithm.**     - **The [vivo] source show that the positioning performance of LOS/NLOS detection method degrades as LOS detection error probability increases.**   + **~~LOS/NLOS identification and NLOS mitigation are recommended as a solution to overcome the problem of NLOS excess propagation delay offset for indoor factory scenarios especially in the NLOS-heavy scenarios like InF-DH.~~** |
| LG | Ok with first bullet. But for second bullet, we agree with QC’s comment. |
| Intel | Support in general.  Suggest rephrasing the last bullet as follows:   * + **LOS/NLOS identification is beneficial ~~and NLOS mitigation are recommended as a solution~~ to overcome the problem of NLOS excess propagation delay offset for indoor factory scenarios especially in the NLOS-heavy scenarios like InF-DH.** |
| Apple | Share a similar view with LG and QC |
| Nokia/NSB | Okay with the first bullet. |
| Futurewei | Support Intel’s revised wordings |
| OPPO | Firstly, we suggest update the 3rd sub-bullet in the observation as follows. The NLOS mitigation method out tdoc is UE implementation-based method. The change tries to clarify that.   * + - **The [1] source shows that UE implementation-based NLOS mitigation can improve positioning accuracy. In InF-SH scenario, gain from the method of LOS classification is marginal.**   Secondly, we share the same view as Qualcomm and vivo that the 2nd bullet (conclusion) shall be deleted here. It is good to only make the observation here. |
| ZTE | Agree with changes from Intel. Suggest to revise the first sub-bullet in first bullet as follow,   * + - **The [6] sources show that LOS/NLOS identification provides performance gain and reporting of assistance information for the LOS/NLOS detection need to be considered as NR positioning enhancement relative to Rel.16 solutions.** |

### Aggregation of Positioning Frequency Layers

#### Discussion Round #1

1. **(On aggregation of NR positioning frequency layers)**
   * **Evaluation results for aggregation of positioning frequency layers were provided by [4] sources out of [17].**
   * **Aggregation of NR positioning frequency layers improves positioning accuracy and achieve the target IIoT positioning accuracy.**
   * **Further work is needed to decide on details of supported configurations for NR positioning frequency layer aggregation, including practical impairments such as: channel spacing, timing offset over frequency layers, frequency offset over frequency layers, phase discontinuity and possible amplitude imbalance.**

