**3GPP TSG-RAN WG2 Meeting #113e R2-2100xxx**

**Elbonia, January 25th – Feb 5th, 2021**

**Agenda item:** 8.11.2

**Source:** Intel Corporation

**Title:** Report of [Post112-e][616][POS] End-to-end latency analysis (Intel)

**Document for:**  Discussion and decision

# Introduction

This contribution provides report for RAN WG2 email discussion:

* [Post112-e][616][POS] TP for latency analysis results (Intel)

Scope: Capture the latency analysis results in a TP, taking into account any input from RAN1/RAN3/SA2.

Intended outcome: Endorsable TP

Deadline: Long

Rapporteur proposes to divide the discussion in two phases:

**Phase 1**: To check companies’ view on how to capture latency reduction related evaluation, recommendation in the TR, and continue the discussion on which steps can be skipped.

Deadline: Jan 4th

**Phase 2**: Check the draft TP.

Deadline: Jan 11th

To make it easier to find the correct contact delegate in each company for potential follow-up questions, the rapporteur encourages the delegates who provide input to provide their contact information in this table:

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| Company | Delegate contact |
| COMPANY\_NAME | NAME ([email@address.com](mailto:email@address.com)) |
| Intel | yi.guo@intel.com |
| InterDigital | Jaya Rao ([jaya.rao@interdigital.com](mailto:jaya.rao@interdigital.com)), Fumihiro Hasegawa (fumihiro.hasegawa@interdigital.com) |
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# Discussion

## Background in last RAN1, 2, 3 meeting (for information)

**RAN2 situation:** RAN2 discussed the latency from high layer perspective and endorsed the results as

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| [R2-2010866](file:///C:\Users\mtk16923\Documents\3GPP%20Meetings\202011%20-%20RAN2_112-e,%20Online\Extracts\R2-2010866%20Summary%20of%20latency%20results%20-%20V06.docx) Summary of latency results Intel Corporation discussion Rel-17 FS\_NR\_pos\_enh   * Endorsed to be sent to RAN1, with the addition to the introduction: “Results in this document are the status as of RAN2#112-e and represent the worst-case values. RAN2 are still discussing which steps can be skipped for optimal cases.” * Revised in R2-2010872 and endorsed with the change above. |

**Therefore the results in R2-2010872 will be used as baseline for this email discussion.**

**RAN1 situation:** RAN1 did not agree the dedicated value for physical layer latency, but just captured results from companies as observations in the TR38.857;