Companies are invited to provide views on above observations in table below

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| **CATT** | **For 2nd bullet, we may say “Aggregation of NR positioning frequency layers improves positioning accuracy and achieve the target IIoT positioning accuracy, under certain scenarios…** |
| Qualcomm | Similar comment to previous observations. Suggest to summarize what the companies that provided results have demonstrated. E.g., gains are shown under specific scenarios/impairments/configurations. An example of wording:   * + Evaluation results for aggregation of positioning frequency layers were provided by [4] sources out of [17]:     - Aggregation of NR positioning frequency layers improves positioning accuracy and achieve the target IIoT positioning accuracy, under certain scenarios, configurations, and impairments such as: channel spacing, timing offset over frequency layers, frequency offset over frequency layers, phase discontinuity and possible amplitude imbalance. |
| **vivo** | Agree with CATT and QC.  Beside, based on our evaluation results in case E18, the accuracy is 0.23, can't meet [0.2m@90%](mailto:0.2m@90%25), it is too early to say “Aggregation of NR positioning frequency layers achieve the target IIoT positioning accuracy.” And if the bandwidth of two FL is smaller than 50M， it is impossible to meet the requirement too.   |  |  |  |  | | --- | --- | --- | --- | | Simulation case  (Horizontal Error) | Gain vs Rel.16 solution, @[90]%, [m] | Accuracy achieved @[90]% | IIoT horizontal accuracy requirements of [0.2]m @[90]%are met - Yes/No. If no, provide performance gaps | | [Case E103], [SH, perfect sync], [FR1], [50M] |  | 0.31 | 0.11 | | [Case E104], [SH, perfect sync], [FR1], [100M] |  | 0.094 | Yes | | [Case E105], [SH, perfect sync], [FR1], [50M+50M] |  | 0.21 | 0.01 | | [Case E106], [DH, perfect sync], [FR1], [50M] |  | 0.44 | 0.24 | | [Case E107], [DH, perfect sync], [FR1], [100M] |  | 0.17 | Yes | | Case E108], [DH, perfect sync], [FR1], [50M+50M] |  | 0.23 | 0.03 |   So, we prefer the wording as following   * + Evaluation results for aggregation of positioning frequency layers were provided by [4] sources out of [17]:     - Aggregation of NR positioning frequency layers improves positioning accuracy ~~and achieve the target IIoT positioning accuracy~~, under certain scenarios, configurations, and impairments such as: channel spacing, timing offset over frequency layers, frequency offset over frequency layers, phase discontinuity and possible amplitude imbalance.     - FFS whether the performance of aggregation of multiple FLs is better than one FL with the same bandwidth of aggregating |
| LG | We agree with both CATT and QC’s views. |
| Intel | We are OK with the original proposal and additional revised wording from CATT. |
| Nokia/NSB | Suggest to follow the prior observation structure and just describe which sources show improvement for this topic rather than the generic statement in 2nd bullet. |
| OPPO | Regarding the 2nd bullet, suggest to make the following change:   * + **Aggregation of NR positioning frequency layers improves positioning accuracy and achieve the target IIoT positioning accuracy with assumption of time offset <= [x] ns.**   The reason for the suggested change is the time offset in CA could be very large. Even for the intra-band contiguous CA case, the time offset could be 260ns as shown in RAN4 spec. But in the submitted evaluation results, only one source provides the results with time offset value and the time offset value used is some small value as <20ns for InF. All the other sources seem to assume there is time offset. We shall clarify that in the observation to avoid misunderstanding that any time offset value can achieve the IIOT performance requirement.   |  | | --- | | TS 38.104  6.5.3.2 Minimum requirement for *BS type 1-C* and *BS type* 1-H  For MIMO transmission, at each carrier frequency, TAE shall not exceed 65 ns.  For intra-band contiguous *carrier aggregation*, with or without MIMO, TAE shall not exceed 260ns.  For intra-band non-contiguous *carrier aggregation*, with or without MIMO, TAE shall not exceed 3µs.  For inter-band *carrier aggregation*, with or without MIMO, TAE shall not exceed 3µs. |   Furthermore, same comments as Nokia, suggest to only summarize the observation and do not make recommendation. |
| ZTE | Agree with Qualcomm. |

### On Network Synchronization / gNB/UE TX/RX Timing Errors

#### Discussion Round #1

1. **(On Network Synchronization / gNB / UE TX/RX Timing Errors)**
   * **Accurate network synchronization as well as solutions to cope with gNB/UE TX/RX timing errors are needed to achieve precise positioning**
     + **FFS impact on specification**

Companies are invited to provide views on above observations in table below

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| **CATT** | **The sub-bullet of “FFS” can be removed here, unless we want to discuss the impact on the specification in the AI.** |
| Qualcomm | Is this Observation really needed in light of the Observation in Section 2.1.4? There will be overlap with the Summary from CATT on Enhancements if we start discussing enhancements here also. |
| **vivo** | **Agree with QC** |
| LG | We think if we remain FFS in this AI, it may be collide with discussion in the 8.5.3 AI. So, it seems apposite to keep first main bullet only. |
| Intel | Support the proposal.  We are OK to remove the FFS bullet. |
| Nokia/NSB | We don’t agree with this observation. Multi-RTT does not suffer from synchronization errors (or angle based techniques). |
| ZTE | Remove FFS |

# NR Positioning Physical Layer Latency Evaluation

## Rel.16 UE-Assisted DL-TDOA/DL-AOD Positioning

### Discussion Round #1

Companies are invited to fill in the table below for achievable physical layer latency of UE-assisted DL-TDOA/DL-AOD positioning

|  |  |  |
| --- | --- | --- |
| Source  Reference to Tdoc # | Physical layer latency for DL-TDOA/DL-AOD, ms | Comments on major assumptions and physical layer latency components |
| Source #1: | FR1:  FR2: | Major assumptions:  Major components: |
| Qualcomm | [57-823] | Major Assumption: Connected state, FR1, (N,T) = (6,8) PRS capability  Major components: Location Request reception, MG request & configuration, PRS/MG Alignment, PRS processing capabilities |
| Huawei/HiSilicon1  R1-2007576 | FR1:  51.5-66ms (1 samp.)  111.5-126.5ms (4 samp. CSSF = 1)  171.5-186ms (4 samp. CSSF = 2) | Major assumptions:  PRS periodicity is 20ms  MG is requested  Major components  PRS measurement |
| Huawei/HiSilicon2  R1-2007576 | FR1:  171.5-178.5ms (1 samp.)  651.5-658.5ms (4 samp. CSSF = 1) | Major assumptions:  PRS periodicity is 160ms  MG is not requested (sharing with existing RRM gap 6ms/40ms)  Major components  PRS measurement |
| ZTE | FR1:106.23 ms  FR2: 667.87 ms | Major assumptions:  RRC Connected;4 samples;CSSF=1;Measurement Gap Repetition Period is 20ms.  Major components:  Measurement gap request procedures  UE positioning measurement |
| vivo  R1-2007665 | FR1:  [64-11556]  FR2：  [728-328996] | Major assumptions and components:  For FR1: DL measurement &process delay=**,** PRS and MG is periodicity   * the minimum value is 22ms for **，**(N,T) = (6,8) * the maximum value is 11514 ms for **，**(N,T) = (6,1280)   For FR2:  **,** ,   * the minimum value is 20\*4\*8+2ms =642ms * the maximum value is (10240+1280-6)=328954ms   MG request and configuration  Location Request and report |
| Lenovo, Motorola Mobility1 (R1-2007997) | FR1: [38-235.6]  FR2: [35-229.6] | Major Assumptions: Start and End States: RRC\_CONNECTED, MG configuration enabled, MGRP = 20ms-160ms, 1 DL PRS occasion, T=8-160 ms DL PRS processing time.  Major Components: Request Location reception and processing, MG request & configuration, DL PRS Measurement and Processing, Provide Location transmission and processing. |
| Lenovo, Motorola Mobility2 (R1-2007997) | FR1: [17-5147.8]  FR2: [15.5-5144.8] | Major Assumptions: Start and End States: RRC\_CONNECTED, Without MG configuration, DL PRS periodicity =4-5120ms, 1 DL PRS occasion, T=8ms DL PRS processing time.  Major Components: Request Location reception and processing, DL PRS Measurement and Processing, Provide Location transmission and processing. |
| LG (R1-2008416) | FR1:  For UE capability-1:  73.12+[X]ms ~ 217.12+[X]ms  For UE capability-2:  71.68+ [X]ms ~ 215.26+[X]ms | Major assumptions:  -For PUSCH transmission:   * Uplink switching gap is not configured. * No BWP switching * No overlapping symbols of the PUCCH and the scheduled PUSCH * # of PUSCH symbols = from 4 to 14 for Type A * # of PUSCH symbols = from 1 to 14 for Type B   -For PDSCH transmission:   * No overlapping symbols of the scheduling PDCCH and the scheduled PDSCH * # of PDSCH symbols = from 3 to 14 for Type A * # of PDSCH symbols = from 2 to 14 for Type B   -[X]: Processing delay at gNB in terms of physical layer (Up to gNB capability)  Major components   * RRC processing time for LPP message at both gNB and UE (LPP request location information message, measurement gap request message, LPP provide location information message) * PRS measurement (LCM of PRS resource periodicity and repetition periodicity of the measurement gap)   - If the latency components related with higher layer are excluded, the physical layer latency is described as follows:   * For UE capability-1: 23.12ms ~ 167.12ms (FR1)   For UE capability-2: 21.68ms ~ 165.26ms (FR1) |
| CATT(R1-2007859) | FR1: 51.5ms | -Major Assumptions: Case 1, 15kHz, FR1, DL-TDOA  Source UE/Destination NW  Positioning technique DL-TDOA, type DL, mode UE-assisted,  Initial and Final RRC States CONNECTED.  -Major Components: require measurement gap, measurement gap configuration, the delay between the time when DL PRS is received and the time when measurement gap configuration is received, the time from UE begins to measure PRS until the measurement result is ready to report, measurement reporting. |
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## Rel.16 UE-Assisted UL-TDOA/UL-AOA Positioning