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| Agreement:  Capture the following observations (Editorial modifications and updates to references to be made when capturing in the TR):   * Summary table on physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-Assisted NR positioning from discussion round #1 in the TR in Section 3.1.1 of R1-2009606 * Summary of physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning in FR1 was provided by [11] sources * Summary of physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning in FR2 was provided by [4] sources * For evaluation in FR1,   + results from [11] sources out of [11] sources (Qualcomm, Huawei, ZTE, vivo, Lenovo, LGE, CATT, Nokia, OPPO, Interdigital, Intel) show that minimum estimated physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning exceeds 10ms   + results from [2] (ZTE, Intel) sources out of [11] sources (Qualcomm, Huawei, ZTE, vivo, Lenovo, LGE, CATT, Nokia, OPPO, Interdigital, Intel) show that minimum estimated physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning exceeds 100ms * For evaluation in FR2,   + results from [4] sources out of [4] sources (ZTE, vivo, Lenovo, OPPO) show that minimum estimated physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning exceeds 10ms   + results from [2] (ZTE, vivo) sources out of [4] sources (ZTE, vivo, Lenovo, OPPO) show that minimum estimated physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning exceeds 100ms * The following list provides the major physical layer latency components for Rel.16 DL TDOA/DL-AOD UE-assisted NR Positioning   + DL PRS alignment, transmission, measurement (including processing time) and report delay   + Measurement gap request, configuration and alignment time   + UE/gNB higher layer (LPP/RRC) processing times   Agreement:  Capture the following observations (Editorial modifications and updates to references to be made when capturing in the TR):   * Capture summary table in Section 3.2.1 of R1-2009606 on physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning from discussion round #1 in the TR * Summary of physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning in FR1 was provided by [8] sources (Huawei, vivo, LGE, CATT, Nokia, OPPO, Interdigital, Intel) * Summary of physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning in FR2 was provided by [2] sources (vivo, OPPO) * For evaluation in FR1,   + results from [3] sources (Huawei, CATT, Nokia) out of [8] sources (Huawei, vivo, LGE, CATT, Nokia, OPPO, Interdigital, Intel) show that minimum estimated physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning does not exceed 10ms   + results from [8] sources out of [8] sources (Huawei, vivo, LGE, CATT, Nokia, OPPO, Interdigital, Intel) show that minimum estimated physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning does not exceed 100ms * For evaluation in FR2,   + results from [2] sources out of [2] sources (vivo, OPPO) show that minimum estimated physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning exceeds 10ms   + results from [1] (OPPO) sources out of [2] sources (vivo, OPPO) show that minimum estimated physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning does not exceed 100ms * The following list provides the major physical layer latency components for Rel.16 UL-TDOA/UL-AOA NR Positioning   + SRS for positioning processing time   + SRS for positioning alignment time (depends on periodic or aperiodic SRS for positioning)   + gNB higher layer processing delays (RRC/ NRPPa processing times)   Agreement:  Capture the following observations (Editorial modifications and updates to references to be made when capturing in the TR):   * Capture summary table on physical layer latency for Rel.16 Multi-RTT UE-assisted NR positioning from discussion round #1 in the TR * Summary of physical layer latency for Rel.16 Multi-RTT UE-assisted NR positioning in FR1 was provided by [6] sources (Qualcomm, Huawei, vivo, LGE, Interdigital, Intel) * Summary of physical layer latency for Rel.16 Multi-RTT UE-assisted NR positioning in FR2 was provided by [0] sources * For evaluation in FR1,   + results from [6] sources (Qualcomm, Huawei, vivo, LGE, Interdigital, Intel) out of [6] sources (Qualcomm, Huawei, vivo, LGE, Interdigital, Intel) show that minimum estimated physical layer latency for Rel.16 Multi-RTT UE-assisted NR positioning exceeds 10ms   + results from [4] sources (Qualcomm, Huawei, vivo, Interdigital) out of [6] sources (Qualcomm, Huawei, vivo, LGE, Interdigital, Intel) show that minimum estimated physical layer latency for Rel.16 Multi-RTT UE-assisted NR positioning does not exceed 100ms * The following list provides the major physical layer latency components for Rel.16 Multi-RTT UE-assisted NR positioning   + DL PRS alignment, transmission, measurement time and report delay   + Measurement gap request, configuration, alignment time   + SRS for positioning processing time   + SRS for positioning alignment time (depends on periodic or aperiodic SRS for positioning)   + UE/gNB higher layer (LPP/RRC/NRPPa) processing times   Agreement:  Capture the following observations (Editorial modifications and updates to references to be made when capturing in the TR):   * Capture summary table on physical layer latency for Rel.16 E-CID NR positioning from discussion round #1 in the TR * Summary of physical layer latency for Rel.16 E-CID NR positioning in FR1 was provided by [3] sources (Huawei, ZTE, LGE) * Summary of physical layer latency for Rel.16 E-CID NR positioning in FR2 was provided by [0] sources * For evaluation in FR1,   + results from [2] sources (ZTE, LGE) out of [3] sources (Huawei, ZTE, LGE) show that minimum estimated physical layer latency for Rel.16 E-CID NR positioning exceeds 10ms   + results from [3] sources (Huawei, ZTE, LGE) out of [3] sources (Huawei, ZTE, LGE) show that minimum estimated physical layer latency for Rel.16 E-CID NR positioning does not exceed 100ms * The following list provides the major physical layer latency components for Rel.16 E-CID NR positioning   + Higher layer signaling processing   Agreement:  Capture the following observations (Editorial modifications and updates to references to be made when capturing in the TR):   * Capture summary table on physical layer latency for Rel.16 DL-only UE-based NR positioning from discussion round #1 in the TR * Summary of physical layer latency for Rel.16 DL-only UE-based NR positioning in FR1 was provided by [6] sources (Qualcomm, Huawei, vivo, Lenovo, OPPO, Interdigital) * Summary of physical layer latency for Rel.16 DL-only UE-based NR positioning in FR2 was provided by [2] sources (vivo, Lenovo) * For evaluation in FR1,   + results from [4] sources (Huawei, vivo, OPPO, Interdigital) out of [6] sources (Qualcomm, Huawei, vivo, Lenovo, OPPO, Interdigital) show that minimum estimated physical layer latency for Rel.16 DL-only UE-based NR positioning exceeds 10ms   + results from [6] sources out of [6] sources (Qualcomm, Huawei, vivo, Lenovo, OPPO, Interdigital) show that minimum estimated physical layer latency for Rel.16 DL-only UE-based NR positioning does not exceed 100ms * For evaluation in FR2,   + results from [2] sources out of [2] sources (vivo, Lenovo) show that minimum estimated physical layer latency for Rel.16 DL-only UE-based NR positioning exceeds 10ms   + results from [1] (vivo) sources out of [2] sources (vivo, Lenovo) show that minimum estimated physical layer latency for Rel.16 DL-only UE-based NR positioning exceeds 100ms * The following list provides the major physical layer latency components for Rel.16 DL-only UE-based NR positioning   + DL PRS alignment, transmission, measurement time and, if requested, report delay   + Measurement gap request, configuration, alignment time   + Higher layer (LPP/RRC) processing times |