### Discussion Round #1

Companies are invited to fill in the table below for achievable physical layer latency of UE-assisted UL-TDOA/UL-AOA positioning

|  |  |  |
| --- | --- | --- |
| Source  Reference to Tdoc # | Physical layer latency for UL-TDOA/UL-AOA, ms | Comments on major assumptions and physical layer latency components |
| Source #1: | FR1:  FR2: | Major assumptions:  Major components: |
| Huawei/HiSilicon  R1-2007576 | FR1:  6.5-26ms (1 samp.)  66.5-86.5ms (4 samp) | Major assumptions:  SRS periodicity is 20ms  Major components  SRS measurement |
| vivo 1  R1-2007665 | FR1:  30.5-2570.5  FR2:  650.5-10250.5 | Major assumptions:  FR1:SRS periodicity is {1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 160, 320, 640, 1280, 2560}slots   * + 15kHz 1ms-2560ms   + 30kHz 0.5ms-1280ms   + 60kHz 0.25ms-640ms   + 120kHz 0.125ms-320ms   FR2: Multiple positioning occasion (4) and beam sweeping (8)   * UL measurement equals to the periodicity of SRS   gNB processing delay is assumed as zero；  The minimum periodicity of SRS is 20ms and the same as the DL minimum periodicity.  Major components:  SRS measurement;  NRPPa process time |
| vivo 2  R1-2007665 | FR1:  11-43 | Major assumptions:  SRS is aperiodic and the slot offset of aperiodic is 0-32 slots   * + 15kHz 0ms-32ms   + 30kHz 0ms-16ms   + 60kHz 0ms-8ms   120kHz 0ms-4ms  Major components:  SRS measurement;  NRPPa process time;  Activation; |
| LG (R1-2008416) | FR1:  For UE capability-1:  31.49+[Y] ms ~ 34.42+[Y] ms  For UE capability-2:  30.77+[Y] ms ~ 33.28+[Y] ms | Major assumptions:  -For SRS transmission:   * One shot transmission (2 OS ~ 12 OS)   -For PDSCH transmission:   * No overlapping symbols of the scheduling PDCCH and the scheduled PDSCH * # of PDSCH symbols = from 3 to 14 for Type A * # of PDSCH symbols = from 2 to 14 for Type B   -[Y]: Processing delay at gNB in terms of physical layer (Up to gNB capability)  Major components   * RRC processing time for LPP message at both gNB and UE (SRS configuration, SRS activation message)   -When the latency related with higher layer is excluded, physical layer latency is described as follows:   * For UE capability-1: 1.49ms ~ 4.42ms (FR1)   For UE capability-2: 0.77ms ~ 3.28ms (FR1) |
| CATT(R1-2007859) | FR1: 5ms | -Major Assumptions: Case 2, 15kHz, FR1, UL-TDOA  Source UE/Destination NW  Positioning technique UL-TDOA, type UL, mode UE-assisted,  Initial and Final RRC States CONNECTED  -Major Components: the time to activate the SRS transmission, the delay from effective time of SRS activation until UE begins to transmit SRS, the time from gNB begins to measure SRS until the measurement result is ready. |
|  |  |  |
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## Rel.16 UE-Assisted Multi-RTT Positioning