RAN1 also captured the recommended solutions in the TR.

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| Agreement:  Capture the following in the TR:   * The enhancements of signaling & procedures for reducing NR positioning latency are recommended for normative work, including DL and DL+UL positioning methods   + The details of the solutions are left for further discussion in normative work, which may include the following aspects:     - Latency reduction related to the measurement gap     - Latency reduction related to the reporting and request of the measurements (e.g., via RRC signaling, MAC-CE and/or physical layer procedure, and/or priority rules)     - Latency reduction related to measurement time * The following enhancements of signaling & procedures for reducing NR positioning latency can be studied and specified, if needed   + Latency reduction related to the request and response of positioning assistance data (e.g., via RRC signaling, MAC-CE and/or physical layer procedure)   + Latency reduction related to the reception of DL PRS (e.g., priority rules for the reception of DL PRS) * No assumptions are made on whether the LCS architecture specified in TS 23.273 is enhanced or not. |

**Note:**

* **The evaluation results for Rel-16 were captured in clause 8.1.2;**
* **The evaluation results on enhancements were captured in clause 8.2.2;**
* **The summary of evaluation was captured in clause 8.4;**
* **The recommendations were captured in clause 10.8;**

**RAN3 situation:** RAN3 also discussed the values provided by RAN2, but there is no consensus on values reported by RAN2.

## TP skeleton for latency reduction evaluations

First, Rapporteur would like to check companies’ view on which clauses should be used to capture RAN2 results. Based on current TR skeleton (RP-202588):

* Clause 8.1 is used to capture the results for Rel-16;
* Clause 8.2 is used to capture the results for enhancements;
* Clause 8.4 is used to capture the summary;
* Clause 10.8 is used to capture the recommendation for latency reduction;

Therefore the potential approach could be:

* To capture the procedure, assumptions and evaluation results for rel-16 in clause 8.1.3 as “High layer latency analysis for Rel-16”
* To capture the evaluation results for enhancements if any in clause 8.2.3 as “High layer latency analysis for NR positioning enhancements”
  + Note: This is related to email discussion [Post112-e][617][POS] Evaluation of latency enhancement solutions (CATT);
* To capture the summary for Rel-16 existing solutions from high layer perspective in clause 8.4;
* To capture the recommendation from high layer perspective in clause 10.4 for latency reduction;

**Question 1: Do companies agree the way to capture evaluation results, summary and recommendation listed as above?**

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| **Company** | **Yes/No** | **Remark** |
| InterDigital | Yes |  |
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In last meeting, RAN2 discussed the evaluation results, and concluded “Results in this document are the status as of RAN2#112-e and represent the worst-case values. RAN2 are still discussing which steps can be skipped for optimal cases.”.

## Call flow and latency analysis for DL-TDOA/DL-AoD

The figure 1 is used for latency analysis for DL-TDOA and DL-AoD.



Figure 1 procedure for DL-TDOA/DL-AoD

Table 2 summarizes the latency for UE assisted DL-TDOA and DL-AoD.

Table 2: Latency for UE assisted DL-TDOA and DL-AoD

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| **Positioning technique [DL-TDOA/DL-AoD, mode [UE-A] Figure 1** | | |
| **Latency Component** | **Value Range (ms)** | **Description of Latency Component** |
| Step 1 LPP Request capabilities | 18-34.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+ TUEProc-RRCDLInfo  Processing delays: 14ms  - UE: TUEProc-RRCDLInfo= 5ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms  Note 1: the LPP capability processing delay is counted together in response message. |
| Step 2 LPP Provide Capabilities | 25-54.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCULInfo+ TUEProc-LPPCapab  Processing delays: 21-34ms  - UE:  TUEProc-RRCULInfo= 2-5ms  TUEProc-LPPCapab= 10-20ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 3 LPP Provide Assistance Data | 28-44.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCDLInfo+ TUEProc-LPPAssi  Processing delays: 24ms  - UE:  TUEProc-RRCDLInfo= 5ms  TUEProc-LPPAssi= 10ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 4 LPP Request Location Information | 23-39.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCDLInfo+ TUEProc-LPPLocationRe  Processing delays: 19ms  - UE:  TUEProc-RRCDLInfo= 5ms  TUEProc-LPPLocationRe = 5ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 5 RRC Location Measurement Indication | 5-8.5 | TUEProc-RRCLocationMeas + TUE-gNB+ TgNBProc-RRC  Processing delays: 5-8ms  - UE:  TUEProc-RRCLocationMeas = 2-5ms  - gNB: TgNBProc-RRC= 3ms  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB= 0-0.5ms |
| Step 6 RRC Measurement Gap configuration | 13-13.5 | TgNBProc-RRC+ TUE-gNB+ TUEProc-RRCReconf  Processing delays: 13ms  - UE:  TUEProc-RRCReconf = 10ms  - gNB: TgNBProc-RRC= 3ms  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB= 0-0.5ms |
| Step 7 DL PRS measurement | **TDL-Meas** | RAN1 inputs |
| Step 8 LPP Provide Location Information | 20-39.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCULInfo+ TUEProc-LPPLocationRe  Processing delays: 16-19ms  - UE:  TUEProc-RRCULInfo= 2-5ms  TUEProc-LPPLocationRe= 5ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 9 LMF calculation | 2-30 | TLMF-Calc |
| Total values | 134-264.5 | Note 2: **TDL-Meas** is not counted. |

**Question 2.1: For DL-TDOA/DL-AoD, which steps can be skipped for optimal cases? Please explain the reason.**

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| **Company** | **Step xx** | **Remark** |
| InterDigital | Steps 5 and 6 | The RRC signalling for measurement gap configuration can be skipped or replaced with lower layer signalling (e.g. MAC CE), considering enhancements to support priority rule for reception of DL PRS and/or use of preconfigured measurement gap. It appears that the procedure provided in Fig. 1 is intended for UE-assisted positioning. Clearly, for UE-based positioning further optimizations are possible. For example, the steps that may be skipped in this case include Step 3 (assuming UE receives AD in SI), Step 4 (assuming MO-LR) and Step 8 (assuming MO-LR). |
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## Call flow and latency analysis for UL-TDOA/UL-AoA

The figure 2 is used for latency analysis for UL-TDOA and UL-AoA.



Figure 2 procedure for UL-TDOA and UL-AoA

Table 3 summarizes the latency for UE assisted UL-TDOA and UL-AoA.