### Discussion Round #1

Companies are invited to fill in the table below for achievable physical layer latency of UE-assisted Multi-RTT positioning

|  |  |  |
| --- | --- | --- |
| Source  Reference to Tdoc # | Physical layer latency for Multi-RTT, ms | Comments on major assumptions and physical layer latency components |
| Source #1: | FR1:  FR2: | Major assumptions:  Major components: |
| Qualcomm | [59-823] | Major assumptions: Connected state, FR1, (N,T) = (6,8) PRS capability  Major components: Location Request Reception, MG Request & Configuration, PRS/MG Alignment, PRS processing capabilities |
| Huawei/HiSilicon1  R1-2007576 | FR1:  51.5-66ms (1 samp.)  111.5-126.5ms (4 samp. CSSF = 1)  171.5-186ms (4 samp. CSSF = 2) | Major assumptions:  PRS periodicity is 20ms  MG is requested  Major components  PRS measurement |
| Huawei/HiSilicon2  R1-2007576 | FR1:  171.5-178.5ms (1 samp.)  651.5-658.5ms (4 samp. CSSF = 1) | Major assumptions:  PRS periodicity is 160ms  MG is not requested (sharing with existing RRM gap 6ms/40ms)  Major components  PRS measurement |
| vivo 1  R1-2007665 | FR1:  [94.5-14126.5] + | Major assumptions and components:  For FR1: DL measurement &process delay =**,** PRS and MG is periodicity   * the minimum value is 22ms for **，**(N,T) = (6,8) * the maximum value is 11514 ms for **，**(N,T) = (6,1280)   FR1:SRS periodicity is {1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 160, 320, 640, 1280, 2560}slots   * + 15kHz 1ms-2560ms   + 30kHz 0.5ms-1280ms   + 60kHz 0.25ms-640ms   + 120kHz 0.125ms-320ms   : The alignment delay is the gap between End trigger of DL positioning and Start trigger of UL positioning.  MG request and configuration  Location Request and report |
| LG (R1-2008416) | FR1:  For UE capability-1:  145.34ms+[Z] ~ 293.32+[Z]ms  For UE capability-2:  142.8+[Z]ms ~  289.75+[Z] ms | Major assumptions:  -For PUSCH transmission:   * Uplink switching gap is not configured. * No BWP switching * No overlapping symbols of the PUCCH and the scheduled PUSCH * # of PUSCH symbols = from 4 to 14 for Type A * # of PUSCH symbols = from 1 to 14 for Type B   -For PDSCH transmission:   * No overlapping symbols of the scheduling PDCCH and the scheduled PDSCH * # of PDSCH symbols = from 3 to 14 for Type A * # of PDSCH symbols = from 2 to 14 for Type B   -For SRS transmission:   * One shot transmission (2 OS ~ 12 OS)   -[Z]: Processing delay at gNB in terms of physical layer (Up to gNB capability)  Major components   * RRC processing time for LPP message at both gNB and UE (SRS configuration, SRS activation message, LPP request location information message, measurement gap request message, LPP provide location information message) * PRS measurement (LCM of PRS resource periodicity and repetition periodicity of the measurement gap)   -When the latency related with higher layer is excluded, physical layer latency is described as follows:   * For UE capability-1: 25.34ms ~ 173.32ms (FR1)   For UE capability-2: 22.8ms ~169.75ms (FR1) |
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## Rel.16 UE-Assisted E-CID Positioning

### Discussion Round #1

Companies are invited to fill in the table below for achievable physical layer latency of UE-assisted E-CID positioning

|  |  |  |
| --- | --- | --- |
| Source  Reference to Tdoc # | Physical layer latency for ECID, ms | Comments on major assumptions and physical layer latency components |
| Source #1: | FR1:  FR2: | Major assumptions:  Major components: |
| Huawei/HiSilicon 1  R1-2007576 | FR1  8.5-15ms | Major assumptions:  DL E-CID  RRM measurement available  Major components  Higher layer signaling processing |
| Huawei/HiSilicon 2  R1-2007576 | FR1  6-26ms | Major assumptions:  UL E-CID  RRM measurement available  Major components  Higher layer signaling processing, or  Additional AoA measurement at gNB |
| ZTE | FR1  10.30 ms | Major assumptions:  DL E-CID  RRM measurement is available at UE side.  Major components:  UE interprets and applies the measurement configuration |
| LG (R1-2008416) | FR1:  For UE capability-1:  21.56+[M]ms ~ 23.56+[M] ms  For UE capability-2:  20.84+[M] ms~22.63+[M] ms | Major assumptions:  -For PUSCH transmission:   * Uplink switching gap is not configured. * No BWP switching * No overlapping symbols of the PUCCH and the scheduled PUSCH * # of PUSCH symbols = from 4 to 14 for Type A * # of PUSCH symbols = from 1 to 14 for Type B   -[M]: Processing delay at gNB in terms of physical layer (Up to gNB capability)  Major components   * RRC processing time for LPP message at both gNB and UE (LPP provide location information message)   -When the latency related with higher layer is excluded, physical layer latency is described as follows:   * For UE capability-1: 1.56ms ~ 3.56ms (FR1) * For UE capability-2: 0.84ms~2.63ms (FR1) |
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## Rel.16 UE-Based DL Only Positioning