Table 3: Latency for UE assisted UL-TDOA and UL-AoA

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| **Positioning technique [UL-TDOA/UL-AoA, mode [UE-A] Figure 2** | | |
| **Latency Component** | **Value Range (ms)** | **Description of Latency Component** |
| Step 1 LPP Request capabilities | 18-34.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+ TUEProc-RRCDLInfo  Processing delays: 14ms  - UE: TUEProc-RRCDLInfo= 5ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms  Note 1: the LPP capability processing delay is counted together in response message.  Note 2: Should not be counted if the LMF does not need the capability, e.g. only use Rel-15 SRS for UL positioning. . |
| Step 2 LPP Provide Capabilities | 25-54.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCULInfo+ TUEProc-LPPCapab  Processing delays: 21-34ms  - UE:  TUEProc-RRCULInfo= 2-5ms  TUEProc-LPPCapab= 10-20ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 3 NRPPa POSITIONING INFORMATION REQUEST | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 4 RRC SRS configuration | 13-13.5 | TgNBProc-RRC+ TUE-gNB+ TUEProc-RRCReconf  Processing delays: 13ms  - UE:  TUEProc-RRCReconf = 10ms  - gNB: TgNBProc-RRC= 3ms  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  Note 3: Should not be counted if the SRS configuration has been configured before the procedure. |
| Step 5 NRPPa POSITIONING INFORMATION RESPONSE | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 6 NRPPa Request UE SRS activation | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms  Note 4: Should not be counted if the periodic SRS is used. |
| Step 7 MAC Activate UE SRS transmission | 1-3.5 | TUE-gNB +TUEProc-MAC-SRSAct  Processing delays: 13ms  - UE:  TUEProc-MAC-SRSAct = 1-3ms  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  Note 5: Should not be counted if the periodic or aperiodic SRS is used. |
| Step 8 NRPPa Request UE SRS activate Response | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms  Note 6: Should not be counted if the periodic SRS is used. |
| Step 9 NRPPa MEASUREMENT REQUEST | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 10 UL SRS measurement | TUL-measc | RAN1 inputs |
| Step 11 NRPPa MEASUREMENT RESPONSE | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 12 LMF calculation | 2-30 | TLMF-Calc  LMF calculation/estimation delay: 2-30  TLMF-Calc |
| Total values | 137-310 | Note 7: TUL-measc is not counted;  Note 8: The total number will be further reduced if step 1, 2, 4, 6, 7 and 8 are not counted; |

**Question 2.2: For UL-TDOA/UL-AoA, which steps can be skipped for optimal cases? Please explain the reason.**

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| **Company** | **Step xx** | **Remark** |
| InterDigital | Steps 6,7,8 | The NRPPa procedure for SRS activation request/response for aperiodic and semi-persistent SRS may be skipped by piggybacking the request/response in Step 6/8 with positioning information request/response in Step 3/5.  It may also be possible for merging positioning information request (Step 3) and measurement request (Step 9) and the corresponding response messages (Step 5 and Step 11). These optimizations may be applicable for deployments with multiple TRPs associated with the same gNB. |
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## Call flow and latency analysis for Multi-RTT

The figure 3 is used for latency analysis for Multi-RTT.



Figure 3 procedure for Multi-RTT

Table 4 summarizes the latency for UE assisted Multi-RTT.

Table 4: Latency for UE assisted Multi-RTT

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| **Positioning technique [Multi-RTT] [UE-A] Figure 3** | | |
| **Latency Component** | **Value Range (ms)** | **Description of Latency Component** |
| Step 1 LPP Request capabilities | 18-34.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+ TUEProc-RRCDLInfo  Processing delays: 14ms  - UE: TUEProc-RRCDLInfo= 5ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms  Note 1: the LPP capability processing delay is counted together in response message. |
| Step 2 LPP Provide Capabilities | 25-54.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCULInfo+ TUEProc-LPPCapab  Processing delays: 21-34ms  - UE:  TUEProc-RRCULInfo= 2-5ms  TUEProc-LPPCapab= 10-20ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 3 NRPPa POSITIONING INFORMATION REQUEST | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 4 RRC SRS configuration | 13-13.5 | TgNBProc-RRC+ TUE-gNB+ TUEProc-RRCReconf  Processing delays: 13ms  - UE:  TUEProc-RRCReconf = 10ms  - gNB: TgNBProc-RRC= 3ms  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB= 0-0.5ms |
| Step 5 NRPPa POSITIONING INFORMATION RESPONSE | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 6 NRPPa Request UE SRS activation | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 7 MAC Activate UE SRS transmission | 1-3.5 | TUE-gNB +TUEProc-MAC-SRSAct  Processing delays: 13ms  - UE:  TUEProc-MAC-SRSAct = 1-3ms  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB= 0-0.5ms |
| Step 8 NRPPa Request UE SRS activate Response | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 9 NRPPa MEASUREMENT REQUEST | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms  Note 2: Step 9 (NRPPa Measurement Request) can be performed in parallel with Steps 10/11 (LPP signalling). Hence, only the bigger number of the two procedures are considered (i.e., the latency for NRPPa Measurement Request is not counted in the summation). |
| Step 10 LPP Provide Assistance Data | 28-44.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCDLInfo+ TUEProc-LPPAssi  Processing delays: 24ms  - UE:  TUEProc-RRCDLInfo= 5ms  TUEProc-LPPAssi= 10ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 11 LPP Request Location Information | 23-39.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCDLInfo+ TUEProc-LPPLocationRe  Processing delays: 19ms  - UE:  TUEProc-RRCDLInfo= 5ms  TUEProc-LPPLocationRe = 5ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 12 RRC Location Measurement Indication | 5-8.5 | TUEProc-RRCLocationMeas + TUE-gNB+ TgNBProc-RRC  Processing delays: 5-8ms  - UE:  TUEProc-RRCLocationMeas = 2-5ms  - gNB: TgNBProc-RRC= 3ms  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB= 0-0.5ms |
| Step 13 RRC Measurement Gap configuration | 13-13.5 | TgNBProc-RRC+ TUE-gNB+ TUEProc-RRCReconf  Processing delays: 13ms  - UE:  TUEProc-RRCReconf = 10ms  - gNB: TgNBProc-RRC= 3ms  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB= 0-0.5ms |
| Step 14 a DL PRS measurement | TDL-measc | RAN1 inputs |
| Step 14 b UL SRS measurement | TUL-measc | RAN1 inputs |
| Step 15 LPP Provide Location Information | 20-39.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCULInfo+ TUEProc-LPPLocationRe  Processing delays: 16-19ms  - UE:  TUEProc-RRCULInfo= 2-5ms  TUEProc-LPPLocationRe= 5ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 16 NRPPa MEASUREMENT RESPONSE | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms  Note 3: Step 16 (NRPPa Measurement Response) can be performed in parallel with Step 15 (LPP Provide Location Information). The UL- and DL- measurements are made concurrently, hence the results are send at about the same time. Only the bigger number of the two procedures need to be considered (i.e., the latency for NRPPa Measurement Response is not counted in the summation). |
| Step 17 LMF calculation | 2-30 | TLMF-Calc  LMF calculation/estimation delay: 2-30  TLMF-Calc |
| Total values | 200-397.5 | Note 4: TDL-measc and TUL-measc are not counted;  Note 5: DL PRS related procedure may be performed in parallel with UL SRS related procedure, and therefore we may only need to count the latency caused by DL PRS related procedure, i.e. the latency for Multi-RTT could be similar to the latency of DL-TDOA/DL-AoD |

**Question 2.3: For Multi-RTT, which steps can be skipped for optimal cases? Please explain the reason.**

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| **Company** | **Step xx** | **Remark** |
| InterDigital | Steps 12, 13 | Considering concurrent configuration of UL and DL positioning, where NRPPa Positioning information request (Step 3) can include the DL PRS configuration, it may be possible for skipping RRC configuration for measurement gap (Steps 12 and 13). The gNB may configure with RRC (in Step 4) the alignment and timing for UL+DL positioning such that DL PRS measurement and UL SRSp transmission can be done with low latency.  In addition, Step 4 should not be counted if SRS is configured via RRC already.  Regarding Note 5, “we may only need to count the latency caused by DL PRS related procedure” may not be the case. For example, for UL, longer measurement time of SRS (compared to PRS) may be needed to mitigate interference and increase link budget for SRS, as noted in the RAN1 agreement. Therefore, if SRS and PRS measurements are performed simultaneously, it should be max(TDL-measc, TUL-measc). |
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## Call flow and latency analysis for NR E-CID

The figure 4-1 is used for latency analysis for Downlink NR E-CID



Figure 4-1 procedure for Downlink NR E-CID

Table 5 summarizes the latency for UE assisted Downlink NR E-CID.