### Discussion Round #1

Companies are invited to fill in the table below for achievable physical layer latency of UE-based DL-only positioning

|  |  |  |
| --- | --- | --- |
| Source  Reference to Tdoc # | Physical layer latency for ECID, ms | Comments on major assumptions and physical layer latency components |
| Source #1: | FR1:  FR2: | Major assumptions:  Major components: |
| Qualcomm1 | [46-811] | Major assumptions: Start from RRC Connected, FR1, (N,T)=(6,8), External client  Major components: Location Request reception, MG request & configuration, MG/PRS alignment, PRS processing capabilities |
| Qualcomm2 | [8-780] | Major assumptions: Start from RRC Inactive, FR1, (N,T)=(6,8) , Internal client  Major components: PRS alignment time, PRS processing capabilities |
| Huawei/HiSilicon  R1-2007576 | FR1  51-58.5ms (1 samp.) | Major assumptions:  PRS periodicity is 20ms  MG is requested  MO-LR  Major components  PRS measurement |
| vivo 1  R1-2007665 | FR1:  [66-11558]  FR2：  [730-328998] | Major assumptions and components :  For FR1: DL measurement &process delay=, PRS and MG is periodicity  MG request and configuration  Calculation of Location Estimate at the UE  Location Request and report  MT-LR |
| vivo 2  R1-2007665 | FR1:  [55.5-11547.5]  FR2：  [719.5-328987.5] | Major assumptions and components:  For FR1: DL measurement &process delay=, PRS and MG is periodicity  MG request and configuration  Location Request  Calculation of Location Estimate at the UE  MO-LR |
| Lenovo, Motorola Mobility1 (R1-2007997) | FR1: [29-207.8]  FR2: [27.5 -204.8] | Major Assumptions: Start and End States: RRC\_CONNECTED, MGRP = 20ms-160ms, 1 DL PRS occasion, T=8ms-160ms PRS processing time, Request and provide location information messages omitted.  Major Components: MG request & configuration, DL PRS Measurement and Processing. |
| Lenovo, Motorola Mobility2 (R1-2007997) | [8-5120] | Major Assumptions: Start and End States: RRC\_CONNECTED, Without MG configuration, DL PRS periodicity=4-5120ms, 1 DL PRS occasion, T=8ms DL PRS processing time, Request and provide location information messages omitted.  Major Components: DL PRS Measurement and Processing. |
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## NR Positioning Enhancements

### Physical Layer Latency of Enhancements

#### Discussion Round #1

1. **(On Physical Layer Latency of Enhanced NR Positioning Solutions)**
   * **The following latency reduction enhancements are considered/recommended by companies**
     + **Support of on demand DL PRS transmission**
     + **Support of a-periodic / semi-persistent DL PRS transmission**
     + **Measurement gap enhancements (e.g. gap less operation, pre-configured gaps activated by low layer signaling, etc.)**
     + **Enhanced UE DL PRS processing capabilities**
     + **Low layer signaling (DCI/MAC CE) for NR positioning procedures and procedural enhancements**