Table 5: Latency for UE assisted Downlink NR E-CID

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| **Positioning technique [Downlink NR** **E-CID] [UE-A] Figure 4-1** | | |
| **Latency Component** | **Value Range (ms)** | **Description of Latency Component** |
| Step 1 LPP Request capabilities | 18-34.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+ TUEProc-RRCDLInfo  Processing delays: 14ms  - UE: TUEProc-RRCDLInfo= 5ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms  Note: the LPP capability processing delay is counted together in response message. |
| Step 2 LPP Provide Capabilities | 25-54.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCULInfo+ TUEProc-LPPCapab  Processing delays: 21-34ms  - UE:  TUEProc-RRCULInfo= 2-5ms  TUEProc-LPPCapab= 10-20ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 3 LPP Request Location Information | 23-39.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCDLInfo+ TUEProc-LPPLocationRe  Processing delays: 19ms  - UE:  TUEProc-RRCDLInfo= 5ms  TUEProc-LPPLocationRe = 5ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 4 UE measurement |  | FFS whether should be counted or not. |
| Step 5 LPP Provide Location Information | 20-39.5 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NAS/LPP +TUE-gNB+  TUEProc-RRCULInfo+ TUEProc-LPPLocationRe  Processing delays: 16-19ms  - UE:  TUEProc-RRCULInfo= 2-5ms  TUEProc-LPPLocationRe= 5ms  - gNB: TgNBProc-NAS/LPP= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 6 LMF calculation | 2-30 | TLMF-Calc  LMF calculation/estimation delay: 2-30  TLMF-Calc |
| Total values | 88-198 | Note 2: TDL-measc is not counted; |

**Question 2.4: For Downlink E-CID, which steps can be skipped for optimal cases? Please explain the reason.**

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| **Company** | **Step xx** | **Remark** |
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The figure 4-2 is used for latency analysis for Uplink NR E-CID



Figure 4-2 procedure for Uplink NR E-CID

Table 6 summarizes the latency for UE assisted Uplink NR E-CID.

Table 6: Latency for UE assisted Uplink NR E-CID

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| **Positioning technique [Uplink NR E-CID] [UE-A] Figure 4-2** | | |
| **Latency Component** | **Value Range (ms)** | **Description of Latency Component** |
| Step 1 NRPPa E-CID Measurement Initiation Request | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 2 RRC Measurement/SRS configuration | 13-13.5 | TgNBProc-RRC+ TUE-gNB+ TUEProc-RRCReconf  Processing delays: 13ms  - UE:  TUEProc-RRCReconf = 10ms  - gNB: TgNBProc-RRC= 3ms  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  Note 1: should not be counted if the configuration has been configured before the procedure; |
| Step 3 MAC Activate UE SRS transmission | 1-3.5 | TUE-gNB +TUEProc-MAC-SRSAct  Processing delays: 13ms  - UE:  TUEProc-MAC-SRSAct = 1-3ms  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  Note 2: should not be counted if the periodic or aperiodic SRS is used or the SRS has been activated before the procedure. |
| Step 4 gNB measurements | TUL-measc | RAN1 inputs |
| Step 5 RRC Measurement report | 5-8.5 | TUEProc-RRCULInfo+ TUE-gNB+ TgNBProc-RRC  Processing delays: 5-8ms  - UE:  TUEProc-RRCULInfo = 2-5ms  - gNB: TgNBProc-RRC= 3ms  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB= 0-0.5ms  Note 3: should not be counted if the gNB already has valid measurement results from the UE. |
| Step 6 NRPPa E-CID Measurement Initiation Response | 13-29 | TLMFProc+ TAMF-LMF+ TAMFProc +TgNB-AMF + TgNBProc-NRPPa  Processing delays: 9 ms  - gNB: TgNBProc-NRPPa= 3ms  - AMF: TAMFProc= 3ms  - LMF: TLMFProc= 3ms  Signalling delay:4-20ms  - gNB-AMF: TgNB-AMF= 3-10ms  - AMF-LMF: TAMF-LMF= 1-10ms |
| Step 7 LMF calculation | 2-30 | TLMF-Calc  LMF calculation/estimation delay: 2-30  TLMF-Calc |
| Total values | 47-113.5 | Note 4: TUL-measc is not counted;  Note 5: The total number will be further reduced if step 2, 3 and 5 are not counted; |

**Question 2.5: For Uplink E-CID, which steps can be skipped for optimal cases? Please explain the reason.**

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| **Company** | **Step xx** | **Remark** |
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# Summary

Based on the inputs from companies, we have following proposals:

**To be added**

# Reference

[1] RAN2-112-e-Positioning-Relay-2020-11-13-1745\_eom

[2] Chairman's Notes RAN1#103-e 8.5 v011

[3] RAN3\_110-e\_agenda\_with\_Tdocs20201112\_EOM

[4] RP-202588 TR 38.857 v100: Study on NR positioning enhancements; Ericsson

[5] R2-2010872 Summary of latency results Intel Corporation