Companies are invited to provide views on above observations in table below

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| **CATT** | **Okay** |
| **Huawei/HiSilicon** | **As commented, any enhancement on physical layer latency/E2E latency that requires complicated signalling design (i.e. introducing new signalings and procedures) cannot have easy conclusions, as the addition of procedures add another issues.**  **For this particular observation, since we are listing company recommendation here, we suggest to address the potential enhancement on ePos-03.** |
| **vivo** | **Support** |
| **LG** | **This observation is related to the enhancements, so it seems that this issue could be jointly discussed in the second main bullet in 2.3.2.1** |
| **Intel** | **Support the proposal.**  **Suggest rephrasing the main bullet as follows:**   * + **The following latency reduction enhancements were evaluated ~~are considered/recommended~~ by companies and have shown latency reduction:** |

### NR Positioning In RRC\_INACTIVE State

#### Discussion Round #1

1. **(On UE Positioning in RRC\_INACTIVE States)**
   * **Support of UE positioning in RRC\_INACTIVE state provides latency saving due to lack of transition to RRC\_CONNECTED state**

Companies are invited to provide views on above observations in table below

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| **CATT** | **Okay. Maybe change “due to lack of” to “due to no need of”** |
| **Huawei/HiSilicon** | **We are not sure of the baseline that the latency gain is achieved against. For example, if the UE is always in CONNECTED state, we do not see latency reduction compared to IDLE/INACTIVE state.** |
| **vivo** | **Change RRC\_INACTIVE States to RRC\_IDLE / RRC\_INACTIVE States**   1. **(On UE Positioning in RRC\_IDLE /RRC\_INACTIVE States)**    * **Support of UE positioning in RRC\_IDLE /RRC\_INACTIVE state provides latency saving ~~due to lack of~~ due to no need of transition to RRC\_CONNECTED state** |
| **LG** | **Agree with CATT’s comment.** |
| **Intel** | **Agree with comment from CATT.** |

# Summary

TBD

# References

|  |  |
| --- | --- |
| [1] | R1-2007576 Evaluation results for Rel-16 positioning and Rel-17 enhancement, Huawei, HiSilicon |
| [2] | R1-2007720 Evaluation of achievable positioning accuracy, BUPT |
| [3] | R1-2007754 Evaluation of achievable accuracy and latency, ZTE |
| [4] | R1-2007859 Discussion of evaluation of NR positioning performance, CATT |
| [5] | R1-2007908 NLOS Identification and Mitigation, FUTUREWEI |
| [6] | R1-2007997 NR Positioning Latency Evaluations, Lenovo, Motorola Mobility |
| [7] | R1-2008225 Evaluation of NR positioning in IIOT scenario, OPPO |
| [8] | R1- 2008300 Results on evaluation of achievable positioning accuracy and latency Nokia, Nokia Shanghai Bell |
| [9] | R1-2008364 Discussion on performance evaluation of Rel-17 positioning, Sony |
| [10] | R1-2008416 Discussion on evaluation of achievable positioning accuracy and latency for NR positioning, LG Electronics |
| [11] | R1-2008489 Evaluation of achievable positioning latency, InterDigital, Inc. |
| [12] | R1-2008709 Evaluation of positioning enhancements, Fraunhofer IIS, Fraunhofer HHI |
| [13] | R1-2008720 Positioning evaluation results on potential enhancements for additional use cases, CEWiT, IITM, Tejas Networks, IITH, Reliance Jio, Saankhya Labs |
| [14] | R1-2008764 Evaluation of Achievable Positioning Accuracy and Latency, Ericsson |
| [15] | R1-2008618 Evaluation of achievable Positioning Accuracy & Latency, Qualcomm Incorporated |
| [16] | R1-2007665 Evaluation of NR positioning performance, vivo |
| [17] | R1-2007945 Evaluation Results for NR Positioning Performance in I-IoT Scenarios, Intel Corporation |
| [18] | R1-2007945 Feature lead summary for evaluation of NR Positioning enhancements - AI 8.5.2, Intel Corporation |
| [19] | R1-2009375 Summary #1 of RAN WG1 E-mail Discussion [103e-NR-ePos-02]- AI 8.5.2, Moderator (Intel Corporation) |
| [20] | R1-2009376 Summary #2 of RAN WG1 E-mail Discussion [103e-NR-ePos-02]- AI 8.5.2, Moderator (Intel Corporation) |